A CRITICAL REVIEW OF THE RECENT LITERATURE

PERTAINING TO

TRAUMATIC INJURIES OF THE JAWS

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This Critical Review Thesis is presented as an integral part of the examination for the Degree of Master of Dental Surgery in the subject of Oral Surgery. It embraces a general review of the current text books on Oral Surgery, Oral Pathology, Oral Medicine, in addition to books and periodical publications, which are listed in the pages of reference.

The accompanying illustrations are purely diagramatic in nature and are included in an endeavour to facilitate the reading of this thesis.

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MAXILLA, MANDIBLE, AND ASSOCIATED BONES

A SIDE VIEW OF THE SKULL.
1.

THE AETIOLOGY OF TRAUMATIC INJURIES OF THE JAWS.

Traumatic injuries of the jaws are due to violence, either direct or indirect, resulting in injury to the soft tissues of the jaws and fracture of the bony structures.

Direct fractures occur at the point of impact, whereas indirect fractures are found in other areas, as a result of transmission of the blow through the bone to a weak area, such as the neck of the mandibular condyle.

This injury may be caused by:

1. Blows, as with a club or bat.
2. A fall.
3. A kick from an animal.
5. Precipitation from some height.
6. Automobile accidents.
7. Projected missiles.
8. The injudicious removal of teeth where undue force is exerted. This may occur during the removal of lower impacted third molars, resulting in fracture of the mandible.

Various analyses of the aetiology of violence resulting in traumatic injuries to the jaws have been undertaken, presenting us with statistical data. (1)

Rowe and Killey in an analysis of 500 cases of maxillo-facial injuries, which occurred during peace time, present the following information regarding the aetiology of an individual percentage basis of the total cases presented:

1. Fights ... 18.6% of cases
2. Motor cycle accidents... 15.8% " "
3. Pedal cycle accidents... 14.8% " "
4. Falls ... 12.0% " "
5. Automobile accidents... 11.6% " "
6. Accidents occurred while playing collective sport ... 8.0% " "
7. Pedestrians injured by motor vehicles 4.6% " "
8. Injuries occurred as a result of fainting ... 3.4% of cases
9. Injuries occurred as a result of epileptic fits ... 1.8% " "
10. Miscellaneous accidents ... 9.4% " "

An examination of this analysis reveals that road traffic accidents account for 46.8% of the total number of the injuries sustained. This indeed stresses the need for greater road safety measures.

In this same analysis, it was shown that the greatest number of fractures of the bony structures occurred between the ages of 20-29 years, and that the relative frequency of fractures sustained by the lower and middle-third of the facial skeleton was as follows:

1. Fractures which occurred in the mandible alone - 336 cases
2. Fractures which occurred in the maxillae and associated bones ... 118 "
3. Combined fractures, which occurred in the mandible, maxillae and associated bones ... 46 "

It follows, therefore, that the total number of cases exhibiting mandibular fracture was 382, or 76.4%, whereas the total number of cases with involvement of the middle third of the facial skeleton amounted to 164, or 32.8%, of the total.

The authors also noted that in the mandible 35.6% of fractures were discovered in the region of the mandibular condyle, and that the region of the angle of the mandible was slightly more liable to be fractured than the molar area. In fractures of the middle third of the face, however, fractures of the zygomatic bone, presented the greatest number of cases, viz. 39.6% of the total, closely followed by fractures of Le Fort I and II types, showing 18.8% of the total.
Similar surveys have been carried out in various parts of the world, due mainly to the rapidly increasing evidence of automobile accidents. It has been shown that in accidents of this type 56.7% of the total are sustained in the region of the head and neck.

Enghoff and Siemssen in Copenhagen point out that the incidence of brawls and industrial accidents is closely related to the incidence of automobile accidents in maxillo-facial injuries, and they present a ratio of these groups in the following manner:

<table>
<thead>
<tr>
<th>Category</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Accidents</td>
<td>2</td>
</tr>
<tr>
<td>Brawls</td>
<td>2</td>
</tr>
<tr>
<td>Industrial Accidents</td>
<td>1</td>
</tr>
</tbody>
</table>

These men also maintain that:

1. Nearly half of the patients presented multiple jaw fractures.
2. The majority of fractures of the upper jaw consisted of bilateral fractures.
3. Multiple mandibular fractures were found to occur more frequently than isolated mandibular fractures.
4. Fractures of the horizontal ramus of the mandible, combined with fracture of the opposite condyle, occurred in two thirds of the total number of multiple mandibular fractures.

From the above, it is noted that of the bony framework comprising the facial skeleton, the mandible is the bone most frequently fractured upon sustaining traumatic injury to the jaws. No doubt this is because the mandible is the most prominent part of the face and therefore most frequently exposed to external violence. Again, its anatomical shape, likened to a horse shoe, and its lack of support - other facial bones obtain support from contiguous bones - make it more prone to fracture than other facial bones. The articulation of the teeth aids greatly in withstanding traumatic forces which may be brought to bear upon the mandible, and give it support with the other facial bones. This is strongly suggested by the fact that the
percentage of fractures in individuals who have a projecting lower jaw, or a poor complement of teeth, seems to exceed the proportionate ratio for similar accidents in more normal individuals.

Fractures of the maxillae are rare in comparison with fractures of the mandible, but on occurrence may present greater difficulties in treatment. These injuries are usually compound, comminuted and often depressed. This type of injury is usually the sequel to alcoholic brawls, or violent impact with the facia panel in automobile accidents.

In recent years traumatic injuries of the facial skeleton due to gunshot wounds have been prominent, following the conflicts of the Second World War and the Korean Campaign. Fractures caused by gunshot, shrapnel or shell, are as a rule comminuted, and the shattered fragments are driven into the surrounding tissues. The soft parts within the track of the projectile are badly lacerated and bruised, often foreign bodies are present. These conditions must complicate treatment to a great extent, and retard cicatrisation.

It is obvious, therefore, that injuries to the jaws require highly specialised technical treatment. This must be directed towards the establishment of the normal function of the jaws and teeth, together with prevention of infection and facial disfigurement.
The Examination of the Patient.

The examination should include:

2. A general examination.
3. Regional examination.
4. A detailed radiographic examination of the jaws.

The History of the Patient

This is most important as it may bring to light the presence of debilitating diseases such as diabetes, or the presence of vitamin deficiencies or again blood dyscrasias. These have a direct bearing on the healing of the tissues and therefore must influence subsequent treatment.

The General Examination

This general examination will show:

1. Any great loss of blood as a result of haemorrhage.
2. Whether a state of shock exists.
3. Any serious brain injury.
4. Whether a general anaesthetic can be considered, as in cases of depressed multiple fractures of the maxillae, nasal and zygomatic bones.
5. The pulse rate. A low pulse rate between 50 to 60 may be a symptom of cerebral pressure, involving fracture of the skull.
6. Ophthalmological signs. Failure of the pupils to react to light, and diplopia are signs of intra-cranial injury.
7. The presence or absence of infection.

High level fractures of the maxillae, and upper facial bones which exhibit mobility and displacement, together with obvious or suspected cranial injuries, should always be treated with extreme caution.
It has been found that bilateral fractures of the maxillae with detachment of these bones from their cranial base are seldom solitary clinical entities. Other injuries of the buttressing bones, such as the zygoma and the pterygoid plates of the sphenoid bone, are generally involved, which may result in cranial injuries. In any maxillary fracture with mobility, displacement concomitant with fracture of the pterygoid processes of the sphenoid bone, would appear likely. A considerable portion of the force required to fracture a maxilla is transmitted via the pterygoid plates to the base of the skull. This could easily result in the fracture of the pterygoid process at the base of the skull. Many severe injuries of the facial bones are associated with fracture of the cribiform plate of the ethmoid bone. Under such circumstances, cerebro-spinal fluid usually drains from the nose for several days following the injury, and a danger in these cases is the possible development of meningitis. Accordingly, every patient with a serious maxillary or nasal injury should be examined for possible cerebro-spinal rhinorrhea. One must in these cases be able to distinguish mucus from cerebro-spinal fluid draining from the nose.

Brain injury, as a result of a basal skull fracture, would be suggested by several neurological signs, such as stupor, confusion, and mental lassitude. Therefore, early consultation to rule out intra-cranial damage must be an early diagnostic procedure in injuries of this type. The presence of brain injury will not affect the technique of reduction and immobilisation of a maxillary fracture, but it may have a bearing on the optimal time for this procedure.

**The Regional Examination**

This regional examination may present difficulties. Swelling of the face and muscular trismus, which is present in most cases of mandibular fracture, may prevent a thorough inspection of the mouth and teeth. A clinical examination should
be conducted systematically. If the patient is in great pain due to swelling, cuts and contusion of the tissues, or if there is marked muscular trismus present, it may be necessary to employ a general anaesthetic to complete the examination.

The outstanding signs and symptoms denoting traumatic injuries of the jaws are:

1. **Deformity:**
   This will be directly related to the amount of swelling of the soft tissues present, and to the displacement of the fracture bone or bones. The swelling will depend upon the amount of contusion of the soft tissues, its region and the extravasation of blood. The displacement of the fractured bone will vary according to the force and the direction of the violence causing the injury, and the muscular tension affecting the symmetry of the face.

2. **Abnormal Mobility:**
   This sign is pathognomonic of fracture.

3. **Crepitus:**
   This is yet another positive sign of fracture of bony structures. The ends of the bones causing a grating against each other when manipulated and this gritting is often audible.

4. **Disability or interference of function:**

5. **Malocclusion:**
   Retraction of the maxillae is common in horizontal fractures of the upper jaw. Open bite relationships, and often retraction of the mandible occur in bilateral fractures of the condyles of the mandible. A unilateral fracture of the mandibular condyle can produce a cross bite and lateral deviation in a forward extension of the lower jaw.
6. **Trismus:**

Trismus of the elevator muscles is a common symptom of a mandibular fracture. The patient is often unable to open the mouth. Inability to open the mouth may also be caused by functional interference due to impaction and overriding of the fragments.

7. **Pain:**

This may be variable but is usually severe.

8. **Draising and tenderness of the tissues:**

9. **Neurological signs:**

Paralysis may be noted. This is due to compression of the facial, auditory, or optic nerves, either directly by the displaced bone, or indirectly by oedema. Lacerations of the face may also affect the branches of the facial nerve influencing certain muscles of the face and so exhibiting "Bell's Palsy" sign. Injury to the trigeminal nerve may also give rise to varying degrees of numbness in the area of its distribution. This may be particularly in evidence when the inferior dental nerve is impinged in fractures of the mandible.

10. **Salivation and Feter:**

Increased salivation and fetor of the breath, generally accompany fracture of the jaws. These are the results of the absence of normal jaw movements, stagnation of food debris, and the presence of infection.

On recognising any of these clinical signs and symptoms of injuries to the jaws, our regional examination must be extended to include a full radiographic examination.

A **Radiographic Examination** is indispensable, saving much time for the operator and discomfort to the patient.

This examination should include:

1. A lateral view of the head.
2. An exposure for the body of the mandible.
3. An exposure of the ramus of the mandible.
4. Posterior-Anterior views.
5. Occlusal films.
6. Dental films.

One cannot be too critical of inadequate radiology, as by this means the exact location and type of fracture, together with its involvement with surrounding structures, can be ascertained. Two radiographs at right angles to each other should always be the minimum for the diagnosis of any fracture. Each radiograph is designed to show certain areas to the best advantage, and if an apparent abnormality is seen in another area of the film, the appropriate radiograph for that area should be taken before any diagnosis is made.

In radiographic interpretation, it is paramount to recognise such bony structures as the orbits, maxilla, antra, zygomatic arches, mandible ... and to be able to trace them out for any breaks or steps.

The radiographic appearance of fracture lines may vary according to:

1. The amount of destruction of bony tissues.
2. The amount of displacement of the fragments.
3. The angle of projection of the rays.
4. The stage of repair of the fracture. The edges of a fracture line are sharp and well defined. They tend to change direction by angles and not curves, to cross arterial and other lines.

In the maxillae, the diagnosis of fractures by radiographs is often difficult, for a continuous fracture line is rarely seen. Fractures may be seen, however, according to the type at the rim of the orbit, fronto-malar suture, fronto-nasal suture, and the zygomatic arch. In radiology of these regions, certain normal structures closely simulate fractures which could cause a pit-fall diagnosis - such as the superimposed shadows of the hyoid bone and the intervertebral spaces.
Routine Exposures include:

1. **Posterior-anterior views for the ramus and condyle of the mandible.**
   
   In this case, in order to see the condyle head, clear of the heavy bony structures of the skull, the rays should pass parallel to the base of the skull. The head is placed on the cassette with the nose and forehead touching it, and the external auditory meatus should be vertically above the centre of the eye, and the X-ray tube centred above the nape of the neck.

2. **Views of the orbital margins, antra, nose, coronoid processes and malar bones.**

   The chin is here placed on the cassette and the head moved until the external occipital protuberance is vertically above it, and the ear eyelike approximately at 45 degrees to the occipito-chin line.

3. **Lateral Views.**

   The head is here placed sideways upon the cassette, one ear being vertically above the other.

4. **A Thirty Degree Lateral View.**

   This view is often taken to show an ascending ramus and condyle head of the mandible. The position is the same as for the lateral view, except that the head and cassette are tilted at 30 degrees from the horizontal, thus avoiding superimposition of the near side of the mandible upon the film.

4. **A Rotated thirty degree lateral.**

   This is often a useful exposure and will show the coronoid process and the body of the mandible from the angle to the canine, according to the degree of rotation. Here the position is the same as for a thirty-degree lateral view, except that the head is rotated upon the spinal column from 15 to 30 degrees. In this case it is most important that the plate be maintained parallel to the spinal column, otherwise a
very distorted picture will result.

6. **A Rotated posterior-anterior exposure.**
   This view will show the lower incisor and canine region of the mandible. This position is similar to the posterior-anterior position except that the chin is placed nearer the cassette. The head is then rotated about the spinal column, approximately 20 degrees in order that the central rays will pass midway between the ramus of the mandible and the spinal column.

7. **Water's Radiographic Position.**
   This position has been found to give the clearest view of the maxillae and the maxillary sinuses. The face of the patient is placed so that the nose and chin are in contact with the cassette, the latter held at an angle of 23 degrees. The central ray is then projected in a vertical direction, so that it strikes the upper lip. This technique will show clearly the external wall of the maxillary sinus, and the antro-nasal wall, together with the nasal septum which may be disorganised, particularly in cases of horizontal fracture of the maxilla.

Upon the completion of a systematic general and regional examination, together with adequate radiography, a plan of treatment can be decided upon. It is directed towards the prevention and control of infection, and the re-establishment of normal function of the jaws.

It must be stressed that treatment be intelligently planned. Hasty procedures are often harmful. The individuality of each case must be recognised, and at times little may be lost by delaying treatment, especially if any risk is involved in moving a patient whose general condition is considered poor.
The execution of primary first-aid measures and the planning of definite treatment must always be considered with the greatest care. The re-establishment of normal function is considered as important as the aesthetic result in injuries of the face and jaws. At times a compromise must be made between function and aesthetics. It is a fundamental principle of any surgical technique to conserve as much tissue as possible. Hastily and incorrectly applied bandages, together with premature suturing can complicate the treatment. Radical debridement of tissue may also produce unnecessary disfigurement. Unnecessary manipulation should also be avoided as it may cause needless suffering and unnecessary further traumatization.

The treatment of traumatic injuries of the jaws should conform to the following steps:

1. Render first-aid treatment to the patient.
2. Prevent and/or control infection.
3. Secure temporary immobilisation of the fracture fragments.
4. Attend to the soft tissue injuries.
5. Determine the type and the exact location of the bone fracture.
6. Select the best method of anaesthesia for future reduction and fixation of the fracture fragments, if necessary.
7. Reduce the fracture fragments to their correct anatomical relationship.
8. Select the best method, or combination of methods, for the fixation of the fracture fragments.
9. Render appropriate post-operative care to the patient.
FIRST AID TREATMENT OF TRAUMATIC INJURIES OF THE JAWS

This must be both general and regional in nature.

The General Care of the Patient:

It has been said that the major threat to life in maxillo-facial injuries is from suffocation. Thus preservation of the airway is vital. In comminuted and bilateral fractures of the anterior portion of the mandible, the genioglossus muscle is deprived of a stable anterior attachment, and its contraction, in an attempt to move the tongue, is unopposed and ineffective. Thus the dorsum of the tongue may fall back against the posterior pharyngeal wall and the airway may become obstructed, particularly when the patient is unconscious. In such cases some temporary fixation of the mobile anterior fragment should be attempted, such as the direct wiring of the teeth. At the same time the tongue should be secured by means of a suture or pin to some firm part, in order to prevent the tongue falling back.

Where the injuries involve the middle third of the facial skeleton, the airway may be severely obstructed, firstly due to the blockage of the nasal passage by blood clot formation, secondly due to the effect of the soft palate being pushed downwards and backwards onto the dorsum of the tongue as a result of the repositioning of the maxillae. In such cases the maxillae may be repositioned to a certain extent by digital manipulation by exerting an upwards and forwards traction.

In the majority of cases a well lubricated nasopharyngeal tube or a Magill tube, which is prevented from slipping back into the nose, will relieve any respiratory embarrassment. However, constant care must be exercised to ensure that the tube does not itself become blocked with either blood or mucous or both.

The first-aid treatment of maxillo-facial injuries has been forefronted and studied extensively in recent years as a result of the Korean War. Here again, stress has been placed
initially on the relief of respiratory embarrassment. In this field Kwapis has stressed the value of the judicious use of the operation of tracheotomy in lessening mortality. He has shown that suffocation may cause death within minutes in patients with extensively avulsed or comminuted fractures, as already mentioned, especially in the region of the mandibular symphysis. Under these conditions he recommends the operation of tracheotomy, which can usually be performed under a local anaesthetic. Here a medial longitudinal incision over the trachea is made and a circular section of the trachea, the diameter of the tracheotomy tube, is removed from the anterior tracheal wall at the level of the second tracheal ring. The tracheotomy tube is then inserted for the relief of the respiratory embarrassment. Kwapis also feels that often tracheotomy may be indicated for deep penetrating wounds of the floor of the mouth and the base of the tongue. Haematomas may form in these regions, producing respiratory embarrassment without the evidence of gross injury.

The next step in the procedure of the general care of the patient must concern the arrest of haemorrhage if present. Haemorrhage can be controlled by digital pressure, the use of saline gauze pads with pressure, tourniquet if applicable, or the clamping of any large vessel if the haemorrhage is especially difficult to arrest until deliberate treatment can be undertaken. Upon the control of the haemorrhage, a blood transfusion may be indicated in cases where there has been a rapid or copious loss of blood.

Serious accidents are often the cause of syncope, the patient collapsing because of cerebral anoxia, and long continued collapse may develop into shock. Syncope is generally of short duration. It is recognised by palor of the face, cold sweat appearing on the forehead and the hands, a rapid weak and thready pulse rate, and frequently nausea, terminating in vomiting. Shock, however, is of a more serious nature. It may terminate fatally, and accordingly the general first-aid treatment must be directed towards the alleviation of it. The patient
should be placed in a horizontal position with feet raised for ease of blood circulation and to increase the blood supply to the brain. This may be considered contra-indicated in cases where there is much bleeding from the nose, or again where severe facial soft tissue injuries are present. Warmth should be applied to the patient as soon as possible to decrease the effect of shock. The patient may be wrapped in blankets and the use of hot water bottles instituted. These heating devices should be placed at the feet, between the thighs, and over the abdomen. As soon as possible the patient should be transported to a warm room.

The value of the use of stimulants in cases of shock is considered controversial. Alcohol in any form must never be given. Aromatic spirits of ammonia are often useful. If the patient is unconscious, a few drops may be placed in the patient's nostrils, and if there is no respiratory embarrassment the patient is thus forced to inhale it. If the patient is conscious however, 15 drops of aromatic spirits of ammonia administered in a small amount of water may be effective. Coffee is a very good stimulant in these cases, and its effects last longer than the ammonium. If freshly prepared it will aid by warming the patient's stomach. It is also of great value because many injured patients are dehydrated from loss of blood. Dehydration may be present as a result of haemorrhage, shock, vomiting, diarrhoea, and psychic influences. These are frequently associated with traumatic injuries. Symptoms of dehydration may be manifest by the presence of a dry tongue, shrunken lips, shrunken eyes, loss of skin elasticity, and especially an unquenchable thirst. Fluid administration is therefore essential either orally, rectally, or by injection of a normal saline solution thickened with gum arabic into the loose subcutaneous tissues of the axillae, and in severe cases by way of the intravenous route.
The prevention of infection must be a part of our general treatment. In contaminated wounds it is advisable to use prophylactic measures to prevent the onset of tetanus and gas-gangrene. Specific serological treatment should be instigated. Injections of tetanus antitoxin should be administered to all patients exhibiting compound fractures, the amount given lying between 50,000 and 100,000 units intra-muscularly. Gas gangrene of the facial tissues is rare but may occur in deep facial wounds, especially war wounds. Large doses of a polyvalent serum, 100,000 units per dose, is recommended by the intravenous route every six hours.

The control of pain may be necessary. Severe or long continued pain will exhaust the patient. It may accentuate shock and retard recovery. Morphia 1/6 gr. - 1/4 gr. may be administered subcutaneously provided there is no respiratory embarrassment or intra-cranial damage present. If these are present, a suitable alternative such as an injection of 100 mgm of pethidine may be given.

**Regional First-Aid Treatment:**

This should consist of:

1. The removal of gross debris from the wounds.
2. The toilet of the wound.
3. A detailed examination of the wound.
4. The temporary immobilisation of the fragments concerned in the fractures of bony structures.

Careful debridement of all wounds must be carried out. This includes the removal of foreign materials, detached bone fragments, non-retainable teeth from the fracture area, together with the excision of any non-viable soft tissues. The estimation of the available blood supply is a basic criteria for the removal or retention of soft tissue or bony fragments. Dentures, if worn, should be removed, nasal passages freed from blood clots, and the tongue prevented from falling back. The wound should be thoroughly irrigated with normal saline solution and emphasis be placed upon conservative debridement of the osseous structures, leaving as many foci for regeneration as
as possible for a future functional and aesthetic result. The wound should then be dressed as well as possible, through the medium of sterile gauze and bandage. If regional haemorrhage is still a feature of the injury, bleeding from these wounds can generally be arrested by pressure applied to the external maxillary artery at the lower border of the mandible. Again, the superficial temporal artery may be compressed where it crosses the zygomatic arch just anterior to the ear. Bleeding from deep wounds may be controlled by compressing the external carotid artery at the anterior margin of the sterno-mastoid muscle.

Temporary immobilisation of the fractures of the bony structures should then be attempted. Often the general condition of the patient precludes the use of the ideal method of immobilisation. The method of fixation chosen must be that best suited to the patient's general condition. If an anaesthetic is necessary, and of necessity be of short duration, then a simple method of fixation such as the direct wiring of the fragments should be used. It must always be remembered that the fixation of fracture fragments is a time consuming operation, even simple wiring methods may take an hour for a satisfactory result.

There are three general methods employed in the temporary immobilisation of fracture fragments:

(a). The use of a barrel bandage.

(b). The application of temporary arch wire splints and intermaxillary ligation.

(c). The temporary horizontal wiring fixation of the fracture fragments.

The temporary immobilisation of the fracture will decrease the dangers of secondary haemorrhage and infection. It will also relieve pain by giving rest to the injured part, decrease shock and minimise disfigurement.
(a). The use of a barrel bandage for the temporary immobilisation of a fracture has the advantage of ease of application. It minimises the manipulation time, which is a comfort to the patient. In some cases of fractures of the maxillae this method is satisfactory, but in cases of mandibular fractures great care must be taken to ensure that the bandage does not cause further displacement of the fragments by exerting pressure in the wrong direction, thus creating further damage. According to statistics there is a greater incidence of mandibular fractures.

(b). The application of temporary arch wire splints. The use of temporary arch wire splints of German silver, contoured about the dental arch, will give a far greater degree of immobilisation of a fracture than the use of a barrel bandage. These types of splints are indicated when there is a sufficient number of teeth in the dental arch of suitable shape and distribution which can be utilised to effect. This method of temporary immobilisation of a fracture is particularly useful for the fixation of fractures resulting from gunshot wounds. This method is also suitable for the immobilisation of an alveolar fracture containing several teeth, when there is an unavoidable delay in the construction of cast splints. These arch wire splints are attached to the teeth by means of fine ligature wires which are passed between some of the teeth to connect the outer and inner parts of the wire arch, thus preventing it from being displaced. This method depends upon having the required material readily available, and that the amount of manipulation can be tolerated by the patient at this stage.

Intermaxillary fixation of these temporary arch wire splints, as a first-aid measure, has been considered contra-indicated. This is especially so when the patient's general condition is such that difficulty is experienced in feeding, and
also when the placing of elaborate wiring would place too
great a strain upon the patient. Similarly, it is considered
contra-indicated:

1. Where there remains a full complement of teeth.
2. Where the nasal passages are occluded with a
   blood clot.
3. Where there is oedema of the tongue.
4. Where soft tissue injuries of the pharynx are present.

A previous disadvantage of intermaxillary fixation by temporary
arch wire splints was the problem of nausea and regurgitation,
with the consequent danger of choking and suffocation. Today,
however, this danger has been overcome with the introduction
of a rip-cord device for the emergency release of an immobilised
mandible. Particular attention had been drawn to the fact that
in war time, aerial evacuation posed this question of nausea
and regurgitation. Normal intermaxillary wiring, such as direct
interdental eyelet wiring, is out of the question for immobi-
larisation in first-aid measures because of the time that would be
required for the patient to remove it in an emergency.

Similarly, intermaxillary fixation of these tempo-
ary arch wire splints cannot be removed quickly enough in
cases of emergency. However, this method of temporary immob-
ilisation of the mandible is suited to rip-cord release methods.

Traeger has devised a quick and simple method of intermaxill-
ary release—he makes use of two 20 gauge hypodermic needles
as a rip-cord. After the application of the arch wire splints
balanced traction is applied to these needles, instead of
directly to the teeth on the opposite arch. The needles
thus are held parallel to the occlusal plane on each side of
the arch. On removing these two needles, intermaxillary
traction is immediately released and the mouth can be opened.

This method may be used in a number of combinations
of wiring and fixation appliances, including an arch bar
attached to the teeth of one arch with eyelet wire loops used
in the opposing arch. Strickland has even designed an
improved release mechanism with the use of lateral wires,
instead of hypodermic needles, joined anteriorly thus giving a single release for ease and quickness of operation.

If the use of these temporary arch wire splints, together with intermaxillary fixation of the mandible, are considered inadvisable because of previously stated factors, then my choice of temporary immobilisation of the fracture as an emergency treatment is by temporary horizontal wiring fixation of the fracture. This method has been found to give satisfactory results, and as its application does not cause much discomfort to the patient an anaesthetic is rarely required.

It is conceded however, that a method of horizontal fixation across a fracture line is inefficient by itself, permitting movement at the site of the fracture as well as the movement of the entire jaw. It should always be superseded or combined with intermaxillary fixation as soon as conditions permit. In other words, it is only considered valuable in the field of emergency until deliberate treatment can be undertaken. This method of temporary fixation will also allow intra-oral wounds to be attended to if necessary. Horizontal wiring of the fracture consists of attaching annealed brass wires or stainless steel wires (25 gauge) individually to the third and fourth teeth on each side of the fracture line, and fastening the wires around the necks of the teeth. In some cases it may be considered necessary to use the second and third teeth on one side, and the fourth and fifth teeth on the other side, according to their strength and position. The fixation can then be completed by twisting together across the fracture line the wire from the second tooth on one side of the fracture and the wire from the third tooth on the other side. The same is done with the wires around the third and second teeth on their respective sides.
This method is a simple and excellent method of fixation in the field of emergency, but in cases of oblique fractures care must be exercised since it may cause overriding of the fragments. To prevent this overriding a twisted wire on the second tooth on one side of the fracture is passed around the third tooth on the lingual side and then around the first tooth to the labial. Here it is connected with a wire fastened on the third tooth on the other side of the fracture. This will bring the fragments into position and hold them in place by means of a cross wiring technique.

These techniques described for the emergency immobilisation of a fracture can be quickly applied. They are simple, time saving, and well suited to the field of emergency treatment. However, they do depend on some or all teeth being present and suitable as regards shape and position in the arch.

What methods of fixation can be applied in the field of emergency for the treatment of facio-maxillary injuries in the edentulous patient?

Emergency immobilisation of a fracture in these cases would seem to be limited. Barrel bandage may be used which could be effective if dentures can be retained and worn. If, however, there is any danger of nausea and vomiting these must be removed until all such danger passes. If, as is usually the case, the dentures are unusable and a splint is required, it is often possible to make some form of a cradle by cutting down an impression tray and lining it with gutta percha or impression compound. To hold such a splint in position it may be necessary to resort to circumferential wiring in order to hold the splint firmly upon the arch. This technique is described fully later when dealing with deliberate treatment, but at times it may be a useful technique in the field of emergency.
Skeletal fixation of the fracture can offer the best method of emergency treatment for the edentulous or partially edentulous cases. It has many advantages - simplicity of application, quick reduction of any respiratory embarrassment, and the patient's temporomandibular joint movements are not impaired. Extra-oral means of fracture fixation would also permit the patient to eat, speak, travel, and attend to his own mouth hygiene. These points have been stressed by Brandao. He maintains that the extra-oral skeletal fixation of the fracture should take place within a few hours of the accident, and also that it should be performed under an intravenous or nasotracheal intubation general anaesthetic, and that it is wise to prescribe anti-biotic medication. (The extra-oral skeletal fixation of fracture fragments is dealt with in detail in the chapter dealing with the treatment of mandibular fractures.)

Rest for the injured parts may thus be gained by the temporary immobilisation of any fracture fragments. This, combined with the removal of gross debris, and the toilet of the wound in association with the general care of the patient, allows time for the deliberate treatment of maxillo-facial injuries to be instigated. The first-aid treatment of these injuries aims at the preservation of the patient's life. It aims, at the same time, to lessen the patient's pain and discomfort and to prepare the operative field for the ensuing deliberate treatment of these wounds.
SOFT TISSUE INJURIES

The treatment of soft tissue injuries, accompanied by fracture of the jaws, is of great importance because infection of the soft tissue wounds may become a more serious factor than the bone injury itself. In any case, it presents a complication.

The contours of the face are maintained by the underlying bony structures, and loss or mal-position of any of these latter must always affect to some degree the external contour of the soft tissues. The reduction of any fractured bones and their fixation, with or without the use of splints, is a fundamental requirement for the healing of the surface wound, giving rest to the soft tissues, and thus favouring healing.

Soft tissue injuries or wounds may be classified thus:

1. A Contused Wound:
   This is a wound of bruised tissues generally caused by an impact with a blunt object. This type of wound affects the skin and the subcutaneous tissues. Subcutaneous haemorrhage is frequent and it may cause extensive areas of ecchymosis, which appear twenty-four to forty-eight hours after the injury.

2. An Abrasive Wound:
   This is a superficial wound presenting a raw and bleeding surface.

3. A Lacerated Wound:
   The skin and tissues are torn and a ragged wound is presented. Wounds which are caused by an industrial accident usually fall into this class.
4. **Incised Wound:**
These wounds result from contact with a sharp object, which may leave a clear cut wound with smooth edges, in contra-distinction to a lacerated wound.

5. **Penetrating Wounds:**
In facio-maxillary injuries, penetrating wounds are often seen opening into a cavity such as the maxillary sinus or the mouth. These are usually referred to as puncture or stab wounds.

6. **Gunshot Wounds:**
These wounds are caused by high velocity missiles. They can usually be classified into one of three principal groups:

**Group I - Penetrating Wounds**
These wounds are usually caused by a bullet or a small particle of shell. The fragment penetrates the skin, fractures the bony tissue, and comes to rest within the tissues.

**Group II - Avulsed Wounds**
In these cases a large fragment of shell which is spinning rapidly "ploughs" through the tissues avulsing the jaws.

**Group III - Perforating Wounds**
This type of wound is caused by the same variety of missile as in group I, but in this case its velocity is very much greater, so that the fragment is not arrested in the tissues. The missile therefore travels on scattering secondary missiles resulting from its impact with the bone and the teeth. This combines to produce a large "explosive" type of an exit wound.
Burns of the soft tissue:
In civilian life these mainly occur in industrial accidents and the burns may be:
(a) A first degree burn - this is an erythema of the skin.
(b) A second degree burn - here the skin presents a reddish white appearance with the presence of many blisters.
(c) A third degree burn - these burns are severe. All layers of the skin are involved, also the underlying fascia. They are usually ivory white or black in colour. It must always be remembered that shock is usually the major complication in cases of burns of the tissues.

The treatment of soft tissue injuries of the jaws:
This treatment is directed towards aiding the body's natural process of healing of wounds which is by the process of inflammation. It is found convenient to speak of the healing process as divided into two types:
1. That which takes place in a clean approximated wound.
2. That which takes place in an open or an infected wound.
The first is called healing by first intention or primary healing. The second is spoken of as healing by second intention or healing by granulation. Although the healing processes in these cases differ clinically, essentially they are identical in nature. When the surfaces of a clean cut wound are held in opposition, they are first agglutinated by the wound secretion and later are permanently united by granulation tissues, which turns to scar tissue. In open or suppurating wounds, the surfaces cannot be immediately agglutinated by the wound secretion, nor can the granulation tissue grow directly across the gap from one cut surface to another. In this case the granulation tissue must obliterate the open wound by gradual filling of the cavity.
Local infections, mechanical irritations, a constitutional disease, or general depression all exert a malign effect on the healing process. Accordingly, the treatment of wounds of the soft tissues must be both of a general and a regional nature. It should aim at:

1. Building up of the patient's general health and resistance.
2. Eliminating sepsis from the wound.
3. Bringing about good apposition of the torn tissues.

The general care of the patient should be directed to overcome shock, to secure a proper diet and water balance. Units of plasma may be given until improvement is noted in the blood pressure, pulse, and the colour of the patient. Morphine may be administered if the patient is restless, but in the presence of brain injury it should be avoided and moderate amounts of bromides and chloral hydrate should be prescribed.

The steps in the surgical treatment of these wounds must consist of anti-infection steps:

1. Thorough wound toilet.
2. Removal of non-viable soft tissues.

These procedures should then be followed by reparative steps, comprising the exclusion of the mouth and the layered closure of the wound.

The soft tissue covering the bony skeleton of the face is at no place very thick. It is highly vascular, which obviously accounts for its freedom from gas gangrene, and its rapid healing. If, however, infection overcomes local resistance, the presence of accessory sinuses, nasal and oral cavities in the middle third of the face will assist drainage of the wounds, and is of considerable aid.
in treatment. The soft tissues about the mandible, being
anatomically below the oral cavity, do not receive such
assistance as regards drainage.

Haemostasis and the general anti-infective
measures, as against tetanus and gas gangrene, have been
dealt with in the first-aid treatment of these injuries.
At this stage, however, measures designed to prevent or
control pyogenic infection should be instituted by approp-
riate anti-biotic therapy. In this regard sensitivity
determinations should be carried out. It is important to
make a careful bacteriological study by culture of some
wound material, since it is known that all strains of one
organism are not equally sensitive to the anti-biotics,
some being completely resistant, whilst others exhibit an
essential metabolic need for the therapeutic agent. In the
choice of a suitable anti-biotic, one must bear in mind any
history of an allergy to any one of these drugs, and at the
same time be conversant with the side reactions of the
specific anti-biotic chosen.

Penicillin is often the anti-biotic preferred.
It is generally administered by intra-muscular injection,
the usual dose being 300,000 units which produces a satis-
factory blood level of 0.16 to 1.3 units per cubic centi-
metre. In acute cases, this dose is repeated every three
hours until infection has subsided. Aureomycin and terram-
yycin are also often chosen. These have the advantage of
oral administration. The dosage of aureomycin being 250
mgs. to 500 mgs. every 4-6 hours for adults, with similar
doses for terramycin, but the latter may be increased to
750 mgs. every 4-6 hours in cases of severe infection.
Terramycin is also available in an ointment preparation for
infected traumatic facial wounds for local anti-bacterial
action. As these anti-biotics are used so widely in oral
surgery for the treatment of infection of the facial tissues, a word of warning is given. Precautions are necessary for their administration. Nausea and vomiting, which could be distressing particularly to a patient suffering from traumatic injuries of the jaws, may be eliminated by giving an alkali simultaneously. For any skin manifestation following the administration of an antibiotic, anti-histamines such as benadryl 25-50mgs. every four hours may be prescribed. The antibiotics may also induce vitamin deficiencies, particularly of vitamins K and B/2 complex, and these should also be prescribed. It should be noted also that the blood of patients receiving antibiotic therapy clots more readily than normal, and thus patients who are suffering from coronary thrombosis, varicose veins, or vegetations on the cardiac valves, should be given heparin or dicumarol.

The toilet of the wounds is now undertaken. Abrasions should be carefully scrubbed with soap and water, washed with an antiseptic solution, such as "Metaphen" or dichloride of mercury 1:5,000, and a sterile dressing applied to protect the wound from further irritation. Where contusions are present, the application of dressings, maintained in cold water, are helpful. If extensive areas of ecchymosis are present, hot applications may aid in the resorption of any extravasated blood. A haematoma, if present, should be evacuated by aspiration through an incision. Lacerated wounds are contaminated wounds and special care is needed in their treatment. The operative field is prepared by removing any grease, tar, powder marks, or dirt on the skin with ether. The skin to the wound margin is thoroughly cleaned with soap and water, applied with gauze, then wiped with alcohol or ether, followed by painting with an antiseptic solution such as "Zephiran".
A fountain syringe is found to be of great value in the cleaning of these wounds, as a constant stream is available. It washes out dirt and small particles of grit or other materials from pockets which may extend deep under the wound edges and even into the facial cavities.

Any necessary debridement of tissue should be carried out cautiously and conservatively. However, blood clots, necrotic or fragmental, and non viable tissue should always be removed. They are fertile soil for bacterial activity. Foreign bodies as well as broken pieces of bone should be curetted. One must bear in mind, however, that the radical excision of tissue as may be practised on other parts of the body, is contra-indicated in this region because of the many branches of the facial nerve which, if cut, may produce serious facial disfigurement.

The lacerated edges of the wound are then carefully trimmed so as to make accurate approximation and suturing possible. Suturing is inadvisable if much tissue has been lost. In such cases the wounds should be packed with boric strips, or gauze saturated with petrolatum. It has been found that these wounds will heal and leave little scar in the absence of suture tension. A great deal of recent literature concerning the treatment of soft tissue wounds has appeared as a result of the Second World War (11) and the Korean conflict. McIndoe states that the primary suture of wounds can be performed up to 24 hours after the injury, but that it is inadvisable later due to the risk of separa. He also states that deep wounds should have drainage tubes inserted for four or five days to prevent future complications. Howell shows a wide choice of safe procedures allowed to the oral surgeon with today's increasing effectiveness of the anti-biotics. Facial injuries incurred in battle usually result from the pena-
etration of multiple shell fragments into the soft tissues, eyes, and facial bones. The passage of these missiles through the tissues produces a track with a devitalised central zone, which provides an excellent area for the propagation of bacterial contaminants. Until recently it was the accepted practice to delay primary closure of such wounds. Now, however, they are seen clearly in the operating room and the surgeon can close them after thorough wound toilet has been performed, and before swelling, distortion, and infection have occurred.

In war time, penetrating wounds of the maxillary sinus are fairly common. In these cases the involved sinus should be irrigated profusely with normal saline solution, and a sinusotomy performed to remove foreign bodies. Drainage in these cases may be carried out through a nasal antrostomy by means of the insertion of a trocar and cannula under the inferior turbinate bone of the nose. The antrostum may be packed with iodoform gauze leaving a small tail projecting through the nasal window for drainage.

It must be again stressed that the correct reduction of the fractured bones and their fixation are fundamental requirements for the healing of the surface wounds. Often by so relieving tension on the soft tissues, we allow their close approximation, thus enabling suturing to be completed without undue tension. Finally, in the treatment of soft tissue injuries, one must bear in mind the fact that it may be necessary to cover the facial defects, due to the loss of tissue, and the underlying bony support, by later secondary and reconstructive plastic surgery. This could influence our surgical closure of the wounds, in order that bone grafts may be employed later and the use of pedicle flaps for the replacement of lost soft tissue.
A fracture may be defined as a solution or a break in the continuity of bone. The clinical varieties of these fractures may be broadly grouped as follows:

1. Simple or closed fractures.
2. Compound or open fractures.

In this latter group, the external wound communicates with the fractured bone.

These two broad groups may again be subdivided and described as:

A. Those according to damage incurred.
B. Those according to the direction of the break in the bone.

This direction may be:

(a). Transverse due to direct violence.
(b). Longitudinal as in bullet wounds.
(c). Oblique
(d). Spiral Due to "direct violence."
(e). Comminuted

Specifically the fractures of bones may be:

1. Comminuted. Here the bone is shattered into several fragments.
2. Complete. Here the continuity of the bone is completely severed.
3. Incomplete. Here the continuity of the bone is not completely severed, and where the fracture may be:
   (a). Greenstick fracture - the bone partly bends and partly breaks like a soft sapling. The break is on the convex side.
   (b). A fissured fracture - this is simply a crack in the bone.
(c). A depressed fracture - in this case the outer layer of compact bone is driven into the soft cancellous underlying bone or the whole thickness of a flat bone is driven into the underlying tissue.

Before the treatment of an injury can be instigated, the deformity must first be recognised and classified according to its type. Treatment is then directed to assist the healing processes of the tissues. Accordingly, in order to direct the correct treatment for bone injuries, the pathology of bone repair must be basically understood and the anatomy of the related areas known.

The Pathology of Bone Repair:

Bone repair takes place, like the repair of other tissues, by the process of inflammation, with the formation of bone instead of fibrous tissue. Of the facial bones, the mandible has a central blood supply derived from the inferior dental artery in addition to the periosteal blood supply. In the region of the middle third of the face, there is a rich source of blood supply derived from the linings of the nose and para-nasal sinuses. An adequate blood supply is absolutely essential to the proper healing of a bone following fracture. The rapidity with which union occurs in fractures of the facial bones, and the relative absence of serious complications, is largely due to this generous blood supply of the area. Rupture of these blood vessels results in the formation of a blood clot around and between the bone fragments. There are endothelial outgrowths with the formation of new capillaries, and fibroblasts assume the function of osteoblasts, so that the granulation tissue becomes converted into an unorganised kind of bone known as a callus. As this is a temporary structure it is called a provisional callus and named according to its location as:

1. Ensheathing callus, which surrounds the ends of
the fractured bones.

2. Medullary callus, which occupies the medullary cavity.

3. The intermediate callus, which lies between the bone fragments and maintains the continuity of the cortical bone.

Rarefying osteitis then takes place in the compact bone on either side of the fracture, with the development of osteoblasts growing into the intermediate callus, and so the structureless callus becomes transferred into normal compact bone with the development of regular Haversian systems.

The rarefying osteitis is then followed by a sclerosing osteitis, with the restoration of the continuity of the normal bone. Meanwhile the ensheathing and the medullary callus become resorbed by the action of giant cells. Where the apposition of fragments is poor, as when angular contact only is made, the defect is made up by an excess of ensheathing callus, which is never resorbed and so deformity results. If movement between the broken ends of the bone takes place, the amount of ensheathing callus is also greater.

There has been much discussion on the local physiology of bone repair and Urist and McLean, among others, have referred particularly to a theory of "induction" in relation to new bone formation. The principle involved is that the formation of a specialised organ or tissue can only take place when two different layers of tissue are in close contact. One layer functions as an inductor, the other being the induced layer from which the specialised tissue is created. On this principle, following a fracture biochemical changes are induced by vaso-dilation and protein breakdown products which lead to the absorption of the calcium from the bone ends during the acid phase of the fracture haematoma. The cancellous bone and the endosteum together with the cortical bone now act as an inductor tissue inducing new bone formation, by the perivascular connective
tissue, which is derived from the modulated cells of the periosteum and the bone marrow and which accompanies the invading capillary net-work. Thus, after the formation of a "scaffolding" of coarse primary woven bone, mature lamellar bone is slowly substituted by osteoclastic and osteoblastic cell activity respectively. It is possible that the final modelling resorption is brought about by the active control of the cells from the bone marrow. Thus it can be seen that the healing of a fracture is by growth from the bone ends and the surrounding periosteum. The greater the distance apart of the surfaces from which the growth commences, the longer will it be before the healing tissues have bridged the gap. If this gap between the fracture surfaces is too great, healing by bony tissue may not occur, but a fibrous union may take place. Non-union of fracture fragments will occur wherever similar or dissimilar tissues intervene between the fragments, and a false joint may thus eventuate. Where the bone fragments become united with dense fibrous tissue, instead of bone, it is called a fibrous union. Again, malunion may occur where we have faulty coaptation of the fragments due either to considerable muscular displacement or inadequate care.

Both movement and infection will result in the absorption of bone. The presence of granulation tissue in association with inflammation predisposes to bone absorption. This will occur as a result of irritation either by movement or infection.

It has been shown that following a fracture uncomplicated by infection, there is initial inflammation due to trauma and the development of granulation tissue at the fracture surfaces. Absorption of bone at the surfaces of the fracture follows, and is evidenced by a widening of the fracture line upon the radiograph in about fourteen days.
As soon as the inflammation due to the injury has resolved, healing commences. If the inflammation is kept up by movement or infection, bone absorption continues and healing is delayed until the inflammation has subsided.

Let us consider bone repair complicated by movement. If the bone ends are permitted to move relative to each other, the young granulation tissue, which is very delicate and friable, will be torn as it tries to bridge the gap. This tearing will produce a further effusion of blood and the need for organisation to start all over again. This trauma will keep up the inflammatory process and, as we have seen, lead to continued absorption of bone, thus widening the gap between bone fragments.

If immobilisation is instituted without too great delay, healing by bony tissue will at once commence, but if delayed, healing will be by fibrous tissue and result in the non-union of the fragments. Granulation tissue is elastic to some extent, and so the degree of movement between bone fragments is important. Where the movement is sufficient to cause a tearing of the granulation tissue, it is said to be traumatic; if it does not tear, but only distorts, it is called subtraumatic. This movement may be of a shearing or an angular nature and repair will proceed only in zones of subtraumatic movement. Thus in treatment, it is important to distinguish between these two types of movement, for whilst the permission of a certain amount of angular movement will probably do no more than delay, the permission of a shearing movement with traumatic force may completely prevent healing by callus formation. A good example of this may be seen where an edentulous posterior fragment is inadequately controlled. Deglutition may cause a shearing motion liable
to entail non-union. When traumatic movement is occurring, inflammatory conditions are maintained, and bone absorption continues at the expense of the fracture surfaces. As a result, the fracture site is widened and the amount of granulation tissue between the bone ends becomes greater. In some cases, a time may come, if this amount of movement does not increase, when the layer of granulation tissue between the bone ends is so wide that the movement no longer causes a tearing of the granulation tissue, only a distortion. In other words, a movement which was initially traumatic may become subtraumatic, and then healing by bony tissue can commence. Often traumatic movement present may not be sufficient to tear the ensheathing granulation tissue and callus formation. Thus, with the formation of a strong repair tissue around the fracture, movement is progressively reduced, thus allowing repair to commence nearer and nearer the fracture line itself until it is finally so reduced that the movement between bone ends becomes subtraumatic and the deposition of an internal osteoid tissue can commence. Thus the movement of fragments not only will delay repair, but also may result in non-union. The granulation tissue springing from the bone ends and the periosteum contains fibroblasts and osteoblasts. The fibroblasts are the more primitive cell and therefore are able to proliferate under more adverse conditions.

The worse the conditions under which repair has to take place, the more likely that it will be affected by a primitive tissue.

If adverse conditions are allowed to persist long enough during the repair of a bone fracture, the repair will be by fibrous instead of bony tissue and non-union will result, for the fibrous tissue does not become calcified.
It has been suggested that subtraumatic movement will stimulate repair of a fracture in a therapeutic manner. This is not proven. Subtraumatic movement has been found to stimulate external callus formation but it is a false premise, that the evidence of an external callus is evidence of internal callus formation. There does come a time, however, when clinical bony union is near complete when the permission of function appears to hasten the final healing. The determination of this time is difficult and the greatest care must be exercised in deciding to permit function.

In compound fractures, where the bone repair is complicated by infection, delay is always the rule, as the inflammatory process keeps up the bone absorption and there is no deposition of callus. A localised osteomyelitis takes place, sequestra may form, and a persistent discharge occurs. In these cases free drainage must be established and then necrotic fragments removed as they separate from the healthy bone.

Infection can reach the site of a fracture:
1. From the mouth by direct spread.
2. From the external wound or from the adjacent infected soft tissues.
3. From adjacent infection in the bone.
4. By the lymphatic channels.
5. By way of the blood stream.

Of paramount importance in this regard are teeth involved in a line of fracture. Trauma may readily cause the death of the pulp of the teeth. When the pulp of an otherwise healthy tooth dies as a result of trauma, it does not necessarily become infected and break down with the formation of pus, but it usually does. The infection resulting from this breakdown and suppuration is passed straight into the
depth of the fracture. Again, where a fracture line runs through a tooth socket, the cementum on the side of the tooth will be deprived of its nourishment and will rapidly die. Because of its closeness to the mouth and the probable infected gingival trough, its infection may be presumed as certain. It will then act like an infected, necrosed piece of bone with the production of pus in the immediate vicinity of the fracture. Thus it is a very real potential source of infection.

An understanding of the pathology of bone repair directly influences any treatment instigated. It has been shown that for good healing of the tissues there must be:

1. Control of infection.
2. Early reduction of the fragments to eliminate movement in the line of fracture.
3. Early rigid immobilisation of the bony fragments in close anatomical apposition.

With the establishment of these clinical varieties of fractures of the jaws, and the pattern of bone repair understood, we are now in a position to deal with the regional anatomy and the treatment of specific fractures of the facial skeleton.

Fractures of the facial skeleton may be conveniently subdivided and dealt with under the following headings:

1. Fractures of the middle third of the facial skeleton.
2. Fractures of the mandible, excluding fractures of mandibular condylar process.
3. Fractures and fracture dislocation of the mandibular condylar process.
4. Fractures of the teeth and alveolar process.
5. The problem of multiple fractures of the middle third of the facial skeleton and the mandible.

6. Complicated fractures.
The related surgical anatomy:

The maxillae, with the nasal and zygomatic bones, form the framework of the middle third of the face. Each maxillary bone helps to form three cavities - the upper part of the oral cavity, the nasal fossa and the orbit - with the maxillary sinus situated in the body of the maxilla. The maxilla articulates with two cranial bones, the frontal and ethmoidal bones, and with nine bones of the face, namely the nasal, malar, lacrimal, inferior turbinates, palate and vomer. The maxillae are thus largely responsible for the formation of the roof of the mouth, floor and lateral walls of the nasal cavity, and the floor of the orbits. Whereas the mandible is designed to provide a vertical and rotary force of approximately 200 lbs. to the square inch for masticatory function, the maxillae are designed to resist the forces of mastication, absorb the shock of the occluding teeth, and to divide the load as evenly as possible over the cranial base. This is achieved by the arched shape of the palate, and the abutments of the maxillae against the fronto-maxillary, zygomatico-maxillary and maxillary-ethmoidal sutures. Posteriorly a strong buttress is provided by the junction of the pyramidal process of the palatine bone and the pterygoid laminae of the sphenoid bone. The zygomatic bone redistributes the load to the frontal bone via the zygomatico-frontal suture and also to a lesser extent to the temporal bone via the junction of the temporal process of the zygomatic bone and the zygomatic process of the temporal bone. The presence of the maxillary and the ethmoidal air sinuses is responsible for the honeycomb type of bone formation typical of the middle third of the facial
skeleton. The delicate laminae which constitute this lattice framework are principally distributed in a vertical direction, thereby being aligned along the lines of principal stress. Thus it is apparent that, although the middle third of the facial skeleton can resist considerable force applied in a vertical direction from below, force applied from an anterior, superior, or lateral aspect will tend to shear the whole complex from its cranial base.

While the whole complex of these bones is strong and capable of withstanding considerable force before it is fractured, when fracture does occur the complex tends to give way along the weaker structural lines. Thus it is more usual for the tooth bearing segment and the palatine process of the maxilla to be separated in its entirety from the superstructure, than for it to be itself fractured, and fractures of the superstructure tend to pass through the lines of suture.

The zygomatic bone is an important constituent of the middle third of the facial skeleton. It participates in the formation of the lateral orbital rim and wall, the lateral two thirds of the inferior orbital margin, and, to a minor extent, the outer aspect of the orbital floor. Displacement of the zygomatic bone is usually in a downward and a medial direction, which may give rise to an ugly flat deformity in this region. The presence of the maxillary antrum, with its thin lateral wall, readily permits the displacement of the zygomatic bone to take place into the underlying cavity if force is applied from a lateral or an anterior aspect.

The musculature, which has an important bearing on the displacement and reduction of fractures of the maxillae, are the internal and external pterygoid muscles. These are responsible for the backward and downward pull of its posterior end, causing open bite relationships. The
massester muscle comes into the picture only in the involve-
ment of the zygomatic arch. The masseter, although inserted
into the mandible, does not normally exert any great influence
upon the displacement of the zygomatic bone. This is
probably due to the fact that the majority of zygomatic
fractures are impacted medially into the antrum and the
lateral wall of the maxilla; hence it is incapable of any
further downward displacement. The muscles of facial
expression, although originating from the zygomatic bone,
are inserted into the skin of the face and so do not play
any part in furthering the displacement of the bone,
following fracture.

The classification of fractures of the middle third
of the face:

The present day classification of middle face (15)
fractures has been shown to be based upon the experimental
studies of Rene Le Fort in 1901 in Paris. He observed,
following experimental trauma to a cadaver head, that the
apparent complexity of the fracture lines could be broadly
subdivided into three categories, two of which are confined
to the central section of the middle third of the facial
skeleton, whilst in the third category central and lateral
middle face fractures are present. Consequently, middle
face fractures may be classified as follows:

1. Central region fractures:
   Into this category would fall:
   (a). Fracture of the nasal bones and/or the nasal septum.
   (b). Fractures of the frontal process of the maxilla.
   (c). Fractures involving a combination of (a) and (b)
       which extend into the ethmoid bone.

2. Lateral region fractures:
   These fractures involve the zygomatic bone and the
   zygomatic arch. Their severity may be expressed in
degrees in the following manner:
(a). A first degree lateral region fracture. This is one where there is a fracture of the zygomatic arch without interference with mandibular movement, or, on the other hand, where the fracture of the zygomatic bone causes minimal displacement but appreciable contour effect.

(b). A second degree lateral region fracture. This is one where a fracture of the zygomatic bone involves the lateral wall of the maxillary antrum resulting in interference with mandibular movement or alteration of facial contour. This may occur with or without associated zygomatic arch fracture.

(c). A third degree lateral region fracture. This is said to occur when there is present comminution of the orbital floor or gross separation of the zygomatico-frontal suture and depression of the orbital level.

3. Fractures involving the dento-alveolar component:
These fractures may be again subdivided into clinical types that are prone to occur. European authorities, such as Bowe and Killey, generally follow along the broad lines of Le Fort's classification and so divide these fractures of the dento-alveolar component as follows:

(a). Purely alveolar fractures.

(b). A Le Fort type I or Guerin fracture. This group comprises low level maxillary sub-zygomatic fractures.

(c). Le Fort type II fracture. This is shown to be a pyramidal maxillary sub-zygomatic fracture.
Typical types of fractures involving the middle third of the facial skeleton.

An anterior view of the skull.

Middle third and associated bones.
(d). Le Fort type III fracture. In this case high level maxillary supra-zygomatic fractures are present.

It is found that these fractures may occur in varying combinations. They may be unilateral, or associated with fracture of the zygomatic bone. There may also be a midline separation of the maxillae.

Kurt Thoma, of the U.S.A., and his contemporaries, on the other hand, use a broader classification based on Erich's work in 1942, which is self-explanatory and easier to comprehend, although still basically retaining Le Fort's subdivisions. This we will generally follow. Accordingly, we may state that fractures involving the dento-alveolar component may be regarded as:

1. **Horizontal Maxillary Fractures** - these involve the lower part of the maxilla, including fractures of the alveolar process.

2. **Pyramidal or Vertical Fractures** - these may be of an impacted nature with the maxillae impacted under the projecting edge of the frontal bone.

3. **Transverse or Depressed Fractures** - these fractures involve the zygomatic bone and arch.

4. **Comminuted Fractures of the Middle Third of the Face** - fractures of the infra-orbital margin and the bony walls of the maxillary sinus often present comminution of fragments.

**Amplification and symptomology of middle face fractures:**

1. **Horizontal fractures of the lower part of the maxillae**
   These fractures extend through the maxilla between the floor of the orbit and the floor of the maxillary sinus. The entire alveolar process, the hard palate, and the floor of the antrum are detached from their base. The upper jaw is thus mobile, being held by soft tissue only.
This type of fracture has been referred to as a "floating fracture" of the maxilla. Signs and symptoms here include swelling of the face and ecchymosis, together with contusions or cutaneous wounds. The occlusion of the teeth is disturbed, the patient being unable to masticate, and there is a downward displacement, and side to side movement of the upper jaw. In other cases there is a backward displacement, especially in fractures which occur at a higher level and where the pterygoid bony plates are attached to the fractured part. If an upward displacement has occurred, due to the force causing the injury, the vertical dimension of the face is shortened and an open bite relationship will exist. In such cases "telescoping" of the fragments occurs, and the fracture may be of an impacted nature. In the case of the "floating maxilla", where it is freely movable on its cranial base, percussion of the upper teeth will register a "cracked teacup" sound, which is associated with such fractures. This occurs due to the lack of the normal resonance of the maxillary antrum. If comminution of bone in the line of fracture is present, the use of fixation wires to a headcap may set the maxilla at too high a level. Thus in the treatment of "floating" maxillary fractures, with comminution in the line of fracture, it is felt that a positive means of fixation to retain the correct facial vertical dimension is essential. Extra-oral skeletal fixation, with the use of pins, fixation rods, and universal joints, has been recommended for these cases. Further signs may also show that the oral mucosa and that of the nose may be lacerated. There may be a haemorrhage from the maxillary sinuses into the nasal cavity, and consequently the nasal passages may be occluded with clotted blood.
2. **Pyramidal Maxillary Fractures:**

In these cases the maxillary, nasal, lacrimal, ethmoid and sphenoid bones, as well as the vomer and nasal septum, can be involved. Displacement of the entire upper jaw is common. It is always pulled back by the pterygoid muscles, which are attached to the greater wing of the sphenoid bone and the grooved tuberosity of the palatal bone. We may find a telescoping effect which causes a shortening of the upper jaw. Patients with pyramidal fractures may present signs of intracranial damage manifest by cerebro-spinal rhinorrhea due to the fracture of the cribriform plate of the ethmoid bone. Subconjunctival ecchymosis may be present together with neurological symptoms. These latter may exhibit an impaired sense of smell, caused by the shearing of the peripheral branches of the olfactory nerve as they pass through the cribriform plates. Impaired vision and anaesthesia along the course of the distribution of the right infra-orbital nerve may also be a feature of these types of fractures. In these cases consultation with a neuro-surgeon is essential to evaluate and treat any cerebral damage. Fracture of the nasal bones may also be apparent, but at times excessive oedema and consequent swelling may conceal initially the displacement of these bones.

(18) Stockdale has described a case exhibiting emphysema, following a pyramidal fracture of the upper jaw. Blowing of the nose to clear the air passages after an accident produced emphysema of the left side of the face and neck. The air was presumably forced into the left antrum and from there escaped into the soft tissues of the face via the traumatic defects in the continuity of the antral wall. He states:

"The production of emphysema of the face, following middle third fractures, points to the possibility
of the occurrence of traumatic cerebral aerocoele, following high pyramidal fractures with a dural tear, and a resultant cerebro-spinal rhinorrhea. In these cases there is a risk of air and bacteria from the maxillary sinus being forced into the soft tissues presenting a cellulitis complication."

3. Transverse or Depressed Middle Face Fracture:
The nasal and malar bones are here involved. The entire middle part of the face may be pushed back creating a dish-shaped effect. Haemorrhage may take place into the palate, pharynx and the antra. Unilateral epistaxis is usually present, due to the escape of blood from the antrum, the haemorrhage having been initiated by the laceration of the antral lining at the time of the injury. The conjunctiva may be injected with blood and there may be marked swelling of the eyelids. Nerves may be impinged upon. If the facial nerve is involved, a "Bell's palsy" sign may be present and the compression of the optic and motor nerves of the eye may cause diplopia, blindness, and paralysis of the eye-ball. Finally, in cases of fracture of the zygomatic arch, a common symptom is the patient's inability to close his teeth together completely due to the impingement of the coronoid process of the mandible on the zygomatic arch.

4. Comminuted Middle Face Fractures:
These are most commonly seen today as a sequel to automobile accidents. In war time, they result from the penetration of bullet, shell and bomb fragments. The bone is shattered into small fragments and the signs and symptoms produced will vary according to the location
of the line of fracture. Comminuted transverse fractures of the zygomatic bone are common, together with comminution of the inferior orbital margin.

The treatment of fractures of the middle third of the facial skeleton.

The correct time for the treatment of fractures of the middle third of the face is in nature controversial, but it is felt that the early reduction and fixation of the fractures should be delayed only by real evidence of skull and cranial injury, not by an assumed one. This view has been presented concisely by Cone, who states:

"That the replacement of all displaced bones, added to safety because of the natural drainage established by proper disimpaction and replacement, with the danger of infection lessened by the use of chemo-therapy."

At this stage of the treatment of the bony injuries, general patient attention has been given, hemorrhage arrested, anti-shock treatment carried out, and lacerations sutured. The fluid balance should be maintained to prevent dehydration, and vitamins supplied - especially ascorbic acid, 200-500 mgs. per day intramuscularly. Restlessness should be counteracted with the judicious prescription of amytal or luminal. The use of morphine is felt to be contra-indicated in cases of head injuries because of its side reaction of respiratory depression. The administration of the appropriate anti-biotic should also be carried out to prevent secondary infection.

The choice of a suitable anaesthetic under which treatment can be safely carried out arises. It is essential that the anaesthetic chosen should give complete freedom of action to the oral surgeon no matter what adjacent
region may be involved. General anaesthesia is usually preferred to local anaesthesia for facio-maxillary work. Pentothal sodium as an intravenous anaesthetic has many advantages. This is particularly obvious in the case of depressed fractures where the air passages are obstructed. It also avoids any post-operative nausea and vomiting, and it can allow the proper immobilisation of the jaws without the attendant dangers of choking. However, in cases where difficulty is experienced in maintaining the patient's airway, its side effect of respiratory depression, will often preclude the use of this anaesthetic. If pentothal sodium is considered dangerous in the circumstances, endotracheal anaesthesia, utilising a mixture of ether and oxygen with the use of a Magill tube, combined with the packing of the pharynx, would seem ideal. However, in many cases the placing of the Magill tube may increase the injury and further displace the fractured bones. A short nasal tube in these cases may be used instead of a Magill tube. The individuality of each case must be recognised and there is no doubt that the acute facio-maxillary injury can present formidable anaesthetic problems. It should always be the endeavour of the anaesthesiologist to provide ideal anaesthetic conditions for the oral surgeon, irrespective of how long or intricate the operation proves to be. No matter which anaesthetic is chosen, premedication should be given careful consideration. Small doses of sedatives are to be preferred such as the use of nembutal 1/2 grains, two hours before the operation.

The deliberate treatment of middle face fractures must thus embrace:

2. The choice of a suitable anaesthetic.
3. The reduction of the fracture.
4. The immobilisation of the fracture.
5. The treatment of any complications.

Methods of reduction of middle face fractures:

These methods fall into the following groups:

1. Closed reduction of the fracture.
2. Reduction by traction methods.
3. Open reduction of the fracture by operative methods.

The choice of method of reduction of the fracture must always be the simplest method, which will provide the best functional and anatomical result. Thus it follows that the conservative methods of closed reduction, or reduction by traction should always be used if possible, and open reduction only employed when it is considered absolutely necessary.

1. Closed reduction of middle face fractures:

Reduction by digital manipulation is indicated in recent fractures of the middle face, where the fractures are fairly loose and in which the deformity is due to a downward and backward displacement, and where there is no impaction of fragments.

(a). In horizontal fractures, reduction may often be accomplished by rocking the maxilla and at the same time applying a downward pressure whilst placing the left hand over the upper part of the head for control. A simple, accurate method of reduction here has been suggested by Harding in either dentulous or edentulous cases. A soft compound impression is taken of the upper jaw, and the compound is then allowed to harden in the impression tray. By grasping the tray, this will allow very accurate manipulation of the maxilla controlling the oral movements in reduction.
In edentulous cases, the accuracy of reduction is not so important, as slight abnormalities in the occlusion will be overcome by future proper denture construction. For fixation in dentulous cases, however, the occlusal relations of the teeth must be exact.

(b). **Pyramidal fractures** are treated in a similar manner. Often it is necessary to spread the malar bones laterally, to allow the central pyramidal fragment to come forward in order to bring the teeth into normal occlusion. The manipulation here can be greatly aided by the introduction of nasal forceps, or some such means, to take a firm hold of the nasal septum, thus allowing a strong forward pull to be exerted.

(c). **In depressed fractures** of the zygomatic bone, as well as digital manipulation of the fragments, the use of an instrument or a towel clip is often very helpful. A blunt elevator may be inserted through a small incision in the bucco-mucosal fold under the zygomatic process and elevating it to position, whilst a towel forceps may be inserted through the skin at the site of depression, one beak above and one below the depressed bone and pressure again exerted outward to elevate the depressed bone. If the nasal bones are depressed, a blunt instrument such as a bayonet elevator or a flat blunt periosteal elevator may be inserted into the nares to assist in moulding into position the laterally displaced bones. To retain these bones in position, modelling compound; trimmed to fit the shape of the nose and softened; is placed over the part and allowed to harden. It is then held in place with adhesive tape; If the ridge of the nose tends
to collapse however, rubber tubes may be inserted into the nares to support it, and at the same time furnish a patent airway.

2. The reduction of middle face fractures by traction methods:

This reduction of the fragments may be accomplished intra-orally, known as intermaxillary reduction, or by external methods - both by means of elastics. Intermaxillary traction is accomplished intra-orally with the use of attached elastics between the upper and lower dental arches, whilst externally elastics may be attached at one end to rods projecting from a headcap and at the other end to splints about the upper dental arch, or pins placed in the fracture fragments. Reduction by traction methods should be employed in these cases, where the effective reduction of the fragments by manipulative means is not successful, and also in those cases where the treatment has been delayed. Failing successful reduction of the fragments by traction methods, operative procedures would have to be employed.

Intermaxillary traction has been found to be very successful in the reduction of horizontal maxillary fractures, to correct the position of the maxilla by bringing the teeth into occlusion. Results show an astonishing rapidity of correction, and there is no doubt that if conditions are suitable for its use, it is a much simpler and less cumbersome method of reduction than the external methods, which involve a headcap with auxiliary wires. For intermaxillary traction to be used, there must be sufficient teeth present for the attachment of dental splints to both the upper and lower jaws, and the teeth must be strong in themselves, and firm within the bone. The traction
is applied by means of small elastic bands attached to the splints on the upper and lower dental arches.

Kazanjian devised a very simple method of providing intermaxillary traction without the use of dental splints and which can be valuable in some cases. Twenty five gauge stainless steel wire is twisted about pairs of teeth in the upper and lower jaws and these wires are finally twisted into the form of a button on the buccal surface of the teeth. The pairs of teeth are occluding teeth, and the buttons are joined by elastic bands providing the traction. Intermaxillary traction cannot be used, however, in cases where insufficient teeth are present. In these cases reduction by external traction methods may be indicated.

External traction is especially useful in middle face fractures where we get the bony facial structure impacted under the projecting edge of the frontal bone, its reduction requiring a downward and a forward pull. Here a plaster headcap is used as anchorage, with attached rods connected by elastics to a splint about the teeth, or alternatively to pins inserted into the facial bones and traction applied. A simple application of this is Thomas's so called "birdcage traction". Here traction is applied by means of elastics extending from a wire cage made of coat hanger wire attached to a plaster headcap. The elastics are attached at the other end to a projection bar, in the centre of the nasal region, of a dental splint on the upper jaw. The wire cage consists of two arms extending downwards from the front of the headcap long enough to apply downward traction on the maxillae, and supported by lateral arms.
Force is applied first in a downward direction to disengage impaction with the frontal bone and later by bending these wires, force is applied to pull the maxillae forward. This same appliance may be used to reduce fractures of the malar bones. Screw eyes are inserted into the malar bone through a skin incision, and by applying elastics between the screw eyes and the appliance, the malar bone can be pulled forward into position.

External traction can also be used to supply the tension for the reduction of the maxilla in edentulous cases. Instead of the use of screw eyes, Stevenson has evolved a simple procedure that can be recommended. A hole is drilled through the hard palate of the maxilla, posterior to the crest of the alveolar ridge. Thirteen gauge stainless steel wire, protected by rubber to prevent injury to the soft tissues, is then inserted into this hole from the palate into the nose. The wire emerges from the nostril to be attached to a rod anchored to the anterior part of a headcap. Traction is then applied by interposing a heavy elastic band.

Instead of the use of rubber or elastic bands, external weight traction for the reduction of the fragments may be applied to maxillary fractures by means of a "Balkan Bean" appliance, attached to a splint fixed to the teeth of the upper arch. A half pound weight is first used, and this is gradually increased daily until a five pound limit is reached and when reduction is found generally to be complete.

External traction should, if possible, be used together with inter-maxillary traction to give the details of occlusion. (The various forms of headcaps and splints will be detailed in sections dealing with fixation.)
If it is found that the correct reduction of the fracture cannot be accomplished by manipulative or by traction methods then operative procedures should be employed.

3. **Open reduction of middle face fractures by operative means:**

Open reduction of middle face fractures is indicated when comminution of fragments is present, and in grossly displaced fractures, especially where foreign bodies have been interposed. Old fractures, where partial or complete union has taken place due to delay of treatment, would also indicate reduction by operative means. In cases of fracture of fracture of the maxilla, surgical access is obtained intra-orally by incisions high in the labial sulcus. Where the maxillary sinus is opened, a Caldwell-Luc antrum operation is carried out and reduction of the fragments may be accomplished. In these cases their fixation is often gained by packing the antrum with gauze or a Penrose tube. The latter is a rubber tube containing gauze which will also provide for any necessary drainage.

A useful method for the reduction of fractures involving the anterior surface of the maxilla and the infra-orbital ridge is the "balloon technique" suggested by Jackson, Abbey and Glanz. Here a completely deflated antral balloon is inserted into the maxillary sinus by way of a nasal antrostomy. This operation is best carried out under endotracheal anaesthesia, and the inserted balloon is then filled with air from a Luer-Lok syringe using a twenty one gauge needle. Approximately 10 to 15 cc of air are found to exert sufficient pressure to force the displaced fragments into their correct position. This balloon technique can be used in conjunction with an internal method of open reduction, for example Gillies, or, again in conjunction with external traction methods of closed reduction for
depressed zygomatic bones, when the anterior surface of the maxilla is severely comminuted and where the balloon itself will not completely align the depressed zygomatic fragments. After the reduction of the fracture, the balloon is deflated, and withdrawn through the antra-nasal opening. This method of reduction would seem to give good functional results in comminuted and depressed zygomatic fractures. The cosmetic result obtained should be excellent since no extra-oral incisions are necessary. It appears to be an ideal method of reduction in those cases where we get displacement of the eyeball due to commination and a downward displacement of the orbital floor. By this active balloon technique the fragments may be pushed upwards into their correct position.

In the choice of a method of reduction for fractures of the zygomatic arch, the time between the injury and the operation for reduction is a big factor, according to Kleitsh. If this time is within four days, the bony elements are usually mobile enough to permit easy manipulative repositioning. The reduction of older fractures in this region may, however, present difficulties. Kleitsh maintains that very good results in these cases are obtained by antrostomy through the median antral wall in conjunction with a Caldwell-Luc antrum operation. This is especially the case where comminution of the orbital floor with depression of the globe of the eye is present. He states that this procedure will allow the evacuation of any haematoma that may be present in the antrum, as well as providing the necessary access for manipulation for the accurate reduction of the fracture. His technique requires an incision to be made in the upper buccal sulcus, from the first bicuspid to the second molar and the line of fracture exposed in the antral wall. From
this position, by instrumental manipulation, the zygomatic bone may be disimpacted and elevated to position. The maxillary antrum is then opened by making a window in the bone through the canine fossa, large enough to permit visualisation of the entire sinus. A wet gauze, sponge soaked in a 5 per cent cocaine solution and lightly packed into the antrum, will at this stage control any pain and aid in haemostasis. A nasal antrostomy is then carried out nasal in the lateral/wall under the inferior turbinate bone and the cocaine gauze removed. The fracture is then examined for satisfactory reduction and the sinus is then packed with an inch wide firm gauze pack moistened with compound tincture of benzoin. When the antrum is filled, the end of the pack is brought through the nasal window. The oral wound is now sutured. This packing is usually removed between the second and seventy day, depending on the severity of the comminution of the fragments.

Two other operative procedures for the reduction of depressed fractures of the zygomatic arch have been especially commended. One is an intra-oral, the other an extra-oral method of open reduction.

The extra-oral method is Gillies method. This consists of inserting through a small incision of the scalp in the temporal region just inside the hairline, a long, flat elevator downwards and forwards under the temporal muscle fascia until it projects under the zygomatic arch. The reduction of the bone is then accomplished by lever action using the skull as a fulcrum to elevate the depressed bone.

The intra-oral method, however, appeals to the oral surgeon as the simpler approach. The patient's mouth is opened widely with the aid of a gag and an incision
is made in the mucosa behind the zygomatic process of the maxilla. A blunt periosteal elevator is then inserted and passed up beneath the zygomatic arch until the fracture is reached. A cotton roll, or the operator's finger, is then placed under the instrument to form a fulcrum and so the displaced fragment may be pressed outwards by lever action to its correct position.

These two latter methods of open reduction for fractures of the zygomatic arch are simple and well recommended. If comminution of fracture fragments is present, involving the infra-orbital margin, together with the anterior wall of the maxillary sinus, then open reduction methods by way of the canine fossa, as in a Caldwell-Luc antrum operation, combined with a nasal antrostomy through the lateral nasal wall are indicated.

It is worthy to note that in some cases of old depressed fractures of the zygomatic arch, impingement on the coronoid process of the mandible may occur. This type of fracture can be easily overlooked at the time of injury because of swelling or ecchymosis of the overlying soft tissues. Failure to reduce the fracture can result in the permanent inability to open the mouth. In these cases, refracturing of the depressed zygoma, in an attempt at repositioning, usually brings about little improvement. Resection of the coronoid process of the mandible is recommended in these cases to relieve the extra-articular trismus, and the implantation of a bone graft or prosthesis is recommended to correct any noticeable depression of the zygomatic region. Lewis of Chicago, champions this procedure, and states:
"This is a much better method than the hazardous undertaking of malar zygomatic refracturing and elevation."

The Fixation of Middle Face Fractures:

Two general methods may be employed in the fixation of middle face fractures:

1. **External methods** - these methods do not involve a surgical procedure but utilise for the fixation of the fragments:
   - (c). Malar mandibular appliances.

2. **Internal methods** - these methods involve either the internal wiring fixation or the transosseous wiring of the fracture fragments, and these involve a surgical procedure.

The choice of the various appliances that may be used for the treatment of middle face fractures depends upon many factors. The type of fracture, the amount of displacement of the fragments, the mobility of the fragments, the condition of the teeth, and lastly, but not least, the availability of materials and the skill of the oral surgeon.

**External Methods of Fixation of Middle Face Fractures:**

External fixation methods are used in most cases of middle face fractures, because these fractures tend to displace if not firmly fixed. An external fixation appliance is needed if the mandible is used to support the middle face fracture, with the upper jaw
fixed to the lower by intermaxillary wiring, elastic traction applied to the teeth, or by the use of a Cuming splint in edentulous cases.

**Craniomaxillary appliances** - utilise a headcap for anchorage. Accordingly, these types of appliances are contraindicated in cases where there are contusions or lacerations of the forehead or scalp, or where a fracture of the vault of the skull is present. Rods or wires are attached to the headcap which provide fixation of the fragments by being connected to splints about the teeth, fixed or pins into facial bones. These appliances are useful where there is no displacement of the fragments, or where after reduction no displacement of the fragments during treatment is feared. The great advantage of these types of appliances is that the mandible is not immobilised, and so function is retained in the eating of food. These appliances will also serve when the cranio-mandibular fixation of fragments is difficult due to insufficient teeth in the mandible for the application of a splint.

**Craniomandibular appliances** - excel where there is considerable displacement of the fragments and a tendency for the deformity to recur. This method allows the use of intermaxillary elastics for reduction, and after the occlusion has been restored, these elastics may be replaced by intermaxillary wiring for fixation of the fracture. As well as intermaxillary fixation, cranio-mandibular appliances may utilise a headcap combined with either a Steinmann pin inserted through the chin or half pins inserted into each side of the mandible. A barrell bandage may also be used. Thus, craniomandibular appliances utilise the mandible as a splint against the maxilla on one hand and the vault of the skull on the other. This is a simple method of
fixation which has been shown to give good results even with the inexperienced.

Malar mandibular fixation - is sometimes employed in cases of middle face fractures when a mandibular fracture also exists. A skeletal appliance is used in the fixation of the mandibular fracture and a cranio-mandibular fixation method is used for the immobilisation of the mandible. Two half pins are inserted into each malar bone, and these are connected with connecting rods to the links attached to the pin fixation appliance used for the fixation of the mandibular fracture. This type of fixation can thus be valuable in the treatment of multiple fractures of the facial skeleton, when fixation of the malar bone is necessary, in the presence of scalp or cranial injury negating the use of a headcap.

Headcaps - are used as anchorage and give an excellent base for the attachment of levers and wires for the fixation of fractures of the maxilla, malar bones and nose. They are also used as a base for traction in the reduction of fragments. Many types of head appliances have been described and prefabricated for ready use. These have the advantage of being ready for use at any time, and consist of leather head bands to which are attached adjustable rods used for fixation. One of the best of these is the "Woodard appliance", which is so constructed that changes may be made in the position of the traction and fixation rods. To the leather head band a stainless steel slotted halo is attached with variable positions for the retention of rods used in reduction and fixation. These rods may be attached at any desired place on the halo. Two bent steel rods, so called wings, are included, which are attached horizontally to the vertical rods fixed to each side of
the head band, and these wings extend into the mouth and are attached to a splint on the upper jaw to immobilise the maxilla. However, this appliance needs careful adjustment and is really useless in the hands of the inexperienced, where it is found that the individual construction of plaster headcaps with the attachment of rods in any desired position, gives better results.

Plaster headcaps may easily be constructed with the aid of a stockinette placed over the patient's head. The hair is clipped, or braided in the case of women, and the stockinette loosely applied. Orthopaedic felt is used under its edges to prevent chafing and strips of orthopaedic felt are placed over the stockinette to act as a cushion. Plaster bandage is then applied and moulded to form, and carried well over the occipital and mastoid processes. Traction rods, straps, hooks and loops are then inserted in favourable positions to give the required directional force, and a second plaster bandage applied, fixing them in position.

The various individual appliances that may be used in these external methods of fixation of middle face fractures will now be discussed.

Cranio-maxillary fixation appliances with the use of a headcap may employ winged maxillary splints, which can be one of the following types:

(a). The Reversed Kingsley Splint

Here, an acrylic splint or denture is made covering the teeth of the maxilla, to each side of which tubes are attached, and into which fit wires which extend out of the mouth and curve backwards in a horizontal direction. These wings are then attached by rods or elastics to the plaster headcap. They exert an upward pull and hold the reduced maxilla against the superstructure. This splint is far from ideal. The
occlusion with the lower teeth cannot be observed, so that angulation of the fractured maxilla may occur, and after the fracture has healed the occlusion of the teeth may be well out and deformity exist. The winged wire and cast metal splints are much more ideal.

(b)(i). Winged Wire Splints

These are easily constructed by contouring sixteen gauge stainless steel wire along the arch of the upper jaw and ligaturing it to the teeth with fine wires. A square tube is soldered to the arch wire on each side, into which the horizontal wings may be inserted. These are in turn attached to vertical rods on the headcap. The occlusion here may be observed.

(ii). Winged Cast Metal Splints

These splints are either cast in a single piece or in sectional units, which are later united and may be cemented to the teeth with attached side tubes. The occlusal surfaces of the teeth are left uncovered, so that the occlusion of the teeth may be checked at any time. These splints are connected to the headcap in a like manner. Fixation by this method will not only prevent displacement of the maxilla in a vertical direction, but it will also eliminate tilting, which so often produces abnormal occlusal relationships.

(iii). Winged Dentures

These may be used in edentulous cases in a similar manner to the Kingsley splint, a metal tube being attached buccally in each flange. In these cases the exact reduction of the fracture is not so important, as the occlusion can be later adjusted
either in the existing denture, or a new denture can be constructed.

Other methods of fracture fixation of a cranio-maxillary nature utilizing a headcap, are the use of cranio-facial wires, or the use of pins attached to either the maxilla or to the individual bones. These latter comprise the use of Steinmann pins or half pins.

Cranio Facial Wires (trans buccal check wires) - by this term is implied the use of wires attached to a framework in a plaster headcap. Wires pass through the substance of the check into the buccal cavity where they are attached to a loop on the gingival edge of the maxillary splint in the premolar region. If these wires are attached directly to a headcap framework, so that upward traction is exerted on the fractured maxillae, then it has been found that the axis of this traction seldom lies along the axis of cheek insertion of the wire, so that a lateral or an anterior posterior tension is exerted on the surrounding skin. This may result in pressure necrosis of the soft tissue with intervening infection, cellulitis and a residual scar. Thus it can be seen that if these wires are used, great care is necessary in order that, at all times, the traction exerted will lie along the axis of the cheek insertion of the wires. Holland has described an apparatus which ensures this, enabling the cheek wires to be placed in any desired position by means of a universally adjustable attachment embodying these principles. These cranio-facial wires may also be looped about fracture fragments of individual bones, and then attached to the head appliance so as to maintain them in position.
Steinmann pins are also used for cranio-maxillary fixation of middle face fractures. These pins are inserted through the face in a transverse direction in such a manner that they extend over the reflection of the mucosa and pass through the maxillary sinuses. The ends of the pins project through the cheek and are attached to rods from a plaster headcap by means of Frac-Sure rods and links, or by means of extension rods. A stab incision is made in the skin and the Steinmann pin is inserted with a hand drill. Care must be taken that the skin is not caught by the wire and lacerated. The use of these pins is a complicated surgical technique and it is not recommended except in very complicated cases. Individual pins may also be inserted into the bony framework of the middle part of the face. They are connected by rods and universal joints to a plaster headcap for the fixation of minor simple fractures in this region, for example in fractures of the nasal and zygomatic bones.

Cranio-mandibular fixation appliances - by this method of external fixation of the middle face fractures, the teeth are brought into normal occlusion by manipulation or traction methods and are held in this position by inter-maxillary fixation, combined with a cranio-mandibular bandage, the skull again being used for anchorage. Dentures or metal arch splints are used, which are inter-maxillary wired, whilst the bandage is a Barton bandage. This is often supplemented and reinforced with elastics exerting a constant pressure between the chin and skull. It is obvious that with this method, deglutition is impossible. There is the possibility of the bandage slipping or the elastics not exerting tension at right angles to the occlusal plane. The patient can willfully
remove the bandage. All these factors can lead to deformity and I would not recommend cranio-mandibular fixation of a middle face fracture in preference to the rigid fixation that can be obtained, either by a cranio-maxillary appliance or the use of internal methods of fixation. Cranio-mandibular fixation of a middle face fracture can also be obtained in conjunction with the use of a Steinmann pin. In this case the pin is placed transversally through the symphysis of the mandible, and, as in cranio-maxillary fixation, attached by rods to a plaster headcap. Instead of Steinmann pins, half pins in each side of the mandible may also be used. Here again, the teeth must be brought into correct occlusion and held there by intermaxillary elastics or with the use of a Gunning splint in edentulous cases. The use of these pins will give much more control and rigidity than the use of just the Barton bandage, but otherwise they seem to have the same disadvantages.

External methods of fixation of middle face fractures cope very well in the treatment of a midline split of the maxillae. A combination of appliances here may be used. The type of fixation chosen will depend upon the mobility of the maxillary fragments and the amount of displacement of the bones present. If the maxillae are separated to a marked extent, splints may be fitted to each maxilla and later joined anteriorly by means of a connecting bar and locking plates, after the reduction of the fracture. The splint may then be held in position by:

2. Cranio-maxillary fixation methods without the use of cheek wires.
3. Cranio-maxillary fixation methods with the use of cheek wires.
4. Cranio-maxillary fixation by soldering a rod anteriorly to each localising plate. These rods are then made to emerge from the angle of the mouth, bent posteriorly on the outer aspect of the cheek, to terminate at a point just short of the anterior border of the ear. These rods are then connected to a plaster headcap by vertical bars and universal joints.

A novel variation in the treatment of this type of fracture of the upper jaw, but still using an external method of fixation, is being employed in Switzerland. Instead of using a sectional splint on the upper jaw, the fragments are stabilised with two screw-bearing pivots. These are placed through the interproximal spaces of teeth which are not lying directly in the fracture line. These pivots are then connected with a cast splint providing fixation of the fragments. A good result is claimed by (25) the author who has used this appliance in many cases involving simple and compound fractures of the upper jaw.

Internal Methods of Fixation of Middle Face Fractures

(a); Internal wiring fixation

This method of fixation of middle face fractures has given good results, if carried out with a careful aseptic technique. It eliminates the use of cumbersome external splints and plaster headcaps or headbands, which can frequently cause great discomfort. The equipment is simple and readily available at any hospital and it causes little or no postoperative pain or discomfort. This type of fixation may be used in horizontal maxillary and depressed facial fractures, and also for the repair and fixation of
minor facial fractures, such as occur around the orbit or nose. The precise positioning and strong fixation of the maxilla in multiple facial fractures facilitates the immobilisation of secondary fractures, since the maxilla may be looked upon as a foundation structure. Provided that care is paid to asepsis, internal wiring fixation allows the patient to resume his normal activities soon after injury, because there are no adjustments to be made, and the danger of accidental displacement of cumbersome external appliances is eliminated.

In horizontal maxillary fractures, wires are inserted through the infra-orbital ridge and attached to a splint about the upper teeth. A small incision is made over the ridge and a hole drilled through the bony ridge. Stainless steel wire is then threaded through the hole and both ends are then attached to the eye of a silver probe. The probe is then passed underneath the lower margin of the incision between the skin and the anterior wall of the antrum, until it appears under the gingiva just above the second molar tooth. The probe is then drawn down until the wire is taut and the infra-orbital incision is then closed by suture. This procedure is performed on each side. If the maxilla can be reduced by manipulation, it is at once fixed, by fastening the wire on each side to a previously attached arch wire or cast splint on the upper jaw. In cases where the fracture must be reduced by traction, the wires are attached loosely until the reduction has been completed. Then the fracture can be fixed by tightening the wires, and fastening them to the upper arch if the fracture is stable,
or to the lower one if intermaxillary fixation is needed to retain the position. If the patient is edentulous, these wires may be attached to the denture or to a specially constructed denture splint. In transverse depressed facial fractures, where the orbits and the malar bone are involved, the attachment of the wire is made higher up in the supra-orbital ridge, and passed behind the zygomatic process into the oral cavity. The wires attached to the eye of the probe are inserted and passed behind the ridge through the post-zygomatic fossa along the temporal surface of the malar bone. The probe will finally be felt in the upper bucco-alveolar sulcus, posterior to the second molar tooth. A small incision is made here through which the probe is drawn and the wire pulled taut. The use of these wires may also serve to reduce a depressed malar fracture. By grasping the wires firmly, the malar bones may be brought forward. These wires are removed after five to nine weeks and are simply pulled into the oral cavity so that infection will not be drawn from the mouth into the wound.

(b). Transosseous wiring or direct wiring of fracture fragments

This type of fixation has also received the name of osteosynthesis, and it applies to the surgical fixation of the ends of the bone fragments with either sutures, stainless steel wires, metal plates, or the use of acrylic resin plates. It is possible by these means to obtain a solid and durable adhesion, even when the fragments of bone have a labile contact. This type of fracture fixation is extensively used in the fixation of mandibular fractures and it will be discussed in detail later.
It is also a useful procedure which will give good results in highly comminuted middle face fractures. It is especially indicated in cases of orbital fracture, either to repair the outer wall of the orbit or the infra-orbital ridge, or for the fixation of fractures of the zygomatic bone. In cases of orbital fracture, a small incision is made in the tissues over the injured bone and continued through the periosteum. With a periosteal elevator, the periosteum and the overlying soft tissues are pushed back and retracted on both sides. A hole is then drilled through each of the bone fragments, after which a 27 gauge stainless steel wire is inserted through the two holes, the fragments reduced, and the wires twisted together. The twisted end of the wire is then cut short, and bent over so as not to irritate the wound. The skin incision is then closed with interrupted sutures. In cases of severe and unstable malar fractures with displacement, transosseous wiring of the fragments is also recommended. After the fracture has been reduced by open operation, the fragments are wired together for positive fixation. These wires remain permanently and become embedded in fibrous tissue surrounding the fracture site. Common to surgical procedure, strict asepsis is essential for success.

Having considered the methods and array of appliances that can be used in the treatment of fractures of the middle third of the face, points that must be stressed are:

1. The necessity of an early and correct diagnosis of the case presented.

2. Adequate control of infection, with full use of appropriate anti-biotic therapy in conjunction with an aseptic operative technique.
3. Early reduction of fractures.

4. Rigid fixation of the fragments and immobilisation of the fractured bones.

Complete immobilisation of a fracture is fundamental for the process of repair. Our choice of appliances must be a calculated one for success, both for function and aesthetics; we should always employ the simplest treatment that will give the best functional and anatomical result.
The related surgical anatomy:

The mandible occupies a prominent and an exposed position in the facial skeleton and we have shown that it is a common site of election for the receipt of violence. The body of the mandible is similar in shape to that of a horse shoe, but at the angle of the mandible there is an abrupt change in the conformation of the bone. The ramus forms an oblique angle with the body of the bone, and, viewed from above, there is a slight divergence of the rami. Further observation of the bone from the inferior aspect will show that, whilst the rami diverge, the alveolar portion of the bone supporting the molar teeth does not follow the same line as that formed by the lower border of the mandible. The adult mandible is composed of a compact outer and inner plate of cortical bone and a central portion of the medullary bone, whose trabeculae are distributed along the line of maximum stress. In the case of the body of the mandible, the outer cortical plate is thickest in the region of the mental prominence and the third molar tooth, where the external oblique line passes upwards towards the coronoid process.

The ramus consists essentially of two thin plates of compact bone, separated by a relatively narrow portion of cancellous bone. The body of the mandible is considerably thicker than the ramus, and the junction of these two portions constitutes a line of structural weakness.

Basically, the mandible is constructed of two components; the mandible proper, and the alveolar or tooth bearing portion of the bone. The alveolus is composed of bone which is structurally weaker than the rest of
THE MANDIBLE.

THE LEFT HALF OF THE MANDIBLE. LATERAL ASPECT.

THE RIGHT HALF OF THE MANDIBLE. MEDIAL ASPECT.
the mandible and thus an alveolar fracture may occur quite independently of the main body of the bone. With advancing age, resorption of the alveolar portion of the bone when the teeth are lost will approximately reduce the vertical depth of the bone by half. The slender neck of the mandibular condyle renders it particularly liable to fracture as a result of direct violence applied to the mental prominence. This anatomical weakness can be regarded as a safety mechanism, as a fracture in this region may prevent the condylar head from being driven through the glenoid fossa into the middle fossa of the skull. It will be appreciated that direct violence applied to one side of the mandible is liable to produce an indirect fracture on the opposite side. For example, a blow to one side of the mental prominence in the region of the canine fossa will probably cause a direct fracture at this site, but as the body of the mandible is forced violently across towards the opposite side a secondary line of stress is created at the opposite angle, often resulting in its fracture. The line of fracture usually extends anteriorly and laterally to pass behind or around the socket of the third molar tooth. Compression of the bone from side to side as a result of a crush injury can lead to a fracture in the region of the mandibular symphysis, the outer plate of the bone undergoing a tension fracture. A fracture in this region may also be caused by direct violence when the shape of the mandible is distorted by its angle being violently forced upwards. Under these circumstances, the inner plate of the bone in the region of the genial tubercles undergoes a tension fracture accompanied by a bilateral fracture of the necks of the mandibular condyles. The presence of teeth in the bone is a
source of structural weakness. This is particularly so in the canine region, where an elongated canine root is present, or, again, at the angle of the mandible where we have a deeply situated unerupted third molar tooth present in the jaw.

There are two principal sources of blood supply to the mandible. Firstly, there is a central blood supply through the inferior dental artery and, secondly, a peripheral blood supply through the periosteum of the bone. When a fracture of the mandible occurs, the blood vessels involved at the site of the fracture are torn, and the resulting effusion of blood into the surrounding tissues produces ecchymosis and haematoma formation. Although the inferior dental artery and vein are commonly ruptured by a mandibular fracture, the bone is adequately nourished by the collateral blood supply derived from the periosteum. For this reason, osteomyelitis as a complication following a fracture is comparatively rare, unless a virulent organism is introduced. Small fragments of bone will maintain their viability provided they are attached to the periosteum, and such fragments of bone should be preserved. On the other hand, the severing of the apical blood supply to a tooth will result in the death of the pulp tissue, which thus forms a focus for the development of infection.

The mandible is freely movable. It is articulated by the temporo-mandibular joint, and held in position by various muscles and ligaments. These muscles are of great importance in contemplating the reduction and fixation of fractures of the mandible. Muscular pull is one of the causes of displacement of the fragments, often hindering proper alignment of the bone, as well as creating trismus. The mandible is closed and the teeth brought into occlusion by the elevator muscles, namely the temporal, internal and external pterygoids and masseter muscles.
The temporal muscle takes origin from the temporal fossa and temporal fascia. It is inserted into the deep surface, anterior border, and the apex of the coronoid process of the mandible and its insertion covers quite an appreciable part of the ascending ramus. The main pull of the temporal muscle is upwards, but its posterior fibres pull backwards and counter the action of the external pterygoid muscle, to a limited extent, its anterior fibres also pull forwards.

The internal pterygoid muscle takes origin from the lateral pterygoid plate and the tuberosity of the maxilla. It is inserted into the medial surface of the mandible at the angle below the lingula, and its direction of pull is upwards, inwards and slightly forwards.

The masseter muscle takes origin from the inferior border and the deep surface of the zygomatic arch. It is inserted into the lateral surface of the ramus and coronoid process of the mandible, and exerts an upwards and slightly outward pull.

Acting as a group, the elevator muscles are extremely powerful. The temporal and masseter muscles can be seen and palpated as they contract, but the internal pterygoid muscle is not normally visible and its power may be overlooked. It is a stronger muscle than the masseter and will displace the ramus inwards against the outward pull of the masseter in the absence of other controlling factors. Thus it may be appreciated that if a fracture occurs in the third molar region of the mandible, these muscles will cause displacement of the ramus. The masseter, internal pterygoid and temporal muscles pull the fragment upwards, whilst the external pterygoid muscle, which is attached to the neck of the condyle, pulls the ramus forward and so, in conjunction with the internal pterygoid muscle, effects an inward and an upward displacement.
MANDIBULAR FRACTURE DISPLACEMENT DUE TO MUSCULAR ACTION.

1. A, INWARD, AND B, UPWARD, DISPLACEMENT OF RAMUS DUE TO PULL OF ELEVATOR MUSCLES.
2. MEDIAL DISPLACEMENT CAUSED BY MYLOHYOID MUSCLE.
3. DIRECTION OF FRACTURE LINE PREVENTING DISPLACEMENT.
4. ANTERIOR FRAGMENT OF MANDIBLE DISPLACED BY GENIOGLOSSUS MUSCLE.
5. LATERAL FRAGMENT OF MANDIBLE DISPLACED BY THE MYLOHYOID AND DIGASTRIQUE MUSCLES.
The external pterygoid muscle takes origin from the infra-temporal surface of the greater wing of the sphenoid bone and from the lateral surface of the lateral pterygoid plate. It is inserted into the anterior aspect of the neck of the mandibular condyle, the meniscus, and the capsule of the temporomandibular joint. Contraction of one external pterygoid muscle results in a rotation of the mandible towards the opposite side. Contraction of both muscles at the same time protrudes the mandible, this movement being usual when the mouth is open. The direction of pull of the external pterygoid muscle is forward and inwards.

The anterior part of the mandible is controlled by the mylo-hyoid, digastric and genio-hyoid muscles, which are the depressor muscles of the mandible. These will cause the displacement of fragments in an inward and a downward direction. These depressor muscles take origin from the lower border of the mandible near the mandibular symphysis, with the exception of the mylo-hyoid. This takes origin along with the mylo-hyoid ridge which extends posteriorly to the mandibular third molar region. These muscles are inserted into the hyoid bone and the median raphe which joins the symphysis to the hyoid bone. The position of the hyoid bone is maintained by the inter-action of two groups of muscles - its depressors and its elevators. These elevator muscles are divided into two groups - those which pull upward and slightly backwards, and those that pull upward and forward - the latter ones are the depressor muscles of the mandible. Thus it can be seen that a fractured segment in the anterior part of the mandible, will be displaced downwards and inwards because of the pull of the genio-hyoid muscles. The lateral segments will be pulled downwards and inwards by the digastric and mylo-hyoid muscles.

When a midline fracture of the mandibular symphysis occurs, both fragments have similar muscles.
attached so that neither an upward nor a downward displacement occurs. However, the internal pterygoid muscles exert an inward tension, whilst the mylo-hyoid muscles pull inwards and backwards, both muscles tending to displace both fragments inwards towards the midline. However, it has been shown that if the line of the fracture is such that the fractured surfaces are at right angles to the body of the mandible, the inward displacement will be prevented. If the fracture line is oblique, or if comminution of the fragments is present, the inward displacement will occur and this will be greater at the occlusal surface than at the lower border of the mandible, which results in a tipping inwards of the fracture fragments.

The classification of mandibular fractures:

Fractures of the mandible conform to the general classification of fractures being complete, incomplete, simple, compound, and other varieties as already expounded. The location of a mandibular fracture, if it is related to the tooth bearing segment or not, and the influence of muscular tension, directly influences the methods of treatment employed. Thus the classification of mandibular fractures in general use today follows Kazanjian's classification, whereby the mandibular fracture is classified according to its location. Accordingly, mandibular fractures may be found:

1. In the horizontal ramus, anterior to the last existing tooth

   This type of mandibular fracture is of common occurrence. It usually permits the use of a method of intermaxillary fixation of the fracture, which is a predominant method of fixation employed in the treatment of fractures of the jaws. This method of fracture fixation
utilises dental splints or arch wires attached to
the teeth. Of paramount importance, relative to
mandibular fractures in this group is:
(a). The condition of the teeth, firm loose or infected;
their number; and their position relative to the
fracture line.
(b). The angulation of the fracture line.
(c). The amount of comminution of bone.
(d). The degree of displacement of the bone fragments.
(e). The related muscular tension to be overcome.

Teeth and their sockets are commonly involved in frac-
tures of the mandibular horizontal ramus. Sometimes
the fracture occurs between two teeth sockets - more
often the socket itself is involved in the line of
fracture. In these cases, the tendency of the post-
erior fragment is to be displaced inwards and upwards.
Where the posterior fragment contains teeth which meet
upper opposers, no upward displacement can occur unless
there is a considerable lingual or a buccal displace-
ment of the posterior fragment. The anterior frag-
ment is usually depressed and rotated towards the
injured side.

In addition to single mandibular fractures found in
this group, multiple mandibular fractures also occur,
which can present various combinations. For example,
it is common to find a fracture in the region of the
mental foramen in association with either a fracture
at the angle of the mandible of the opposite side, or,
alternatively, a subcondylar fracture, or a fracture
or fracture dislocation of the condyle on the opposite
side. Heslop has presented an interesting case, which
is uncommon and which does not fit into the usual classification of fracture and fracture dislocations of the mandible. He reports the case of a midline fracture of the body of the mandible with dislocation of one condyle from the glenoid fossa in the absence of an associated fracture of the neck of the condyloid process, or the adjacent ascending ramus.

2. In the horizontal ramus posterior to the last existing tooth.

3. Fracture at the angle of the jaw:
These latter two groups usually show a marked displacement of the distal bone fragment, which has a tendency to displacement in an upward and a medial direction due to the action of the attached muscles. These groups require the use of special devices to control the displacement of the distal fragment. Kelsey Fry subdivides angular fractures again, according to the direction of the fracture line and its resistance to the muscular pull of the elevator group. He speaks of a fracture line as being "horizontal, favourable or unfavourable", and "vertical, favourable or unfavourable." The posterior bone fragment has attached to it the elevator muscles which tend to pull it upward, forward and inwards. This inward pull, in addition, occurs because the internal pterygoid is a stronger muscle than the masseter. However, division of the internal pterygoid muscle would result in an outward displacement of the posterior fragment due to the unopposed pull of the masseter muscle.

Thus, according to Fry, on being displaced upwards, the posterior fragment will rotate about the temporomandibular joint, moving in an arc of a circle, with the result that the angle of the mandible is displaced upwards and forwards by muscular action. If the line
of the fracture corresponds to this arc, the anterior fragment will permit this upward and forward displacement, whereas, if the line of the fracture crosses the arc, the fracture surface of the anterior fragment will prevent displacement. A line of fracture at such an angle as to permit the upward displacement of a posterior fragment is termed horizontal unfavourable, and vice-versa. In a similar way when viewed from above, the angle of the fracture line may be such as to permit or to prevent an inward displacement of the posterior fragment. The fracture line is thus termed vertical unfavourable or vertical favourable respectively.

Thus, fractures involving the posterior segment of the body, or the angle of the mandible, will present fracture lines being either:

(a). Horizontal favourable or unfavourable against a displacement in an upward direction.

(b). Vertical favourable or unfavourable against a displacement in an inward direction.

It will be appreciated that combinations of types may occur.

4. Fractures in the edentulous mandible:

These are often found combined with atrophy of the alveolar ridge and the fractured bone ends may override each other. In edentulous cases, the periosteum about the body of the mandible, and the presence of a thick tough muco-periosteum on its upper border, do much to limit fragment displacement, which may be either horizontal, vertical, or angular in nature. Fractures of the edentulous mandible, in the region
of both angles, commonly exhibit large displacement of the fragments, the posterior fragments being displaced upwards by the elevator muscles, whilst the anterior fragment is displaced downwards anteriorly by the depressor muscles. Because of the absence of teeth, combined in many cases with pronounced alveolar resorption, the treatment of fractures in the edentulous presents different and at times difficult problems, particularly in the fixation of the fragments.

5. Fractures of the Ascending Ramus of the Mandible, including Fractures of the Coronoid Process and Subcondylar Fractures:

In fractures involving the ascending ramus of the mandible, the line of fracture usually descends from the mandibular notch. The fracture line may be oblique, extending downwards in a posterior direction or again in a forward direction, the latter is a so-called fracture of the coronoid process. On the other hand, the line of the fracture may be vertical or horizontal in nature. Direct fracture of the mandibular coronoid process is sometimes seen in association with a fracture of the zygomatic bone and arch. Simple indirect fracture of the coronoid process is usually caused by a sudden violent contraction of the temporal muscle at the moment of trauma impact, and the site of the fracture is almost invariably situated along a line between the insertions of the temporal and masseter and the internal pterygoid muscles. An upward displacement can occur, but most cases exhibit little or no displacement, and no visible deformity, beyond swelling and a limited opening of the mouth.

Sub-condylar fractures, condylar fractures and fracture dislocations warrant a detailed study in their own right and will be dealt with later.
6. **Multiple Mandibular Fractures:**

These are of common occurrence and may involve one or both sides of the mandible. In rare cases multiple fractures of the mandible have also been found to involve the styloid process of the temporal bone, presenting a complication which could easily be overlooked. Bird (1954) has described such a case of fracture of the styloid process associated with fracture of both mandibular condyles and an oblique fracture at the symphysis of the mandible, following a motor cycle injury. In this particular case, the line of fracture was seen to occur below the origin of the stylopharyngeus muscle. Bird points out that the principal symptom of such an injury is the persistent difficulty in swallowing, even after reduction and fixation of the mandibular fractures. He considers this is due to damage to the stylo-hyoid and stylo-mandibular ligaments, and the style-glossus and stylo-hyoid muscles.

This classification of mandibular fractures, which is based on the location of the line of fracture, governs our plan of treatment. This is directly related to the muscular tension exerted on the bone fragments, with their resultant displacement, and to the presence and location of the teeth in the dental arch. Our reduction of the fracture must overcome this muscular force. Our method of fixation must be rigid in nature to maintain the fragments in correct apposition during the time of healing, in order to prevent movement in the line of fracture resulting from this muscular force. It should be remembered that the further forward the site of the mandibular fracture occurs, the more is the upward displacement of the distal fragment, due to the action of the elevator muscles, counteracted by the downward pull of the mylo-hyoid muscle.
This is attached to the mylo-hyoid ridge on the lingual aspect of the body of the mandible. At the same time, the medial or lingual displacement of the fragment tends to be increased. Accordingly, the factors which influence our future treatment of a mandibular fracture are:

1. The site of the fracture in relation to the dental arch.

2. The direction of the fracture line. This may be favourable or unfavourable in either or both the horizontal or the vertical plane.

3. The tension of the powerful muscles which are attached to the mandible.

**The Treatment of Mandibular Fractures:**

This treatment follows the same lines as those adopted in the treatment of fractures of the middle third of the face, namely:

1. Anaesthesia if necessary.

2. The control of infection.

3. The reduction of the fracture.

4. The fixation of the fragments.

5. The immobilisation of the fracture.

**Anaesthesia**

Many simple fractures of the mandible, especially those which exhibit little or no fragment displacement, can be reduced without anaesthesia, particularly if a simple method of fixation is employed. If muscular trismus is present, which makes it difficult to reduce the displaced fracture, or if the patient has a great many facial injuries that make the procedure of reduction painful, or if teeth are to be extracted and lacerations sutured, then anaesthesia
should always be used. In cases of mandibular fracture, intravenous anaesthesia with pentothal sodium seems to be the ideal method of general anaesthesia, since the danger of nausea and vomiting is less than with the use of ether and oxygen. If it is considered to be contra-indicated, however, ether and oxygen administered by means of a nasal intra-tracheal tube is highly satisfactory if the patient has been properly prepared.

Local anaesthesia may be preferred for certain procedures. A mandibular block injection in many cases makes the reduction painless, provided there are no facial injuries. In combination with narcotic premedication, local anaesthesia may be used to apply a skeletal fixation appliance. Most patients who have been in accidents are extremely apprehensive, and for this reason premedication is of great importance. An anaesthetic that causes prolonged relaxation, such as occurs with averton, should be avoided, and morphine not given until the patient has regained full control of muscular activity. Excessive relaxation of the muscles of the jaw and tongue often leads to respiratory obstruction caused by the tongue falling back into the respiratory channels.

For premedication, small doses of several sedatives are to be preferred, such as:

- 1½ grains (0.1 Gm) nembutal two hours before operation.
- 1/300 grain (0.0002 Gm) scopolamine 1½ hours before  "
- 1/300 grain (0.0002 Gm) scopolamine, and
- 1/120 grain (0.54 mg.) atropine on call.

The prevention and control of infection
This has previously been discussed by me. It follows the same therapeutic procedure both of a general and regional nature, as used in the treatment of fractures of the middle part of the face.
Reduction of mandibular fractures

The same methods of reduction which are applicable to fractures of the middle third of the face, also apply for the reduction of mandibular fractures. The reduction of mandibular fractures may utilise a closed reduction method, open reduction of the fracture, or reduction by traction methods.

Closed reduction by manipulative methods should always be used if possible because of simplicity. A general anaesthetic can often be of great value in these cases, as it produces relaxation of the attendant muscles, facilitating the reduction by manipulation.

Open reduction of mandibular fractures should only be resorted to if splinters of bone, soft tissue, or an organised blood clot, and foreign bodies are interposed between the fracture fragments. Open reduction is also indicated where we have an oblique fracture line and considerable displacement of the bone fragments which cannot be corrected by other means.

Reduction by traction methods is commonly employed for the reduction of mandibular fractures, the most common form being intermaxillary traction. Intermaxillary traction may be used where the immediate reduction of the fracture is not possible, owing to muscular spasm or where treatment has been delayed. This method of reduction requires the presence of sufficient teeth within the dental arches for splints to be applied. These splints may be of a cast metal nature, or ready made arch wire splints of a Winter or a Jelenko type. These latter are arch wire splints of a pliable nature, which can easily be adapted to the dental arch. The end Winter splint has lugs for attachment, with a ball/to pre-
vent irritation of the soft tissues, whilst the lugs of the Jelenko splints are in the form of loops. The lugs are numerous, which allow elastic bands to be used wherever traction is desired. The upper splint is attached by ligature all the upper teeth to the arch bar with 25 gauge stainless steel wire and twisting these ligatures over the bar until it is held firmly in place. The ends of the ligature wires are cut short and bent over so as not to irritate the soft tissues of the cheek. The splint for the lower arch is adapted in the same manner, but cut at the line of fracture. The elastic bands are then applied, which may not only exert a vertical traction to bring the displaced fragment into correct occlusion but may also be positioned to approximate the fragments in an oblique direction. The construction and the use of cast metal splints and arch wire splints for the reduction by intermaxillary traction of mandibular fractures will be dealt with in detail in the section concerning the fixation by intermaxillary methods of mandibular fractures. The indications for their use and the advantages of the various splints appliances will be discussed.

External traction for the reduction of mandibular fractures may be used in a similar manner as with middle face fractures, utilising a headcap or band. External traction is sometimes used for the reduction of displaced fractures involving the angle of the mandible. This procedure involves the surgical exposure of the angle of the mandible for the attachment of a pin or wires, which are then connected by means of elastics to rods on a headcap. Open reduction of the fracture would seem to be the obvious choice in these cases and later fixation of the fragments by means of transosseous wiring.
The open reduction of mandibular fractures, which employs a full aseptic surgical procedure, will also be dealt with specifically. It is used in association with transosseous wiring of the fracture fragments. It is particularly employed where the fracture involves the angle, ramus, coronoid process and condyloid process of the mandible, as well as in the control of an edentulous posterior fragment in the body of the mandible. In other words, its main use is where there is present a marked displacement of the fracture fragments.

The methods of fixation employed in mandibular fractures
Several methods can be employed singly or in conjunction with one another. The method of fixation employed bears directly upon the classification presented — that is the location of the mandibular fracture line. Fixation of fracture fragments may be obtained by:

1. **Horizontal wiring methods:**

   These methods of fixation are applicable only if the fracture occurs in the horizontal ramus of the mandible where sufficient teeth are present on each side of the line of fracture. Their main advantage lies in the fact that the immobilisation of the mandible is avoided. However, these methods are rarely found satisfactory by themselves and they are often combined with the transosseous wiring of the fragments. The combination of horizontal fixation and transosseous wiring will prevent opening of the fracture line when the mandible is used, which has been found to occur if the fracture is fixed at only one end. For similar reasons, the horizontal fixation of oblique fractures of the mandible is not recommended unless it is combined with inter-maxillary
fixation. Where horizontal wiring is used, immobilisation of the mandible for two weeks should be carried out, if only by means of a Barton bandage. In addition to the method already described in the horizontal wiring fixation of the fractures of the maxillae, other efficient methods are:

(a). The Bassig Method:
This method is very efficient for horizontal wiring, and will serve also to reduce a fracture accurately. A (0.02) inch diameter annealed brass wire or a 25 gauge stainless steel wire is passed into the interdental space between the fifth and sixth, or the fourth and fifth teeth away from the fracture. It is laced around the necks of the teeth until the second or third tooth from the fracture site is reached. One end of the wire is now placed over the labial aspect of the adjoining two teeth on each side of the fracture. The other end of the wire is pulled straight across the line of fracture on the lingual side, and laced around two or more teeth, twisted and cut, and the end tucked in. The wire on the lingual side thus extends straight across the fracture site at a distance from the teeth, following the curvature of the arch. Secondary interdental wires are then passed between the teeth to connect the lingual and labial wires. These are twisted tightly on the labial side. These wires are twisted gradually, going back over all the wires several times until the lingual wire comes in contact with the lingual surface of the teeth. This method gives us a reinforced bridge wiring system en bloc at the site of the fracture. It is designed both to reduce and fix a fracture without the immobilis-
section of the mandible.

(b). Ancient's Method:
This method is really a more refined one than the foregoing, using orthodontic bands and wires across the site of the fracture.

(c). The Risdon Method:
This method of horizontal wiring has proved to be of value, particularly in closed bite cases. Strong traction can be applied to impact the fracture, and the arch wire adapts itself nicely to the outer surfaces of the teeth. A 12 inch strand of 24 gauge stainless steel wire or brass wire is passed around the last tooth on each side of the dental arch, and twisted tightly on the mesiobuccal aspect of the tooth. The two ends of each wire are twisted together, and brought forward on the outer surfaces of the teeth to the incisor region, where they are united and twisted together so as to form a continuous arch. Each tooth is then separately wired to this continuous arch wire, and the ends of these ligatures are cut short. They may be bent in order that they can be used for the attachment of rubber bands, but not allowed to irritate the soft tissues.

II. Intermaxillary Fixation Methods:
These methods are used for the fracture fixation and the immobilisation of the mandible. Intermaxillary fixation of a mandibular fracture may be obtained by:

(a). Intermaxillary ligation:
This method of fracture fixation can only be used where an adequate number of teeth are present,
but it offers the simplest method for the treatment of mandibular fractures. It consists basically of utilising the maxillae as a splint against which the mandible is immobilised. Again, it brings the teeth into normal occlusion, which is necessary for future function. This method offers other advantages, as well as its simplicity. One may observe the position of the teeth at all times, and not any change in their position which may be brought about because of undue strain of the ligatures. The patient is able to clean his teeth and maintain fair oral hygiene, as the splints do not cover the teeth under which decay may occur.

In an adult it has proved to be the simplest, and quite a satisfactory method for the fixation of mandibular fractures within the dental arch where there are teeth on both sides of the fracture line. Intermaxillary ligation can also be combined with other methods of fracture fixation, for the immobilisation of the mandible where the site of the fracture is posterior/the last existing tooth, and also where a fracture involves the ramus and condyloid process of the mandible. It has also been found useful for the immobilisation of the mandible in cases where bone grafts have been used.

One of the best methods of intermaxillary ligation or wiring is Gilmer's method. Using this method orthodontic wire is used, being cut obliquely, and introduced through the interdental spaces. It is passed around the necks of selected teeth and twisted tightly to prevent it from slipping
over the crowns of the teeth. In the incisor region, the twisted ends of the wires are passed around two neighbouring teeth. The premolars and molars are wired singly. At least two pair of incisors should be used, and two, if not three, teeth in each posterior quadrant. If too few teeth are fastened together, there may be too great a strain placed on the individual wires, which then may stretch and become loose or break. In addition, the teeth that have been wired may become painful. The fracture is then reduced by manipulation. When the fragments are in position, the mandible is brought into normal occlusion with the maxillae. The wire nearest the fracture in the distal fragment is then fastened to a wire on a corresponding tooth in the upper jaw, and the wire nearest the fracture in the mesial fragment is united to the corresponding wire around the upper tooth. All the remaining ends of wires in the upper jaw are then united with suitable wires in the lower jaw. The direction of the pull of the wires should tend to bring the fragments together and to oppose muscular tension. Crosswise wiring is advised when the cusps of the teeth are worn down, so as to prevent the mandible from slipping in an antero-posterior direction.

Another simple method of intermaxillary wiring is the Eyelet method. This method can be most effective when there is:

i. An almost complete complement of sound teeth of suitable shape.

ii. Where the fracture is recent, and thus capable of reduction without any great difficulty.
Here again, teeth must be present in all fragments, and the articulating surfaces of the teeth are placed in correct occlusion under direct vision with all the fragments correctly aligned. In this method, the wires to be used are prepared by bending them in the middle and twisting them around an instrument to form an eyelet. These wires are then placed through the interdental spaces following the same principles as in the former method, but in this case the eyelets remain on the outer surfaces of the teeth, providing the attachments for intermaxillary wires.

Many variations in this technique of intermaxillary ligation have been presented. All have merits in the hands of the individual operators, but all having the common disadvantage that wires are drawn down over the teeth crowns, and unless the crowns of the teeth are unusually long, there is inadequate space for the intermaxillary wires.

(b). Intermaxillary fixation by means of arch wire splints:

The use of arch wire splints overcomes one big disadvantage of intermaxillary ligation, where undue force may be applied to certain teeth causing them to take heavy strain, especially if an inadequate number is available. In this method all the teeth present are used for support. Again, this method may be used for cases where there is an insufficient number of teeth necessary for intermaxillary ligation. These arch wire splints may be in the form of Angle's bands and arch wires on each jaw, connected by intermaxillary wires, or again of the Winter and Jelenko prefabricated type splints.
These latter splints are bent to conform to the shape of the dental arch, and the ends are bent and extended a short distance around the last teeth. These arch wires are ligatured with 26 gauge stainless steel wire to as many teeth as possible in each jaw to divide the forces that are applied to them. These splints are so applied that in the upper jaw the lugs point up, and in the lower jaw point down, that is towards the teeth apex.

The Hammond Splint is another prefabricated type of arch wire splint and in its essentials is a double arch wire splint, one on the buccal and one on the lingual side of the teeth. The two arches are joined behind the last molar tooth on each side, and the splint is fixed in position by wiring it to the teeth, sufficient being used to attain rigid fixation. For the immobilisation of the mandible with these arch wire splints, intermaxillary elastics are found to be more comfortable than the absolute fixation obtained by the wires. It has been claimed that the healing of a fracture is promoted by slight motion in the line of fracture. It may be true, but elastics do perish and are not subject to rigid control. Thus it is felt that even though wires are not as comfortable as elastics, they do give absolute control. They are certainly cleaner than elastics and limit to a greater degree complications that may arise.

The use of intermaxillary fixation by means of ligation or arch wire splints for the fracture fixation and immobilisation of the mandible, is simple and efficient. The main disadvantages that are apparent in their use are:
1. The loosening of ligatures and the arch wires.
2. The undue strain that may be placed upon certain teeth.
3. The unsuitability of the shape of many of the teeth.

Unless carefully placed, the ligatures about the teeth may also lacerate the gingiva with potential pocket formation. Thus I feel that the fixation and immobilisation of the jaws by these means are best suited to the field of emergency, before specialist attention can be obtained. In the first-aid treatment of faciomaxillary injuries, innovations have been used with arch wire splints, such as the rip cord release mechanism - already described. This will allow the patient to open his mouth quickly if nausea and vomiting create a complication. Because of this, I believe that these methods, utilising ligation and arch wire splints for the intermaxillary fixation of fractures of the jaws, have been allocated to their proper field and should be kept there. For deliberate treatment, one of the following methods should be employed.

(c). **Intermaxillary fixation and immobilisation of mandibular fractures by means of dental splints:** Various forms of dental splints have been devised, some swaged, some cast metal, whilst others have been of a vulcanite or an acrylic nature. The use of dental splints requires an accurate impression to be taken, model made, and then the splint technically constructed. Accordingly, they have one big disadvantage, namely the taking of an accurate impression if marked muscular trismus is
present, or when there is associated injury to the lips and soft tissues of the jaws. Fixation by means of dental splints is, however, the method of choice when teeth are present in one or all of the fragments. Although direct wiring and arch wiring are valuable methods under emergency conditions, cap splints - as they are called - afford a more satisfactory and stable means of effecting the immobilisation of the fracture. This is achieved by virtue of the absolute immobility of properly constructed and affixed splints, and the fact that the whole crown of the tooth may be enclosed within the cap splint. Bucco-lingual rotation about a vertical axis is therefore less liable to occur. One of the disadvantages of a cap splint, which covers the entire crown of a tooth, is that between the articulating surfaces of the teeth two thicknesses of splint metal and two layers of cementing medium are interposed. This will invariably result in some slight error of the articulation upon removal of the splints. Today, the use of open cap splints is advocated. Such splints do not possess any occlusal surfaces and therefore the teeth may be brought into direct apposition. This would eliminate errors of final articulation, but must result in a weaker splint and one which is more easily dislodged due to the reduced surface area available for the cementing medium. Thus, in their construction, they must be light and strong. They should provide a maximum area available for cementation, made to fit the necks of the teeth accurately, also gripping them around the constriction at their neck. They must also be contoured in
In relation to the gingival margin to maintain the gingiva in as healthy a condition as possible.

The use of dental splints is particularly indicated in the treatment of fractures of the jaws of children. Other forms of intermaxillary fixation, as the use of direct wiring or arch wire splints is contra-indicated, due to the shape of the deciduous teeth, their progressive resorption, and their lack of strength. Extra oral pin fixation methods in children are also contra-indicated, because of the possible damage to the permanent tooth follicles. The young injured child is frequently very apprehensive, therefore it should always be the aim in the treatment of children to use as simple a technique as possible with the minimum number of sessions. So instead of cast metal splints, acrylic splints of a similar design are used widely for the treatment of fractures of the jaws in children.

MacLennan maintains that "in the child, the soft nature of the developing bone predisposes to the greenstick type of fracture, and that the fracture lines involving the body of the mandible tend to be long and oblique, running from the upper border of the mandible, downwards and forwards. This is in contra distinction to the more common line of fracture in the adult, which runs downwards and backwards. The fracture line frequently involves the permanent tooth follicles, but it is seldom found necessary to remove these."

In these cases, he recommends the use of a simple Gunning type dental splint in acrylic resin lined with gutta percha applied to the teeth. This
fixation is simple, rigid, not easily disturbed, and facilitates the maintenance of good oral hygiene whilst the splint is in place. In cases of complicated mandibular fractures of children with displacement, however, accessory immobilisation would be necessary. Most established methods may be used, but lack of a sufficient number of teeth to give a bite control can present difficulties. It may be necessary to resort to circumferential wiring in association with the acrylic splints, to obtain total immobilisation of the fracture fragments.

The use of dental splints in the treatment of fractures of the jaws of children is opposed to the beliefs of many of the profession, including (32) Cohen, who believes in an orthodontic technique for the reduction and immobilisation of the fracture. They maintain that the importance of an orthodontic technique in the immobilisation of such a fracture in the young, lies in its ease of reduction of the fragments with the minimum damage to the existing occlusion.

Dental splints in the young or the adult patient can, therefore, provide excellent immobilisation of a fracture for as long as required without any serious loosening of the teeth, pain, or damage to the parodontal structures. They are especially useful where few teeth are present, where the treatment is going to be prolonged, and where extensions for the control of an edentulous posterior fragment are required. Dental splints require minimum attention after cementation. Thus
the patient may be sent home, periodically called and treated as a clinic outpatient.
If these splints are properly made, gingivitis is nil, and the small amount of loosening of the teeth, which can be noticed after their removal, rapidly disappears with the restoration of function. In effect, their only disadvantage is the mechanical laboratory procedure necessary for their construction. Dental splints overcome the inherent faults of direct wiring methods where the teeth become progressively loose, painful, and where the paradontal structures may suffer permanent damage. Again, wiring methods do not allow the ready control of an edentulous posterior mandibular fragment. Accordingly, dental splints are indicated to provide a means for the inter-maxillary fixation of fracture fragments where:
1. Adequate teeth are present.
2. The injuries are severe.
3. The displacement is pronounced.
4. For those cases which are going to take more than a few weeks to heal.

Types of dental splints used in the intermaxillary fixation of the jaws:

1. The simple cast metal splint:
This splint is only suitable where there is no displacement of the fracture fragments. If the fragments are movable, then impressions should be taken of the teeth in each fragment, and a sectional cast splint constructed. The open ferrule type of cast metal splint is today employed. This leaves the occlusal surfaces of the teeth uncovered with metal,
so that during treatment the occlusion may be examined at any time for a discrepancy.

A single overall impression of the mandibular teeth is taken and the model thus obtained, divided at the site of fracture. The two halves of the model are then occluded with the model of the intact maxillae and articulated in this position. A single cast splint incorporating all the teeth is then constructed, and, after the fracture has been manually reduced, the splint is forced into position and held until the cementing medium has set hard. This method may give rise to considerable errors in the position of the fragments due to:

1. The difficulty of performing this manoeuvre.
2. Movement of the fragments during the setting of the cement.
3. The unequal thickness of the cement itself.

These are really prearranged assembled cast splints, but here a single overall impression is taken of the mandible.

2. The pre-arranged cast metal splint:

This splint may be made by taking individual impressions of the fracture fragments, pouring models and assembling these against an occluding model of the maxillae. These splints are again cast in one piece and cemented into position by forcible reduction. Here, again, these types of splints have been recommended where the displacement of the fracture fragments is but slight. The modern trend, however, is the individual splint technique for each fracture fragment, the latter movement of the constructed splint sections
being achieved by means of locking plates, and connecting bars, following the proper reduction of the fragments. This trend is due to the fact that the use of the single cast splint must lead to inaccuracies:

Firstly, correct articulation can be difficult between models if there are few teeth.

Secondly, because the displacement of the fragments has to be reduced in a short time and held in this position whilst the cement is hardening.

Thirdly, because such rapid reduction must occasion pain and would usually require the use of an anaesthetic.

3. **Separate or Sectional Cast Metal Splints:**

These splints have proved themselves to be accurate and reliable in mandibular fracture fixation and immobilisation. Separate cast splints are here constructed for each fragment and another for the opposing jaw. Hooks are arranged both on the upper and lower splints opposite to each other, or in any position which may be desired, for the later reduction and fixation of the fragments. These separate cast metal splints are then cemented into position. Reduction of the fragments may then be undertaken by means of intermaxillary elastics attached to the hooks provided. After the reduction of the fragments, the horizontal and intermaxillary fixation of the fracture is obtained by tight wiring between the preplaced hooks, the opposing sound jaw acting as a splint with the teeth articulated in centric occlusion.

A convenient refinement of this sectional type of cast metal splint is found in the screw/bar method. This is
sometimes used, as it gives improved immobilisation of the fragments and, if desired, earlier freedom of function for the mandible. In this case, the sectional splints are made with tags added, which are drilled to receive screws through a separate localising plate. This allows the separate splints to be converted into a rigid single cast splint after the reduction of the fracture.

Many modifications of these cast dental splints have been presented, all with their particular merits. One of the best of these is the Precision Lock Appliance, which will give a more secure fixation in the immobilisation of the lower to the upper jaw than the use of intermaxillary wires. The construction of the precision lock is similar to that used for the screw connecting bar of sectional splints, but in this case the lock is between the upper and lower splints. These locks are constructed after the splints have been cemented into position and one of the localising connecting bar plates should have a pin register with a tag, to prevent any later possibility of movement. The use of a precision lock, in association with sectional splints, is particularly indicated where we have an edentulous posterior fragment, and the anterior fragment is being used to control the displacement of the posterior fragment. It would also be useful where the bite is found to be abnormal, as in an inferior retraction, for in these cases the tension of intermaxillary wires would tend to pull the teeth out of occlusion.

The fixation of the edentulous mandibular posterior fragment by means of cast metal dental splints:
A mandibular edentulous posterior fracture fragment will occur where the line of the fracture is posterior
to the last existing tooth in the dental arch. Due to the powerful action of the elevator muscles, considerable displacement of the posterior fragment is usual, which presents difficulties, both in the reduction and the fixation of this fragment. This fragment may be controlled, either by the use of dental plates alone, or in association with circumferential wiring, transosseous wiring, or the skeletal fixation of fragments.

The cast metal dental splint is fitted with an extension saddle, lined with gutta percha or impression compound, which extends over the tooth bearing area, and the lingual surface of the posterior fragment. The amount of the tooth bearing surface of the saddle will be an important consideration for the degree of control of the mobility of the posterior fragment.

In cases of simple fractures which are uninfected, and where the fragments are relatively immovable, a lesser area will suffice than for an infected mobile fracture, where perhaps a tooth bearing surface the equivalent of two molars would be necessary for adequate control. Dental splints alone would, therefore, not serve, where the fracture was posterior to the angle of the mandible, but they would have varying degrees of use in conjunction with other methods of control, again dependant on the extent of the tooth bearing surface of the posterior saddle.

For the edentulous or partly edentulous mandible, dental splints can be used to provide the immobilisation of the mandible, which is their vital role, whilst the fracture itself, in cases where there is a considerable displacement of the posterior fragment, would be best suited to the fixation methods of transosseous wiring or skeletal fixation.
Intra-oral dental splints may also be combined with circumferential wiring for the fixation of mandibular fractures:

This method consists of placing circumferential wires around the body of the mandible, and over a dental splint on the alveolar ridge. It may be indicated in cases of comminuted mandibular fractures, or again in the edentulous parts of the mandible, especially where the jaw has been split into longitudinal fragments. It may be indicated also where there are fractures with fragments at the inferior border of the jaw, which may be held in position by wires about the fragment and over a dental splint. This combination of methods can be of particular use in the control of an edentulous posterior mandibular fragment, and also in the edentulous or partially edentulous patient with single or multiple fractures of the horizontal ramus.

In its application, dental splints are constructed with extension saddles over any edentulous area of the mandible. Twenty five gauge stainless steel wire is then inserted about the body of the mandible, usually with the aid of a hypodermic needle whose lumen is sufficient to hold the wire. The needle is bent to follow the curvature of the jaw, and it is inserted first lingually and then buccally, and the wire is brought and tied firmly over the dental splint. Strict asepsis must be observed and local anaesthesia, such as a mandibular block injection, may be used. Circumferential wires are left in place until the fracture has healed. They may then be removed by cutting the wire in the buccal sulcus where it passes over the tissue and the denture. With single fractures of the horizontal ramus, a wire should be inserted on each side of the line of fracture and a further wire may be considered necessary to be placed on the opposite
side of the jaw to prevent the dental splint from tilting. It is also a good procedure to place a groove in the dental splint to receive the circumferential wire, to eliminate any slipping of the wire. In double mandibular fractures, a pair of wires on each side is recommended. They secure the posterior fragment in good position, whilst at times a wire also placed around the mandibular symphysis will pull an anterior fragment forward and aid in immobilisation. It should be noted that circumferential wiring without an associated dental splint may be used to advantage for the fixation of segments in comminuted mandibular fractures, again where the fragments are in a longitudinal direction. In edentulous segments of the mandible the wire is drawn into the mouth through an incision in the alveolar mucosa. This consists of a longitudinal incision in the mucosa on the side of the alveolar ridge, and two further incisions perpendicular to it at each end. A mucoperiosteal flap is detached from the bone on the buccal and lingual sides, the wire is then inserted, twisted tightly and turned down onto the bone. The flaps are then replaced and sutured. If teeth are present, however, the wire may be drawn through an interdental space or it may be passed over a tooth if good occlusal contact is made, so that the wire will not slip between their occlusal surfaces. This means of fracture fixation would not allow the immobilisation of the mandible other than with the use of direct or arch wiring methods. Again, it should be stressed that the circumferential wiring of fractures involves a surgical technique. Thus the surfaces of all the related tissues should be painted with a good surface antiseptic such as "Zephran", in conjunction with a full aseptic operative technique.
4. Acrylic Resin Dental Splints:

These splints were mainly introduced during and just after the Second World War, when metal for a cast splint was unavailable. They have a few advantages over cast metal splints, the foremost being the speed and simplicity with which acrylic splints can be constructed. The use of these types of splints does not change the accepted standard of impression taking, waxing, or the method of fixation employed. The various attachments and fittings which are used in construction of metal splints may be embedded in the wax pattern before processing. Acrylic splints have been found to be of adequate strength for fracture fixation, but their tendency to spring must be watched, and during cementation pressure must be maintained until the cement has fully hardened. If this is not carried out the resilience of the material may drag the splint from the teeth. However, this resilience of acrylic resin splints can also be used to advantage. It may allow a surgeon to spring a splint into place. Cementation failures are rare. Thus, in those cases where a splint is urgently required the adaptability, ease, and speed of processing acrylic resin splints can make possible the construction of an efficient splint without delay, and without special laboratory facilities and equipment.

Acrylic dental splints are widely used in the management of fractures of the jaws of:

1. Children - this has been discussed earlier.

2. For the fixation and immobilization of fractures of the jaws in edentulous cases, by means of a Gunning type splint, either alone or in association with other methods of mandibular fracture fixation.
At this stage it is appropriate to consider the management of:

Fracture of the edentulous mandible:

In many cases the fracture is simple in character, and displacement often minimal due to the intact perios- teum and the mucous membrane of the mouth acting as a splint. On the other hand, if the fracture is compounded into the mouth, particularly in association with a fracture at the angle of the mandible with a horizontally unfavourable line, the displacement of the fragments may be considerable. The upward movement of the posterior fragment is increased owing to the absence of any teeth or alveolar bone, which might limit any further upward displacement. The reduced cross-sectional area of an atrophic edentulous mandible provides a smaller area of bone to bone contact. The diminished metabolic and cellular activity of the elderly patient necessitates a longer period of immobilisation in many cases. The methods of fixation for fractures of the edentulous mandible are:

1. The use of Gunning dental splints combined with occluso-mandibular fixation.
2. Interosseous wiring fixation of the fragments.
4. A combination of any two, or all, of the above methods.

In this section we will deal only with the fixation methods utilising Gunning dental splints. The other methods will be discussed under their appropriate headings.

In the edentulous mandible there is no natural occlusion, therefore the accuracy of reduction of any displacement of the fragments present is not so vital. As long
as the fracture reduction is sufficient to prevent:

1. Facial deformity.

2. Delayed or non-union of the fragments.

Then the final occlusion may be accommodated in the construction of new dentures. Except in an aged or debilitated patient, fractures of the edentulous mandible are found to unite readily. This is due to the tough muco-periosteum covering, the mandible acting as a splint, and the lack of foci of infection consequent upon the absence of teeth. Thus the reduction and fixation of fractures in the edentulous should be effected without delay. The position of reduction of these fractures is that of normal occlusion.

In cases of double mandibular fracture near the angles of the mandible, this position of normal occlusion is quite arbitrary, and so in the selection of the position of fixation of the fragments the satisfactory construction of future dentures is the main consideration. One must also keep in mind that if the edentulous mandible is fixed in an open, or a closed, bite position, then a retruded, or protruded, chin respectively may result.

In the construction of a Gunning dental splint, impressions of the upper and lower ridges are taken and acrylic resin bite blocks made to the correct functional position of the completed dentures. These bite blocks are then wired together and an aperture is usually left on the bite rims in the front of the mouth to allow for feeding. These acrylic bite blocks may be made in one piece, or it may be found easier to construct and insert them into the mouth in two sections, later wiring them together in the pre-
molar and molar region. In some cases, the patient's own dentures may be effectively used if unbroken by the injury. These can be fixed together by wires placed through holes drilled in each denture in the premolar region. This Gunning type of dental splint is usually supported by a tight rubber bandage under the chin to a headcap. This provides anchorage, bracing the mandible to the cranial superstructure, and so providing cranio-mandibular fixation of the fracture fragment.

The use of a Gunning dental splint is indicated in:

1. Fractures of the edentulous mandible and maxillae, which do not exhibit displacement requiring reduction.

2. Fractures that are not grossly infected.

3. Multiple fractures in the edentulous.

This method of treatment alone cannot be very effective in the control of vertical displacement, and it is totally ineffective in controlling horizontal displacement of fragments. It would not be indicated, also, for the treatment of bilateral mandibular angular fractures exhibiting much displacement. Because of these facts, Gunning denture splints should be used in conjunction with circumferential wiring to prevent horizontal displacement of the fragments. If there is a marked displacement of a distal fragment, the use of transosseous wiring or skeletal fixation methods should be used in association with Gunning splints.

The use of Gunning splints, together with circumferential wiring, is a universally suitable procedure for the average case of unilateral or bilateral fracture of the edentulous mandible.
Optimal control of the fragments is achieved when the fracture occurs in the anterior part of the mandible, since the insertion of circumferential wires distal to the first molar region is technically difficult and could even sever the facial vessels. This method does not adequately control fractures occurring distal to the normal denture bearing area of the mandible, and, although the jaws may be immobilised, the stability of the posterior fragment may be far from satisfactory. Gunning type splints secured by circumferential wires are also of little use where a medial or a posterior displacement has occurred. Again, this technique would be totally unsuitable for cases exhibiting gunshot or lacerated wounds involving extensive soft tissue and bone loss.

III. Transosseous Wiring Fixation or the Internal Wiring Fixation of Mandibular Fractures:

The circumferential wiring of fracture fragments is really an internal wiring fixation method, but as a rule it is carried out without surgical incision. The term transosseous wiring implies the direct wiring of fracture fragments combined with open reduction by surgical approach. There has been much difference of opinion concerning the value of this method. In their text, Blair and Ivy state:

"The fixation by wiring or plating of bone fragments should never be attempted in recent fractures which communicate with the mouth. The fragments cannot be sufficiently immobilised by this method, and the wires or plates through mobility or infection nearly always work loose before union of the bone has taken place."
Burch, on the other hand, maintains that nearly all closed methods of reduction and stabilisation of displaced posterior fracture fragments are comparative failures. He advocates the open reduction of the fracture combined with transosseous wiring of the fragments as the method of choice which will give superior results in function and facial symmetry. He stresses that these results far outweigh the objection of an external incision, and he believes that the optimal time for the open reduction of a mandibular fracture is immediately after initial oedema or haematoma has entirely resolved.

Here we have two different views presented relative to the merits of transosseous wiring fixation methods, involving the open reduction of the fracture. Today, however, with the advent of anti-biotic therapy and care of procedure, it is most commonly favoured, superseding even methods of skeletal fixation. In conjunction with appropriate anti-biotic therapy, it can be indicated particularly in the following conditions of fracture:

1. At the angle of the mandible.
2. In edentulous parts of the mandibular horizontal ramus.
3. In bilateral fractures of the mandible which are notoriously unstable, particularly in atrophic cases.
4. Fractures of the ascending ramus, especially if used in conjunction with circumferential wiring methods.
5. In fractures of the mandibular coronoid process. The transosseous wiring of the fragments can be of value in this region to prevent displacement of the bone due to contraction of the temporal muscle.
The use of wire sutures allows accurate reduction, fixation, and the control of fragments that would otherwise be most difficult to manage.

Irby stresses three common errors which are frequently encountered when open reduction and transosseous wiring of fragments are employed:

1. Failure to occlude and fix the teeth of the two dental arches in their normal relationship before an edentulous posterior fragment is positioned and secured to the anterior fragment or the body of the mandible.

2. The use of only one transosseous wire in an attempt to immobilise a fracture.

3. Failure to place the external skin incision in the shadow below the angle of the mandible.

This emphasises that transosseous wiring is not sufficient in itself for proper immobilisation of the fragments, but that it should always be used with a complementary method of fixation, such as intermaxillary wiring in conjunction with dental splints. The internal wiring fixation gives the detail of reduction of the fragments. In effect, fractures involving the regions of the angle of the jaw and the ramus of the mandible—where considerable tension due to muscle action is exerted—would indicate the use of transosseous wiring of the fragments, combined with complementary stabilisation and immobilisation of the mandible. This would be so with all unfavourable fracture lines in either the vertical or horizontal planes.

With the use of transosseous wiring in association with open reduction of the fracture, a note of warning has been sounded by Moorman. In fractures of the mandible
involving the inferior dental canal, care must be taken to correct the displacement of fragments and to re-align the canal. This is particularly emphasised, as otherwise pressure of the bone fragments on the inferior dental nerve is quite likely to be followed by permanent anaesthesia of the related area.

The use of transosseous wires is particularly indicated in fractures of the edentulous mandible, firstly where considerable alveolar resorption has occurred, which would make the insertion and retention of stainless steel pins a difficult problem and secondly, where there is a considerable overlap or displacement of the bone fragments, which remain unstable, following the reduction of the fracture. Again, fractures of the edentulous mandible, which are compounded externally through a skin wound suitable for primary closure, may be treated by this method since direct access to the bone is already present. Fractures compounded intra-orally, however, present a definite risk of infection from the non-sterile oral cavity finding its way down to the fracture site, delaying union of the fracture and possibly causing sequestration of the bone. This risk may be accepted, however, if appropriate antibiotic therapy is administered early.

The Operative Technique of Open Reduction and Transosseous Wiring of Mandibular Fracture Fragments:

This technique is carried out with full surgical asepsis, and it is usually performed under general anaesthesia. Stainless steel wire which need not be removed is inserted into the tissues. Absorption of bone about these wires resulting in osteomyelitis of the jaw has been recorded, but this is mainly due to either infection being introduced, or improper immobilisation,
allowing movement of the fragment. In other words - a faulty technique. The operative field should be well isolated with sterile pads, and swabbed with a good surface antiseptic. For exposure of the bone fragment via an extra-oral approach, the incision through the platysma muscle and deep fascia, in order to avoid the mandibular branch of the facial nerve, should not be placed higher than a finger breadth below the lower border of the mandible. In planning the skin incision, advantage should be taken of natural skin creases where possible. Incisions at the angle of the mandible should never extend upwards beyond a point one finger breadth below the lobe of the ear to eliminate risk of damaging the main trunk of the facial nerve.

For wiring after exposure of the fragments, a hole is drilled in each fragment near the inferior border so as to avoid injury to the mandibular vessels and nerves. A stainless steel wire, 24 gauge, is then drawn through the two holes. The wire is passed into the first hole from the outer aspect of the bone, and it is returned by the aid of a second wire bent upon itself, into which the first wire is inserted, after it is introduced into the second hole. Drawing the double wire back brings the first wire to the surface of the second fragment. When the fracture is properly reduced, the wire is twisted tightly to bring about osseous union of the fragments.

If the transosseous wiring of fragments is carried out in the region of the angle of the mandible, one must choose the site of the drill holes in the bone very carefully, because in oblique fractures in this area
METHODS OF TRANSOSSEOUS WIRING FIXATION.

1. HORIZONTAL TRANSOSSEOUS WIRING.

2. VERTICAL TRANSOSSEOUS WIRING.

3. HORIZONTAL AND VERTICAL TRANSOSSEOUS WIRING.

4. A. ONE TRANSIRCUMFERENCEAL WIRE SUTURE
   B. TWO TRANSIRCUMFERENCEAL WIRES; LONG OBLIQUE FRACTURE LINE
muscular pull will tend to over-ride the fragments causing a slackening of the wire. Such displacement of the bone fragment can be prevented by so placing the drill holes in the fragments that the final fixation by the transosseous wire will be almost vertical in plane. For fractures in this region, it is good procedure to use both horizontal and vertical transosseous wiring fixation across an oblique fracture line.

Another useful modification, is a transcircumferential method of transosseous wiring of fracture fragments. This is especially designed for cases presenting oblique fracture lines. The fracture is reduced by means of bone forceps, and whilst held in the reduced position, one or two holes are drilled through the two fragments. If the overlapping of the fragments is short, one suture wire is used; if long, two wire sutures are inserted through these holes. The wires are passed around the inferior border of the mandible and, after being tightened, are cut short and the end is bent over.

For fractures further forward in the horizontal ramus, a similar incision is made 1 cm. below the inferior border of the mandible, but more anteriorly. In these cases one must locate the external maxillary artery and vein. These vessels need not necessarily be tied; they may be retracted to expose the fracture and then protected with an instrument while the holes are drilled in the fragments. After the reduction and transosseous wiring of the fragments are completed, the subcutaneous tissues are closed with catgut, and the skin by interrupted sutures.
Imobilisation of the mandible must be secured in all cases of transosseous wiring fixation of fragments. If sufficient teeth are present, intermaxillary fixation is ideal. If the patient is edentulous, a Guining splint may be used with an elastic Barton bandage, or some other method of cranio-mandibular fixation employed.

Bradley and Hildreth maintain that the intra-oral open reduction of fractures in the third molar region of the mandible in selected patients has many advantages over the external skin approach. Oral surgeons feel more at home dealing with intra-oral structures, whilst the extra-oral method of open reduction may result in an external scar and possible contamination of an already compound injury. Thus, they advocate the intra-oral open reduction and transosseous wiring of the fragments, with appropriate anti-biotic therapy, combined with the immobilisation of the mandible. Using this method, arch wires are first placed on the upper and lower teeth in readiness for the intermaxillary immobilisation of the mandible. An incision is then made in the mandibular retra-molar region, about 1 cm. distal to a displaced tooth, and the incision extending distal to the region of the second bicuspid. The muco-periosteum is reflected and retracted to expose the fracture site and any displaced tooth removed. A hole is then drilled in each mandibular fragment about 0.5 cms. from the alveolar crest, and a 0.2 inch stainless steel wire is then threaded from one fragment to the other. The displaced fragment is then reduced and impacted if possible. A special U-shaped instrument, adapted to the anterior border of the ramus, is helpful in applying backward and downward pressure on the distal fragment to overcome the pull of the elevator muscle.
The fracture is then immobilised by twisting the transosseous wire across the line of the fracture. Elastic traction is then applied to the previously placed arch bars, providing immobilisation of the mandible, and the muco-periosteal flap replaced and sutured.

Under similar conditions in which transosseous wiring is used, bone plates may also be employed for the internal fixation of fracture fragments. These plates are small metacarpal or Sherman plates. They are attached through an external incision after the exposure and proper reduction of the fracture. These Sherman plates are made of vitallium or stainless steel and the accessory screws must be of the same material. Four screws should be used, two in each fragment, for the adequate fixation of the fragments. These plates are well tolerated by the tissues, and, similar to transosseous wires, they do not need to be removed later unless they worry the patient. These bone plates will give a more secure and rigid fixation of the fragments. Wiring methods mainly prevent distraction, often allowing over-riding of the fragments. The use of these plates will eliminate over-riding as well as the vertical displacement of the fragments. The use of bone plates will also maintain a space between fragments, if bone has been lost, so they are especially useful in:

1. The treatment of complicated fractures, where bone has been lost, due to osteomyelitis.
2. In the treatment of cases presenting mal and non-union of fragments.
The fragments may be anatomically aligned by means of these bone plates, and the space between them filled with bone chips for bone grafting. Once again, these bone plates should not be relied upon for the total immobilization of a fracture. Complementary means of mandibular immobilization should always be used in conjunction with any form of internal fixation of fracture fragments.

These transosseous wires and bone plates are, as previously stated, usually regarded as permanent features. (39) Gibson and Allen maintain, however, that although buried metal may be biochemically inert, it still suffers from the defects inherent in any foreign body, and that infection may develop spontaneously or following minor trauma and once established it will not subside until the metal is removed. To overcome this, they devised a wire suture that can be easily removed at any time without recourse to further operation. They used two varieties of wire:

1. Hard stainless steel wire 0.8 mm. in diameter cut in 6 inch lengths and sharpened at one end.

2. A malleable stainless steel ligature wire 0.35 mm. in diameter. This latter wire is first cut in 12 inch lengths, each of which is folded upon itself and twisted in the lathe to form an eyelet large enough to accommodate the first wire.

Two eyelets and one length of hard wire are required for each fracture.

These wires are used in cases of mandibular fracture. The fracture site is exposed through a submandibular incision. The fracture is reduced and the fragments
As the eyelets pass through the bone they diverge (centre illustration) and incline slightly forwards (bottom illustration) and the eyelets pass through holes near the lower border of the mandible and close to the fracture line (top illustration). This angulation permits easy withdrawal and the wires projecting from the skin are unobtrusive and the wounds heal rapidly after their withdrawal.
impacted. Holes are drilled in each fragment with a 5/64" drill, each hole beginning as near the lower border and as close to the fracture as possible. The drill is angled so that it passes slightly upwards and away from the fracture line. When the fracture is oblique in the vertical plane, the drill holes must be so situated that a line drawn between them crosses the fracture line at right angles. If this is not so, the fragments tend to be pulled out of alignment when the wires are tightened. One of the prepared eyelets is passed through each hole from without, inwards. The sharpened end of the hard wire is pressed through the skin just behind the angle of the mandible, so that the wire comes to be on the lingual aspect of the bone. It is then passed through each eyelet in turn and projects beyond them an inch or so. After the correct reduction of the fracture, the eyelet wires are twisted tightly and the wound closed in the usual manner, the twisted ends of the eyelets being brought out through a separate stab wound below the main incision. Complimentary intermaxillary fixation is used by whichever method is suitable for each case. To remove the suture the hard wire is first withdrawn, the eyelets thus are freed and can be removed. If these have been inserted in divergent fashion, little force is needed to withdraw them and no anaesthetic is required.

This method, using a removable wire suture, would be suitable for the internal fixation of any fracture of the mandible requiring open reduction. It is stressed, however, that these wires should be removed at once, if infection is not controlled by anti-biotic therapy. If they were retained, osteitis and subsequent sequestration may result.
IV. Extra-oral Skeletal Methods of Fixation of Mandibular Fractures:

This form of fracture fixation came to the fore during the years of the Second World War. Roger Anderson was one of the originators, and Clouston and Walker were two of many who further developed this method of fracture fixation. The skeletal fixation of mandibular fractures was used a great deal for a period after the war. Today, there seems to be less enthusiasm for this method. In cases where transosseous wiring can be used, that is preferred. However, with the transosseous wiring of fragments another form of mandibular fixation has to be used in association with it. With its many advantages, I would prefer the skeletal pin fixation. Amongst its disadvantages are the following:

1. It allows early and prompt reduction of the fracture.

2. It allows moderate function, which provides for better nourishment for the patient, and the elimination of a liquid diet.

3. It favours healing, as we know that the use of a bone increases the inflowing calcium and counteracts atrophy that occurs from disuse.

4. It facilitates good oral hygiene.

5. It prevents stiffness of the temporo-mandibular joint and the associated muscles, as they are in use.

Gillies also stresses that by this method we may obtain perfect control of the fragments into which the pins are inserted for easy anatomic positioning in the reduction of the fracture.
Skeletal pin fixation of mandibular fractures can be used widely and gives good results with:

1. Single or multiple fractures of edentulous jaws.
2. Displaced, compound, and comminuted fractures.
3. Excellent control of the post-fragment with fractures near the angle of the jaw, posterior to the last existing tooth.
4. Cases where there is a loss of bone due to infection or otherwise.
5. Multiple fractures of the jaws. The mandibular fracture may be fixed by means of skeletal pin fixation and then the intact mandible can be used as a splint for the fractured maxillae.

Fracture fixation by this method, however, is only suitable in the hands of an experienced surgeon. It should only be used where simple conservative methods are inadequate - in other words, it is a deliberate treatment giving excellent results for fixation and immobilisation, especially under the conditions listed above. It is of great importance in the use of external fixation appliances to recognise the anatomical landmarks of the face, in particular the external maxillary artery and vein, the facial nerve, the parotid gland, the apices of the teeth, the mental foramen and the inferior dental canal.

Types of Appliances Used in Skeletal Pin Fixation:

(a). The Roger Anderson pin appliance:

Various forms of this appliance have been made, which permit each pin to be independently fixed without precise reference to its neighbour.
The pins are fixed together by two universal joints and a T-bar. The pins are constructed of polished stainless steel rods, 2 mm. thick, and of varying length. The apparatus as supplied consists of three sets of four pins, i.e. 12 in all; four universal joints for the pins, two universal joints to connect the pairs of pins together, three connecting bars, and two T-bars for holding each pair of pins.

Ideally, these pins are placed at least half an inch from the fracture line and at the lower border of the mandible. These placed in the ascending ramus should be at its posterior border. These pins are drilled into the bone until they are firmly held, and the pins of each pair are driven in at an angle to each other of approximately 60 degrees. With both pairs of pins in position, the T-bars are placed on them and locked by means of universal joints. The fracture is then reduced and the connecting bar tightened to the T-bars by universal joints, thus maintaining the reduction.

The Roger Anderson appliance may be used without intermaxillary fixation of the fracture, but the degree of stability achieved is not very great. It has been shown to be not capable alone of withstanding the force of mastication; also one notes that displacement tends gradually to recur and so healing is delayed. Therefore, intermaxillary fixation, whenever possible, should also be used with this appliance.
It must be borne in mind that the use of this appliance could constitute a path of infection to the bone along the track of the pins. This could cause a localised osteomyelitis and subsequent sequestration. Fortunately, appropriate anti-biotic therapy can be used as a control. Also, the use of these pins is not suitable for the treatment of those cases which will take more than a few weeks to heal as the pins will loosen after a time.

The Roger Anderson appliance, as well as other pin forms of control, have the disadvantage of not being applied easily if swelling of the tissue is present at the site of the injury, whilst if a mobile fragment has only a small available area for attachment and is covered with bulky soft tissue their application is again difficult. Finally, one big disadvantage of any external appliance is its liability to accidental damage.

(b). The Frac-Sure Appliance:

This skeletal appliance is the most adaptable and useful apparatus for the external fixation of mandibular fractures. The Frac-Sure appliance is made up of pins, which are threaded for a short distance, and single and double fixation clamps. The single clamp is used to attach a short rod to each pair of pins; the double to connect the fixation rods to the pin rods for the fixation of the fracture. These fixation rods are of various lengths. The pins may be inserted either under general or local anaesthesia, but with strict asepsis. In most cases
the pins are placed 1 cm. from the inferior border of the mandible. They should be inserted vertical to the bone in a coronal plane, but may be angulated so that each pair converges, one slanting in an anterior direction and the other in a posterior direction. The soft tissues are pierced and the holes drilled. The first pin of each pair is placed nearest the fracture line, the second about 2 cm. from the first pin. The drill used is a hand drill and it is important that a slow speed be used, so that the bone will not be heated by excessive friction. The outer cortex is penetrated, then the spongiosa, and the drill is then forced into the second cortex of the lingual plate but not through it. After all four pins are inserted, and any additional pins if necessary in cases of multiple fracture, a small fixation rod is attached to these pins in each fragment by means of a fixation rod clamp.

A connecting rod of sufficient length is then selected and attached to each small rod by means of a double clamp. The fracture is then reduced by the surgeon and normal occlusion of the teeth restored, after which an assistant locks the double clamps with a wrench. It is desirable to immobilise the mandible for a few days by means of a bandage as a further precaution to ensure the perfect immobilisation of the fracture. With this apparatus the patient feels very comfortable. A certain amount of seepage normally occurs, and it is allowed to crust. The normal time of healing is about five to six weeks. If
care is exercised, infection should not occur.
Some operators blame this method for introduc-
ing organisms into the tissues, but this is usually
due to a faulty technique. The so-called aseptic
necrosis of bone is usually found to be caused by
undue pressure on the pins, faulty pin insertion
(making a drill hole too large and thus causing
wobbling of the pins), and lastly the overheating
of the bone whilst drilling.

The Frac-Sure appliance may be used for all kinds
of fractures and fracture combinations. It is
extremely adaptable by varying the position of the
pins. In cases of bilateral oblique fracture in
the anterior part of the mandible, the ends of the
two fixation rods may be attached with double fix-
ation clamps to the end of a small rod bent to pass
round the chin for greater stability in immobili-
ation. A further use of this appliance is in cases
of multiple mandibular fracture, where the mandible
must be immobilised, because of a fracture in the
condylar region, but in which intermaxillary fix-
ation cannot be used because the lower jaw is
edentulous or partly so. Immobilisation of the
mandible can then be accomplished by inserting a
pin into each malar bone and fixing this pin with
two connecting rods to a Frac-Sure appliance
attached to each side of the mandible for the fix-
ation of the mandibular fracture, thus immobilising
the mandible against the maxilla by malar mandibular
fixation.

Another similar appliance is:

(c). The Haynes-Griffin Appliance:
This appliance is not as adaptable as the Frac-
Sure appliance, and it cannot be used as easily
in cases of multiple fractures. Several units of this appliance may be united, but this has to be done with contoured 11 gauge wire, which makes accurate fixation difficult. The appliance has given satisfactory results in cases of single fracture of the mandible, except where converging pins are necessary. With this appliance, the pins must be inserted at a specified distance from each other, and parallel to each other, otherwise the assembling block will not fit.

Other skeletal appliances, such as the "Clouston-Walker", are similar but with various modifications.

The use of a Bone Clamp in place of a pair of skeletal pins can, at times, offer definite advantages. Thomas describes a peripheral bone clamp, which may be applied to fractures at the angle of the mandible because in this region the bone is generally too thin to hold pins that are screwed into position. In the ramus of the mandible, pins are also frequently disturbed by pressure exerted on the appliance, while the patient is sleeping. In fractures at the angle of the mandible, the bone clamps should be attached to the posterior fragment, while pins may be used in the horizontal ramus. Although these types of fractures, may be treated by means of transossseous wiring, clamp fixation in association with skeletal rods and universal joints, is recommended for cases in which there are no teeth, or an insufficient number of teeth present, or in cases in which intermaxillary fixation
is impossible for some other reason — that reason being the presence of intra-oral wounds that require treatment. In this location, the peripheral bone clamp is inserted through an external skin incision below the inferior border of the jaw. The clamp is then fitted about the inferior border of the mandible and correctly positioned against the lingual plate of bone. A stab incision is made in the soft tissues on the lateral aspect of the mandible and an attached screw admitted, the clamp then being made fast to the bone by tightening, as in a vice principle. When the reduction is complete, the fracture is immobilised by means of fixation rods attached to the pins and the clamp. The use of a bone clamp in this region would give a greater area of attachment than the use of pins, and correspondingly greater stability and rigidity in the immobilisation of the fracture. It fits snugly and may be likened to a saddle over the bony tissue.

Upon the subsequent healing of the fracture, before removing these skeletal appliances, the skin around the pins should be thoroughly cleaned and washed with alcohol and then painted with tincture of Zephiran or Metaphen. Protection against secondary infection may be obtained by anti-biotic therapy. The pins are unscrewed with a hand drill, which is generally a painless procedure even though they are still held tightly in the bone. In some cases a local anaesthetics may be employed. The incisions which
were made for inserting the screws heal rapidly and leave no noticeable scar. If there is a tendency for the skin to pucker, the margins of the incision may be coapted by means of a Dermalon suture. This is seldom necessary.

Enumerating the features considered to be predominant for successful therapy in the use of these extra-oral skeletal appliances for fixation of mandibular fractures, we should keep in mind the following golden rules:

1. The most rigid rules of asepsis should be adhered to when inserting the pins.

2. The site of the fracture should be carefully noted before inserting the pins so that they will not be placed too close to the fracture line or in any part of the jaw involved by infection.

3. Care must be taken that the pins do not injure important structures, such as arteries, nerves, or teeth.

4. Care must be exercised that no heat is generated when drilling the pin holes.

5. The pins must be inserted so that they penetrate both bone cortices and will not move within the bone, causing irritation and inviting infection.

6. The fracture should be carefully reduced after the pins are inserted and the occlusion, if any, should be checked.

7. Immobilisation of the mandible for one or two weeks is desirable.
V. Kirschner Wire Fixation of Mandibular Fractures:
The use of Kirschner wires has been advocated for the transfixation of mandibular fractures as well as for fractures of the middle third of the facial skeleton. However, for lateral fractures of the mandible this method cannot be recommended.

Proper reduction of the fracture is difficult to achieve and often results in poor approximation of the fragments, associated with mal-occlusion. The fact that the wire is apt to enter the mandibular canal producing haemorrhage and laceration of the inferior dental nerve is one disadvantage. The danger of spreading infection from the subapical area of a tooth or from the fracture site into the proximal fragment is another. This method of fracture fixation may have some advantages in cases of oblique fractures in the anterior part of the mandible which involves the mandibular symphysis. For cases of complicated fractures involving the mandibular symphysis, a Kirschner wire for the internal fixation of the fragments, used in conjunction with a form of intermaxillary fixation for the rigid immobilisation of the mandible, has been recommended by Delk and Letterman. They found the use of a Kirschner wire very satisfactory when there is marked displacement, over-riding or comminution of fragments, particularly in the child or the edentulous cases.

A Kirschner wire is inserted at a pre-determined angle by means of a motor driven drill, the wire passing completely through the bone and emerging from stab incisions in the soft tissues. The wire thus transfixes the fracture fragments, and might prevent over-
riding and distraction of the fragments, but it would not tend to prevent the rotation of the fragments. Additional complementary fixation of the fragments, preferably of an intermaxillary nature, is therefore needed.

This method of fixation of fracture fragments lends itself particularly to the transfixation of the mandibular symphysis in edentulous cases, to provide cranio-mandibular immobilisation of the mandible, in order to prevent the occurrence of an open bite deformity when both mandibular condyles have been fractured. A Kirschner wire in this location, attached by rods to a headcap, will immobilise the mandible in a position of functional occlusion for the future construction of dentures.
FRACTURE AND FRACTURE DISLOCATIONS OF THE
MANDIBULAR CONDYLOID PROCESS INCLUDING
SUB-CONDYLAR FRACTURES.

The mandibular condyloid process enables the mandible to be articulated with the cranial bones through the medium of the temporo-mandibular joint. The consideration of traumatic injuries in this location thus demands a detailed knowledge of the surgical anatomy of this joint, in order that condylar fracture and fracture dislocations with any resultant displacement may be fully understood. This knowledge allows a broad classification of traumatic injuries sustained by the mandibular condyle, and upon which treatment can be based.

Related Surgical Anatomy:

The temporo-mandibular joint is a ginglymo-arthrodial joint. The mandible is a suspended bone, and activated by the muscles of mastication. Its motions are varied. The articulation allows a hinge-like rotary motion, a gliding anterior-posterior motion, and a slight amount of vertical motion. By alternate action of the homologous joints, it allows lateral motion and, by a combination of all, circumduction.

Briefly, the temporo-mandibular joint is comprised of the roller-shaped head of the condyle of the mandible, the inter-articular disc known as the meniscus, and the mandibular or glenoid fossa of the temporal bone which extends as far as the petro-squamosal and pterygo-tympanic fissures. The fossa is bounded anteriorly by the eminence articularis and posteriorly by the posterior glenoid tubercle.

There are, however, several important structures between the head of the condyle and the temporal bone, namely a portion of the parotid gland, vessels and nerves surrounded by connective tissue. Behind these structures
lie the bony auditory canal, and, a little further in, the middle ear. These are protected from injury by the condyle, and by the temporo-mandibular ligament, which prevent contact with the thin layer of bone.

The joint capsule is attached to the base of the skull, anteriorly to the eminence articularis of the zygomatic process of the temporal bone, and posteriorly to the posterior glenoid tubercle, reaching as far back as the petro-tympanic fissure. The external part of the capsule forms the temporo-mandibular ligament and is its strongest part. The anterior part of the capsule is thin, whilst the posterior section is strong, the deeper fibres giving firm attachment to the posterior margin of the meniscus. This prevents the latter from gliding too far forward when the condyle slides anteriorly. The medial wall of the capsule is thin and is its weakest part. The capsule is attached not only to the head of the condyle around the articular cartilaginous surface, but also to the meniscus, so that two joint cavities are formed lined by a synovial membrane.

The temporo-mandibular joint also comprises extra articular ligaments, namely:

1. The Temporo-Mandibular Ligament:

   This ligament extends from the zygomatic process of the temporal bone and tapers down to the external and posterior border of the mandibular condyle. It limits posterior dislocation.

2. The Sphen-Mandibular Ligament:

   This is separated from the capsule by loose connective tissue. It is attached on one side to the angular spine of the sphenoid bone, and is inserted at the lingula of the mandible. The internal maxillary artery and the auriculo-temporal nerve pass between this ligament and the joint capsule.
3. **The Style-Mandibular Ligament:**

This extends from the styloid process of the temporal bone to the posterior border of the mandible, where it is attached near the angle of the mandible. The meniscus, or the inter-articular disc, is attached to the capsular ligament at its periphery and at its concave anterior margin, to fibres of the external pterygoid muscle which controls its forward motion. It is thicker posteriorly and divides the joint into two separate cavities lined with a synovial membrane.

The natural opening of the mandible is affected by the action of the external pterygoid muscles. The superior fibres of the upper head of these muscles are attached to the anterior edge of the meniscus to pull it forward, the lower, more powerful head is attached to the neck of the condyle. As these muscles contract, the mandibular condyle heads slide forward to a position beneath the eminence articularis, which causes the sphenomandibular and the style-mandibular ligaments to become taut, preventing a further forward movement of the mid ramus. A further muscular contraction causes the mandible to rotate on an axis through the region of the mandibular foramen, while the jaw is closed. The mandible is, of course, closed by the elevator muscles, the masseter, the temporal and the internal pterygoids.

The occlusion of the teeth plays an important part in the articulation of the mandible. The greater part of the force exerted during mastication is borne by the dentulous part of the jaw, but if the occlusion is changed, as with the loss of the posterior teeth, a great deal of this force is transferred to the joint.
The blood supply to the mandibular condylar area is quite adequate. The condyle receives its blood supply from the internal maxillary artery via the deep auricular artery. The posterior articular artery also gives off branches to the condylar head. A sensory nerve branch, the auriculo-temporal, and the upper part of the parotid plexus of the facial nerve, extend through the field of operation through a pre-auricular incision. It is most important that these nerves are not injured during operation, either by dissecting instrument or the injudicious use of retractors.

Now, with an understanding of the related surgical anatomy, fractures of the mandibular condyloid process, which may extend through the head, neck, or the base of the condyle, can present any of the following features:

1. **Fractures without displacement:**
   These fractures may be of a green stick nature, or complete fractures of the condyle may be present, but in these cases the fragments remain in their anatomical position. The fractures generally occur through the neck of the condyle and therefore are extra-capsular. Occasionally, however, the fracture may divide the condylar head in a sagittal plane involving its articular surface, in which case it is intra-capsular. In cases without displacement of the fragments, conservative treatment may be employed, intermaxillary fixation being ideal.

2. **Fractures with displacement:**
   Condylar displacement may occur in either a medial or a lateral direction. A forward movement may also be apparent due to the action of the external pterygoid muscle.
Condylar Fractures and Fracture Dislocations.

Capsular Fractures.

1. Involving head of condyle only.
2. Involving head and neck of condyle.

Intracapsular Fractures.

1. Fractures with displacement.
   a. Forward.
   b. Medial.
   c. Lateral.
   d. Posterior.

Fracture Dislocations.

a. Intracapsular dislocation.
b. Complete dislocation.
c. Complete dislodgment.
d. Dislocation of part of head of condyle.
3. **Fractures with over-riding of the fragments:**

This type of condylar fracture is common and it is caused by the action of the elevator muscles pulling the mandibular ramus towards the base of the skull. Open reduction and transosseous wiring of the fragments would seem to be indicated in these cases to correct the displacement, and to maintain the correct impaction of the fracture fragments.

4. **Condylar fracture and dislocation:**

(a). The dislocation of the condyle may be in a medial or a lateral direction. Medial dislocation is more common than the lateral dislocation of the mandibular condyle because the external part of the joint capsular ligament is reinforced with the temporo-mandibular ligament. The condition may be an intra-capsular fracture dislocation, or subluxation of the condyle where the capsule is not torn. Again, there may be a complete fracture dislocation present where the joint capsule is torn and the condyle is partly or completely out of the glenoid fossa. If the dislocation is in a medial direction, an empty joint cavity may be felt and the sharp end of the mandibular ramus may be impacted in the auditory canal. If the dislocation is in a lateral direction, the presence of the head of the condyle will produce a marked palpable swelling under the skin in the region of the joint.

(b). There may be fracture dislocation present with a complete dislodgment of the condyle. This is seen in cases where the condyle is pulled forwards and inwards, and may be found below the
mandibular notch. The condyle head usually remains viable due to the attachment of the external pterygoid muscle.

(c). There may be a dislocation of part of the head of the condyle. This may occur in cases where the medial section of the condyle head is fractured and dislocated.

(d). There may be a fracture dislocation in a forward direction where the condyle head may be found anterior or posterior to the eminence articularis, and where the fracture dislocation is generally intra-capsular.

(e). Finally, there may be a fracture dislocation of the condyle head with displacement of the meniscus, which may prevent closure of the jaws.

5. Comminuted and old condylar fractures:
The latter may present a pseudarthrosis or an ankylosis of the joint with associated deformity.

The majority of fractures in the region of the neck of the mandibular condyle are caused by indirect violence such as a fall or a blow on the opposite side of the mandibular symphysis. It is sometimes accompanied by a fracture in this region. The zygomatic arch protects the condylar and coronoid process of the mandible from trauma applied from the lateral aspect. In this type of injury, an associated fracture of the arch may be present in conjunction with a direct fracture of the condyle. MacLennan, in a review of 180 cases of typical fracture of the mandibular condylar process, showed that following injury the relationship of the condylar head and neck to the remainder of the mandible followed along the lines already stated. In many cases,
only a crack fissure was present without a tearing of the periosteum or the joint ligaments, and without a significant alteration of the normal relationship of the condylar head to the glenoid fossa or of the neck of the condyle to the ramus. Where deviation was present there was usually a combination of a medial and anterior angulation of the condylar head. He also pointed out, that where a considerable displacement of the fragment was present, then in most cases the fracture was subcondylar and the obliquely fractured upper fragment lay lateral to the ramus.

Where fracture dislocation was present, the condylar fragment lay in an anterior and a medial position to normal. Thomas maintains that this movement of the condylar fragment may occur from a spasm of trismus of the external pterygoid muscles.

It has also been shown by MacLennan that comminuted condylar fractures are often associated with fracture of the zygomatic arch and the coronoid process of the mandible, and that this type of injury is commonly the result of severe road accidents.

6. **Mandibular sub-condylar fractures:**

These fractures occur in the region of the joint, but are really fractures of the ascending ramus of the mandible. They are generally transverse in nature. It is, however, important to distinguish between subcondylar and condylar fractures because subcondylar fractures cannot be reduced by transosseous wiring of fragments through an incision above the facial nerve. They can only be approached through an incision below the angle of mandible, that is below the level of the facial nerve. Also in cases of subcondylar fractures, the bone is usually not greatly displaced because the line of fracture extends into
the region of muscle insertion, and because of muscle spasm associated with the injury, the fracture tends to reduce itself if the tooth bearing part of the jaw is placed in occlusion. The healing of sub-condylar fractures in a slightly displaced position, is not as serious as in cases of condylar fractures because, owing to the length of the fragment, condylar angulation is never very great. Therefore, the intra-capsular rotation of the condyle, produced by displacement which is generally the cause of the joint discomfort after healing, is minimal. On the other hand, however, where there is a marked forward and a lateral displacement of the condylar fragment with tissue wedged between the fragments, open reduction alone can restore anatomical conditions.

The Signs and Symptoms of Traumatic Injuries of the Temporo-Mandibular Joint:

There is invariably pain present, which is especially pronounced when the mouth is opened and closed. If muscular trismus is present the injury may not be noticed until the swelling has subsided. Other symptoms include difficulty in opening the mouth widely and in the mastication of food. Crepitus may also be produced by friction of the fragments. The occlusion of the teeth is usually affected, the mandible may be protruding and an open bite relationship exist. If fracture has occurred only on one side, then the action of the pterygoid muscle on the normal side, not being balanced by the one on the injured side, causes a deviation of the jaw towards the fractured side. An outstanding sign of condylar fracture and fracture dislocation is the inability to bring the mandible forward, because the external pterygoid muscle is attached to the condylar head and not to the mandibular part of the fractured bone.
The Methods of Treatment of Mandibular Condylar Fracture and Fracture Dislocations:

Treatment must be based upon a thorough examination of the injuries sustained and the subsequent classification of the type of fracture or fracture dislocation present. Adequate radiography of this region is essential and must include lateral views of the ascending rami and posterior-anterior views. From these a careful study should be made, firstly of the condylar fragment and, secondly, a study of the conditions concerning the repositioning and fixation of the main mandibular fragment.

The method of treatment employed will then fall into one of four main categories:

1. Conservative treatment methods.

2. The method of open reduction and transosseous wiring of fragments by means of a pre-auricular incision.

3. Open reduction with transosseous wiring of fragments by means of a sub-mandibular incision.

4. The radical operation of condylectomy.

There is quite a conflict of opinion concerning the method of treatment of fractures of the neck of the mandibular condyle. The treatment ranges from conservative methods, to the total removal of the condyle head (Condylectomy). McGregor and Fordyce, in the conservative treatment of 250 patients showing fracture of the neck of the mandibular condyle, observed that:

"1. Bony union occurred in all cases, whatever the degree of dislocation even where no fixation of fragments was applied.

2. No case of a false joint or a fibrous union was seen.

3. Remodelling of the condylar head occurred to a very considerable degree in children."
4. No patient showed later signs of limitation of the opening of the mandible or interference with normal function."

These men thus maintain that, provided normal occlusion can be obtained and maintained, then there is no necessity for any surgical intervention save, possibly, in ill treated or neglected cases. Also, there is no necessity for the fixation of a fracture of the neck of the mandibular condyle without the presence of other mandibular fractures. MacLennan holds a similar opinion. He maintains that union of a fibrous or osseous type is generally established in this region regardless of the mode of treatment employed, and thus conservative measures should be employed.

These opinions are opposed, however, to the beliefs held by many other prominent men in this field. Berkner states that a near perfect anatomical reduction of a condylar fracture can only be obtained by open reduction and a transosseous wiring of the fragments. He seconds the opinions of such men as Georgiade, Pickrell, Douglas and Altony, who have observed that:

"In cases where the displaced mandibular condyles are out of the glenoid fossa, and in cases where there is marked over-riding of the fragments, that these will inevitably result in the future mal-function of the joint, if only conservative methods are employed."

These views also coincide with those of Thomas, who has attributed the lack of success in the treatment of fracture and fracture dislocations of the condylar head to the lack of adequate co-aptation and fixation of the fragments, combined with the lack of immobilisation of the mandible.
Thus there are essentially two philosophies, either the fracture is permitted to heal without intervention, or it is reduced by open operation. Although major functional disturbances may be rare after conservative treatment, usually a follow up X-ray examination will demonstrate that condylar fractures disturb the whole complex of the temporo-mandibular joint, which theoretically must work havoc with joint function. Its advocates justify their results only by clinical studies, which show a complete compensatory functional adjustment in nearly every case. However, by means of surgical methods developed during recent years, excellent results can be obtained both from an anatomical and a functional point of view, the hazards of these procedures have been minimised or eliminated by appropriate anti-biotic therapy. Cicatricial complications are not inevitable when sound surgical judgment is employed. The accurate alignment of fracture fragments to restore normal anatomical relationship can be the only basis upon which treatment proceeds. Consequently it is considered that conservative treatment in cases of condylar fracture should be used only for those cases with a very favourable prognosis. If there is little displacement of the condylar fragment, and it is in such a position that it will not interfere with function, then conservative treatment by intermaxillary fixation methods may be satisfactory. On the other hand, open reduction of the fracture is considered indicated in the following cases:

1. A unilateral condylar fracture with considerable over-riding of the fragments.

2. Bilateral condylar fractures with over-riding of fragments with resultant open bite relationship, especially if there is no posterior occlusal support.
3. In cases of gross mal-alignment of a condylar fragment, such that it is situated at an angle to the ramus and projecting over it.

4. Any position whereby the condylar fragment causes interference with the movement of the jaw.

5. In all cases of fracture dislocation.

6. In cases of partial or completely healed fractures exhibiting mal-occlusion or abnormal function.

1. The Conservative Treatment of Condylar Fractures:
Conservative treatment is always the method of choice if possible. When it is employed here, it consists of treating the condylar fracture by immobilisation of the mandible. It should be used in all uncomplicated cases and where there is only a slight displacement or over-riding of fragments. Some surgeons believe that, regardless of what deformity is present, the accurate correction of the occlusion, combined with intermaxillary fixation, will give satisfactory results, even in cases of marked displacement of the shorter fragment or where dislocation of the condylar head is present. They believe that no manipulation is needed as long as the fragments are in close apposition. I do not belong to this school of thought, but consider that a rotated or a poorly positioned condyle may function, but it will not allow the complicated motions that are possible under normal conditions. It may bring about later the conditions of an open incisor bite and traumatic arthritis.

Accordingly, in cases of condylar fracture without displacement of the fragments or the presence of an open bite relationship, treatment by means of the intermaxillary immobilisation of the mandible is deemed adequate.
If only a slight open bite relationship exists, this method of treatment would still be possible, but traction is needed to correct the over-riding of the fragments, which is due to the spasm of the elevator muscles. This traction may be applied by the use of wedges placed between the jaws as far back as possible, and traction applied in the incisor region. It is to be understood, however, that there is a limit to this downward pull of the ramus because of the accessory mandibular ligaments, and the fact that the condylar head would be pulled downwards out of the glenoid fossa.

In the procedure of conservative treatment, intermaxillary traction offers the best method of reduction of the condylar fracture, and later the elastics may be simply replaced by wires for the fixation and immobilisation of the mandible.

Splints, such as the Jelenko type, may be attached to the upper and lower jaws in the usual manner. The elastics are attached for the reduction of the fragments and these are most effective in the anterior part of the mouth, but they may be used also on the lateral side of the arches. An occlusal block, such as a mass of impression compound, is placed between the occlusal surfaces of the posterior molar teeth to act as a fulcrum for the reduction of the fragments in order to correct the slight degree of open bite relationship. Generally the use of an anaesthetic is not required if a conservative method of treatment is employed. If the jaw has to be manipulated, however, in order to reduce the fracture, a general anaesthetic, such as ether and Oxygen, should be used to obtain good muscular relaxation. If an intravenous anaes-
thetic, for example Sodium Pentothal, is used, the use of curare may counteract the muscular spasm. Reduction of the fracture by manipulation may be performed by placing the thumbs on each side on the occlusal surfaces of the mandibular teeth, pressing the ramus down, and at the same time employing a slight rocking motion. Reduction by manipulation is not recommended, as it does not give the same degree of control for the reduction of the fracture, as do the intermaxillary elastics. Further, if the reduction of the fracture cannot be obtained by elastic traction, then the operative procedure of open reduction and transosseous wiring fixation should be undertaken. After the reduction of the fracture has been completed, intermaxillary wires are placed between the arch splints and so the intermaxillary immobilisation of the mandible is obtained. For those cases where there is an inadequate number of teeth present for the intermaxillary reduction of the fracture, as in the case of a partially edentulous patient with posterior saddle areas present, dental splints are made with extensions over the saddle regions. A wedge may then be placed over these posterior extensions and, with elastic traction applied anteriorly, reduction can be effected. Under the same conditions, instead of a wedge being employed, jack screws have been devised. They are embedded in the lower saddle extension and used against a block in the upper splint, and so forcibly reducing the fragments by increasing the vertical distance between the posterior extensions of the dental splints.

In the totally edentulous case, where conservative treatment of a condylar fracture is employed, dentures may be used, again with a wedge such as a piece
NOTE:

Due to a typographical error, the numbering of page 144 was missed. Page 143 continues in sequence to page 145.
of acrylic placed over the occlusal surfaces of the posterior artificial teeth. Cranio-mandibular traction can then be applied. A Barton bandage with elastic traction reinforcement may suffice.

At all times over-correction of the reduction of the fragments must be avoided, otherwise pressure atrophy of the meniscus may result. The wedges should be removed after ten days and the immobilisation of the mandible, either by intermaxillary fixation or by cranio-mandibular methods, maintained for the time necessary for the healing of the fracture.

2. The Operative Procedure of Open Reduction of Condylar Fractures with Transossseous Wiring of the Fragments by way of a Pre-auricular Incision:

Conservative treatment gives good results in cases of simple fractures of the mandibular condyle. However, if there is:

1. A vertical over-riding of the fragments.
2. A considerable displacement and mal-alignment of the fragments.
3. The presence of bilateral fracture.

then the reduction of the fractures by traction methods or by manipulation will not cause any appreciable reduction nor restore the anatomical relationships. Open reduction is, therefore, indicated to effect the accurate reduction and fixation of the fragments.

The Surgical Procedure:

Before commencing the pre-auricular surgical operation, the appliance to be used later for the immobilisation of the mandible should be prepared and attached to the teeth. This will eliminate the necessity of opening
the mouth later for the insertion of the splints and wires for mandibular immobilisation after the condylar fracture has been reduced. Under a general anaesthetic, a vertical incision is made in front of the ear extending as far as the attachment of the lobe where the facial nerve crosses the face, and the incision is angulated to avoid the auriculotemporal nerve. The tissues are bluntly dissected and the joint exposed, which should not be opened unless the fracture is an intra-capsular one.

The method of wiring of the fragments varies according to the type of fracture displacement and dislocation present.

The drilling of the bone fragments is by a hand drill or a slow dental drill to prevent the occurrence of aseptic necrosis of the bone due to heat generated. Where the condyles are displaced generally, the condyle neck is laid bare of its periosteum and a hole is drilled in an oblique direction, extending from the external surface to the fracture surface. The mandibular fragment is then located. Since this fragment is under the condylar fragment, the first manoeuvre consists in reversing its position with the aid of a bone file. The small end of the file is inserted obliquely between the fragments so that the serrated surface engages the mandibular fragment which, by lever action of the file, is depressed until it slides over the condylar fragment and assumes a position on the outside of the latter. A hole is then drilled obliquely in the mandibular segment and a stainless steel wire, 26 gauge, which has been drawn through the condylar fragment, is now drawn through it from the fracture surface by inserting a looped wire in the hole from the outer surface of the mandible. Then
tension applied to the wire, the fragments are guided into position and, because of the oblique holes in the fragments, the wire will pass finally through the centre of the bone in $\Delta$ form. The wire is then tightened, cut, and bent close to the bone to prevent any irritation of the tissues. Where the condyles are medially displaced, the procedure, naturally, is reversed. This operation is usually carried out under appropriate anti-biotic therapy. It has been found advisable to insert a rubber drainage tube for 24 hours to prevent haematoma formation. The incision is then closed by interrupted sutures, followed by the immobilisation of the mandible by means of intermaxillary wires attached to the preplaced arch wire splints.

Fracture Dislocations of the mandibular condylar head are also treated through the pre-auricular approach. In cases of subluxation, where the capsular ligament is intact, the condyle head is usually readily found and reduced, and the wiring of the fracture by the method just described will maintain it in position. In cases of complete dislocation, however, where the condylar head has slipped out of the joint capsule, the tension of the external pterygoid muscle may pull it some distance from the glenoid fossa so that it must be searched for deep in the pterygoid fossa. It may be displaced downwards, inwards, or forwards. Thus, in cases of complete condylar fracture dislocation, the same operation is performed. If the condyle is dislocated laterally it is easily encountered, reduced, wired and held in place by the careful suture of the joint capsule. In cases of medial dislocation, the condyle may be located behind the mandibular fragment, which may have been pulled up into contact with the glenoid fossa. Here, the outer capsular ligaments
must be severed to expose the glenoid cavity. In these cases the meniscus should be carefully examined, and if it is found to be comminuted, it should be excised. Great care must be taken in repositioning a dislocated condyle, and, whilst it may be possible to retain the condyle in its reduced position by the fixation of the fracture, this type of fixation alone is not always adequate. Once the joint capsule has been ruptured, redislocation of the condyle often recurs readily. In these cases, one should use, in addition to the transosseous wiring for the fracture fixation, some form of fixation to prevent the later redislocation of the head of the condyle.

To effect this, a skeletal pin fixation appliance may be employed. One pin is inserted into the condylar head, and the condyle is then immobilised in its correct position by means of a second pin inserted into the eminence articularis to hold the condylar pin by means of a Frac-Sure connecting rod. In applying this method of skeletal pin fixation of the condylar head, one must beware of any lateral angulation which may occur at the fracture site. This is particularly prone to occur if there are associated fractures of the symphysis and the horizontal ramus of the mandible present, and some rotation of the condyle head may be apparent. To overcome this rotation, a blunt instrument may be placed at the fracture site to push inwards the neck of the condyle, whilst its head is held in position with the inserted skeletal pin. The Frac-Sure links are then tightened and the condyle thus immobilised in its correct position of reduction.
A variation of this procedure is suggested by Georgiade and his colleagues. After the reduction of the fracture, these men adopt a method of extraoral skeletal fixation for both the fixation of the fracture fragments and the immobilisation of the condylar head to prevent its redislocation. They use a three pin appliance - one pin is placed in the condylar fragment, and another in the zygomatic process of the temporal bone, and the third in the mandibular fragment. The superior pin is placed at an angle of 30 degrees in the condyle head, with a similar angulation of the pin in the mandibular fragment. By affixing rigid connecting rods, maximum stability may be obtained in the immobilisation of the fragments and the prevention of the redislocation of the head of the condyle. These men stress that, if bilateral condylar fractures are treated by means of pin fixation, immobilisation should not be concluded on one side until the other side has been reduced and fixed.

A simple method of retaining the head of the condyle in its correct position is to attach the head of the condyle with a catgut suture to the edge of the glenoid fossa by the medium of small drill holes. A chromatised catgut suture is drawn through these holes and tied, so that the condyle cannot be displaced medially. This will maintain the position of the condyle until the suture dissolves. It has been proved to give good results and eliminates the use of an external appliance.

A third method takes care of both the dislocation and fracture by means of Sherman plates. These plates are of vitallium and are obtainable in various sizes. After the reduction of the fracture dislocation, the Sherman plate is fitted so that the condyle will be retained in its correct anatomical position, and to
effect this the plate may be bent in order to bring the head of the condyle out. Two holes are drilled in each fragment and the plate screwed into position. The plate must rest parallel with the long axis of the condyle and is screwed first to the ramus and then into the condyle.

After the reduction and fixation of condylar fracture dislocations, the mandible should be immobilised for four weeks. Fracture wire and bone plates remain permanently in the tissues, and after the period of immobilisation function can be allowed.

These methods just described are valuable because condyles, that are completely detached from all structures, may be salvaged, and a replanted condyle, even though slightly displaced, gives a more satisfactory result than could be expected of the radical treatment of condylectomy.

3. Open Reduction with Transosseous Wiring Fixation of the Fragments by Means of an Incision Below the Mandible:

This method of approach has been recommended for the reduction of subcondylar fractures, which are of difficult access, and where, in addition, the use of curare is recommended to obtain the necessary muscular relaxation in order to make it possible to retract the tissues sufficiently to expose the fracture at the neck of the condyle. Results have shown this to be an excellent method of treatment in those cases where open reduction is indicated for sub-condylar fractures. The choice between this method of approach and that
through the pre-auricular incision should depend on which gives the better result in the most conserva-
tive manner. Thus, the pre-auricular approach is the choice for fractures through the head of the con-
dyle, and for cases of fracture dislocation in the glenoid fossa. However, the sub-mandibular approach gives the best conservative results for sub-condylar fractures and low fractures through the base of the condyle. These are always difficult to reduce through the pre-auricular incision.

In operative procedure by this method, splints are attached to the upper and lower jaws pre-operatively, so that immobilisation of the mandible can be obtained at the end of the operation. The skin incision is made below the mandible, extending from below the lobe of the ear around the jaw 1 cm. below the inferior border, and extending approximately to the site of the external maxillary artery. The jaw is then bluntly dissected down upon from below, incising the periosteum at the inferior border of the jaw, and the muscle attachments are detached. This brings the operative area into view, exposing the condylar frag-
ment. A hole is drilled through this fragment near its posterior margin and a stainless steel wire, 26 gauge, is inserted. The mandibular fragment is then pulled down with bone forceps. A hole is now drilled in this near its posterior border just below the fractured end, and by means of a looped wire; the wire emerging from the inner surface of the condylar frag-
ment is pulled through. The fracture can thus be accurately reduced and fixed by twisting together the two ends of the wire. In cases where the fracture involves the neck of the condyle, more extensive
tissue retraction would be necessary, utilizing the sub-mandibular approach. This can be obtained if 60 units of curare are administered or, alternately, 2-3 cc's of metubine iodine may be used. Forcible upward retraction would then expose the fracture site. As conservative treatment is always ideal, it is considered that the pre-auricular approach would give the best results for a fracture involving the neck of the condyle. This would also be true in cases presenting a fracture dislocation of the condylar head. It may be possible, in some cases, to effect conservative treatment through a sub-mandibular approach, if bone plates were used for the fixation of the fragments.

After the reduction and the transosseous wiring of the fragments, the wound is closed in layers and sutured. The mandible is then immediately immobilised by the intermaxillary wiring of the previously placed arch splints, or by any established method of mandibular immobilisation deemed adequate. Again, the mandible should remain immobilised for a period of 4 to 6 weeks, after which function may be gradually restored.

An alternative to the sub-mandibular approach for the reduction and fixation of sub-condylar fractures, is the endaural approach suggested by Rongetti and (47) Devasetti. These men maintain that this approach may be made firstly without the difficult retraction of tissue, as in the sub-mandibular approach, and secondly without the danger of injury to the branches of the facial nerve, and thirdly without resultant scarring of the face. Employing this approach, an
incision is made well within the external auditory canal down to the bone. The incision curves upwards hugging the anterior helix, and becoming less penetrating as it approaches the surface. It ends at about the level of the inferior crus. The temporal muscle fascia is then identified. A second incision is now made, sweeping anteriorly down in a circular manner in the canal, on the posterior surface of the tympanic plate. This incision is half circular in outline. It cuts the cartilage in the area of the incisura intertragica, and ending as it approaches the surface. The temporal muscle is then undermined and the sub-condylar area exposed by sharp dissection.

This approach requires an exacting surgical technique, or otherwise it may result in damage to the ear components. With the use of curare to obtain adequate muscular relaxation for the retraction of the tissues, I would prefer the sub-mandibular approach for the reduction and fixation of sub-condylar fractures. With a knowledge of the regional anatomy of this area, the danger of injury to branches of the facial nerve and the external maxillary artery and vein are minimised. Taking advantage of the natural creases of the skin, the resulting scarring of sub-mandibular incision would be negligible.

4. Condylectomy:
In cases of comminuted or complicated condylar fractures, which may be grossly infected, the operation of condylectomy - the total removal of the mandibular condyle head - may have to be performed. Some of these cases have been found to respond to modern anti-biotic
therapy. However, if resorptive changes occur in the temporo-mandibular joint, for example following supplicative arthritis, condylectomy is indicated. It is a radical treatment and should be used only as a final resort. In the operation of condylectomy, the mandibular condyle is removed through the pre-auricular approach, as previously described. The mandibular stump is smoothed with rongeur forceps and bone files. Muscle or fascia may then be drawn over the mandibular stump, but it is not altogether necessary. The subcutaneous tissue is closed and the skin sutured. By this means, a fibrous false joint in this region is formed following condylectomy. The mandible is immobilised by an established method for two or three days, after which motion of the jaw is encouraged.

The treatment of mandibular condylar fracture and fracture dislocation has often been found to give unsatisfactory results. It is felt that this has been due to lack of immobilisation of the mandible, whether the fracture has been treated conservatively, by skeletal fixation, or by transosseous wiring method. The mandibular condyle is subjected to strong muscular tension, and anyone of these methods is not sufficient in itself to effect healing. They do allow a certain amount of movement in the line of fracture.

In dentulous cases, intermaxillary elastics should be used in addition. They will maintain the reduction of the fragments, by keeping the teeth in good occlusion and thus immobilising the mandible. Where we have an edentulous case, splints should be inserted in the mouth to retain the distance between the jaws. We may
use, for example, the Gunning splints or the patient's dentures wired together. Cranio-mandibular immobilisation of the mandible can then be obtained by means of a Barton bandage reinforced by elastics or, alternately, by the use of a Steinmann pin, transmitting the mandibular symphysis, and connected by rods to a headcap.

The immobilisation of the mandible in cases of condylar fracture by this latter method is recommended in edentulous cases. It not only prevents the patient from moving the mandible, but it will do so without the use of a dental splint, thus leaving the mouth freely accessible and causing no interference with the taking of food or vomiting. This would certainly be an advantage if lacerations and injury to the soft tissues of the mouth were present.

In partially edentulous and edentulous cases, as well as in the management of the child patient, Broadbent advocates the nose-mandibular fixation and immobilisation of the mandible in the treatment of condylar fractures. He recognises the fact that in the treatment of the fractures of the mandibular condyle, particularly in the treatment of bilateral cases, an open bite deformity may ensue unless the immobilisation of the mandible in normal incisal occlusion is maintained for at least four to six weeks. Broadbent thus suggests nose-mandibular fixation in those cases where the usual methods of intermaxillary fixation are not practical or possible. In the partially edentulous patient, where we have a full upper denture and at least five or six anterior teeth present in the mandible, nose-mandibular fixation has certain advantages. Here, the maxillary denture is locked between the jaws by stainless steel wires inserted in the bony piriform aperture of the nose, brought down and fastened to an arch wire splint attached to the mandibular teeth. This
fixation is easily applied and it does not require an external bandage, which may interfere with normal hygiene habits. If the patient is entirely edentulous, this method of immobilisation of the mandible can still be used. Gunning splints are constructed, inserted into the mouth and they are fixed to the mandible by means of circumferential wires. The ends of these circumferential wires are then united with the nasal wires brought through the piriform aperture, thus locking the Gunning splint between the upper and lower jaws. In children, 25 gauge stainless steel wire may be placed circumferentially around the mandible in the midline. The nasal spine is then exposed and perforated with a small bur and one end of the mandibular wire placed through the hole, brought back into contact with the other end of the wire and tightened, so immobilising the mandible. Small felt pads may be placed over the upper gingiva in this case for its protection.

In the final analysis of the methods of treatment employed for condylar fractures and fracture dislocations of the mandible, conservative methods on the whole produce good results, and major functional complications have been shown to be rare. If, however, there is any doubt of accurate reduction, since the correct alignment of fragments to restore normal anatomical relationships is the basis of fracture treatment for efficient function, then surgical methods should be adopted. With the advent of appropriate anti-biotic therapy, the hazards of these procedures have been minimised, when used in conjunction with sound surgical judgment. The immobilisation of the mandible must be maintained for at least four weeks to ensure success in their treatment.
TRAUMATIC INJURIES OF THE TEETH AND THE ALVEOLAR PROCESS OF THE JAWS.

As a result of traumatic injuries to the jaws, a number of teeth are often injured. Some may exhibit tenderness to the touch because of concussion, some may be loose because of luxation, whilst others may have been fractured either at the crown or at the root, or both. The teeth may be only slightly displaced, as where the crown of the tooth is pushed labially or lingually of the dental arch, whilst its apex remains in position. This is referred to as a condition of subluxation. In complete luxation the tooth is completely removed from its normal position and may be impacted in the soft cancellous part of the jaw. It is nearly always completely severed from its blood supply.

Where a tooth is in a position of subluxation, the accumulated extravasated blood in the pulp liberates haemoglobin which causes a pink discolouration of the tooth, which later turns orange-brown to bluish-black because of the formation of haematoidin, methaemoglobin or haemin. If, however, the blood supply is severed at the apex of the tooth, as in a luxated tooth, the pulp tissue will become necrotic or gangrenous, which produces a reddish-green discolouration. This in turn may be followed by suppurative periodontitis and an alveolar abscess, associated with lancinating pain, and swelling of the face.

The presence of injured, displaced, or fractured teeth is usually co-existent with other injuries. In most cases there are present lacerations of the lip, cheek, tongue, and/or fractures of the facial bones.
Their treatment, therefore, becomes an integral part of the general and regional treatment instigated for traumatic injuries to the jaws.

Grossly displaced teeth should be extracted, and this should be done with care so as not to displace any bone fragments, or to further lacerate the soft tissues. In cases of subluxation, the teeth may be forced back into their normal alignment and retained there. This may be accomplished by means of figure-eight ligatures to the adjoining teeth, or they may be wired individually to an arch wire about the dental arch. A small metal or acrylic dental splint, constructed so as to include the adjacent two or three teeth on either side of those subluxated, and cemented into position following their reduction to correct occlusion, offers excellent fixation of the teeth. The appliance is removed after the teeth have become firm, by repair of the periodontal membrane and the surrounding alveolar bone.

If any of the teeth are themselves fractured, individual consideration, following a detailed examination, including dental X-ray films, is necessary. The tooth fracture may be of a fissure nature, or a complete coronal or intra-alveolar fracture. It may also present comminution of tooth fragments. Fractured teeth presenting other than a slight fissured fracture should be carefully extracted, as in many cases they will become infected and inflamed. Fissured teeth may be splinted with a small regional dental splint, but their prognosis is not very favourable except in the teeth of young people. Theirs have a vigorous reactive power and a good blood circulation. Complete union may occur if the space between the fracture fragments is very narrow, but if a wider separation exists connective tissue in growths will prevent a solid union taking place. Where the injured teeth are located
in a line of bone fracture, their extraction is considered essential. This will be further discussed under the heading of "Complicated Fractures".

Fracture of the Alveolar Process:

This may occur singly or in combination with either fractures of the maxillae or mandible, or both. These fractures may be grouped as:
2. Fracture of the Maxillary Tuberosity.

The buccal or the lingual alveolar plate of the bone may be detached together with the teeth. This causes luxation of the involved teeth which may or may not remain viable. In other instances an entire section of the alveolar process, with the inner and outer plates attached to the teeth, may break loose. In such cases the important factor is whether the fracture extends through the apical region of the teeth, or whether it is subapical in nature. If the displacement is not very marked, and if the apices of the teeth are completely included in the fragment with the fracture line well in the subapical bone, the prognosis for the teeth is much better than it is in cases in which the fracture passes through the dental alveoli, removing the apices from their sockets. In such instances, the dental arteries are generally ruptured, cutting off the blood supply to the pulps of the teeth. This predisposes to infection, and if infection sets in, the entire alveolar segment should be removed.

1. Fracture of the Maxillary Alveolar Process:

These fractures may involve a section of the alveolar process only, or they may extend into the palatal
process of the maxilla. There is swelling of the affected side of the face with associated mal-
occlusion of the teeth and deformity. Manipulation will show the mobility of the fragment. The maxillary sinus may be involved and there may be bleeding from the nose. Fractures in this region, caused by a lateral blow, often extend through the palatal suture, disconnecting the fragment in the median line, and are associated with contusions or lacerations of the skin of the face. The bony fragment is displaced medially and a ridge may be visible on the hard palate extending as far back as the soft palate, due to the over-riding of the dislodged palatal process. In some fractures, the alveolar fragment may be displaced outwards causing the palatal bony suture to be opened.

2. Fracture of the Maxillary Tuberosity:
A lateral blow striking the ramus of the mandible and causing a fracture at the angle of the jaw may indirectly involve fracture of the maxillary tuberosity. Fracture in this region may also occur during the extraction of an upper third molar tooth. In these cases, the maxillary tuberosity becomes entirely displaced. The maxillary sinus is always involved, and, as there is an accumulation of blood, infection is possible.

3. Fracture of the Mandibular Alveolar Process:
These fractures are frequently associated with other fractures of the mandible and present special difficulties because loose sections of the alveolar process will limit the number of teeth that may be used for intermaxillary fixation. In such cases another method of fixation must be used for the immobilisation of the mandible. The fractured alveolar process
may be displaced lingually or buccally and, in 
addition, it may project over the occlusal plane, 
preventing complete closure of the jaws.

The treatment of these injuries follows an estab-
lished procedure, both of a general and a regional 
nature. This is followed by proper reduction of 
the fragments to restore normal anatomical relation-
ship and occlusion, and later by a suitable method 
of fixation to immobilise the segment. In these 
cases, a general anaesthetic is usually preferred. 
Injection into traumatised, and often inflamed tissue, 
is not advisable.

Alveolar fractures in both the maxillae and the man-
dible may be brought into alignment and immobilised, 
by means of pre-fabricated arch wire splints, or 
cast metal dental splints such as the open ferrule 
type, attached to the teeth, after reduction of the 
displaced fragment by manipulative means has been 
accomplished. Elastics may be used also for the 
reduction of the alveolar fragment. These elastics 
may be replaced later by wire ligatures for the fix-
atation of the fragment. Intermaxillary traction and 
ligation for the reduction and fixation of the frac-
ture may be found necessary, although many cases 
respond quickly to intramaxillary traction and lig-
atation. In cases where considerable traction is needed 
for the reduction of the displaced alveolar fragment, 
an arch wire of 16 gauge German silver wire may be 
used, bent so that it comes into contact with the 
necks of all the teeth of the dental arch, except in 
the region of the displaced segment. In this region, 
the arch wire is bent a considerable distance away
ALVEOLAR FRACTURES

APPLIANCE TO REDUCE PALATALLY DISPLACED ALVEOLAR FRAGMENT BY TRACTION

FRACTURE OF LATERAL SECTION OF ALVEOLAR AND PALATAL PROCESS WITH FACIAL DISPLACEMENT AND OPENING OF PALATAL SUTURE WITH APPLIANCE DEvised FOR GRADUAL REDUCTION
from the position of the normal alignment of the fragment. This will facilitate the application of direct intra-maxillary traction on the segment concerned, which will thus allow the reduction of the fragment by means of elastics.

Where elastic traction is used for the reduction of a maxillary alveolar fracture, palatal bars are often employed. These will support the maxillary arch and prevent it from collapsing and, at the same time, provide attachment for the elastics used in reduction. For example, if there is a buccal displacement of the maxillary alveolar fragment, an arch wire splint is placed buccally, except at the region of the displaced fragment, and another is placed on the lingual side of the dental arch. These arch wires are then ligatured to the teeth by means of fine interdental wires. A palatal bar may then be used with attached lugs to which strong elastics are applied across the vault of the palate to the displaced alveolar fragment, thus providing the intra-maxillary reduction of the fragment. By later replacing these elastics with wire ligatures, fixation of the fragment is obtained.

Fractured alveolar fragments of the mandible may also be attached to the body of the mandible by means of circumferential wiring of the fragment, and this method may be used in both the dentulous and edentulous patient. The technique that has already been described is used, the circumferential wire being introduced about the body of the mandible by means of a bent hypodermic needle and then brought over the fractured alveolar segment, and twisted down tightly,
This method of alveolar fixation is not as simple as the use of dental splints or arch wires. It does not allow for the reduction of the fragment by means of elastics.

Since the use of dental splints, after the reduction of the fracture, will provide rigid fixation of the fragment, intra-maxillary immobilisation of the alveolar fragment should be sufficient. If there is a vertical displacement of the fragment, in addition to a medial or lateral displacement, then intermaxillary traction, later replaced by intermaxillary fixation of the fragment, should be undertaken for four to six weeks. This is in addition to the intra-maxillary reduction and fixation of the alveolar fragment. By this means the teeth will be maintained in their normal occlusion until bony union has taken place and the splints can be removed.

Whether the teeth themselves, or a segment of the alveolar bone containing teeth, are involved in a fracture of the jaw, the individual teeth must be carefully watched. Discolouration of a tooth indicates pulp haemorrhage or necrosis, and swelling of the periosteum over the apex of a tooth, or a sudden swelling of the face in the region of the involved segment, may indicate infection. In such cases, the affected teeth may have to be sacrificed, and in some cases the entire alveolar segment removed to establish drainage and prevent an osteomyelitis complication.
THE PROBLEM OF MULTIPLE FRACTURES OF THE JAWS.

The occurrence of multiple fractures of the jaws can present difficult problems, because in most of the established methods of treatment, the solid opposite jaw is used as a splint for the immobilisation of the other. If both jaws are fractured, there is no stability in either part. The methods of fracture fixation by means of transosseous wiring, skeletal fixation, transfixation by means of Steinmann pins or a Kirschner wire are here invaluable. These methods will allow us to immobilise a fracture in one jaw so that it may be used as a foundation upon which to assemble the other jaw. In the choice of methods of treatment for these cases presenting multiple fractures of the jaws, no hard and fast rules of treatment can be laid down. A combination of established methods must be employed at the discretion of the surgeon. For the purposes of treatment, cases presenting multiple fractures of the jaws may fall into one of the following categories:

1. Cases in which mandibular fractures can be immobilised in order that a dentulous or a splinted mandible can be used for the fixation of a fractured maxilla:

   If there is an adequate number of teeth present, the mandibular fracture may be fixed by means of a dental splint. If there is an insufficient number of teeth present the fracture fragments may be maintained in their correct position by a skeletal fixation method. This latter method of treatment would not be feasible, however, if the line of the fracture was posterior to the dental arch in the region of the angle of the mandible, where the fragments are notoriously unstable. In this case, the maxillary fracture should be immobilised first, and the intact maxillae used as a splint for the mandibular fracture.
Having obtained the fixation of the mandibular fracture, the fixation of the maxillary fracture can then be accomplished by one of the following methods of fixation:

A. **In patients with an adequate number of maxillary teeth:**
   1. Intermaxillary wiring fixation.
   2. The use of a Barton bandage reinforced by elastics.
   3. The use of immobilisation rods extending from a headcap or band to pins or a Frac-Sure appliance attached to the mandible.

B. **In the edentulous or partially edentulous maxillae** one of the following combinations must be used:
   1. An upper denture splint articulating with the lower teeth with some form of cranio-mandibular fixation as:
      (a). A Barton bandage.
      (b). A Kirschner wire or a Steinmann pin transfixing the chin and attached by rods to a headcap.
      (c). The use of half pins inserted on each side of the mandible in a similar manner as (b).

2. Intermaxillary fixation need not be used at all. The maxillary fracture may be treated by a cranio-maxillary appliance associated with a headcap - for example, the use of a reversed Kingsley splint, Steinmann pins inserted through the maxillae or, on the other hand, transosseous wiring or the internal wiring fixation of the fragments may be employed.
II. Cases in which stabilised middle face fractures may be used for the fixation of the mandibular fracture:

The middle face fracture here may be reduced by an internal wiring method or the use of a cranio-maxillary appliance where there is an adequate number of maxillary teeth present. If there is an adequate number of mandibular teeth present, an intermaxillary fixation method may be employed. If the patient has an edentulous or a partially edentulous mandible, then the mandible may be immobilised by intermaxillary wiring used in conjunction with circumferential wiring over a lower dental splint or, again, one of the other established methods of cranio-mandibular fixation may be employed.

III. Cases presenting multiple fractures of edentulous Jaws:

In these cases the exact reduction of fracture fragments is not of such paramount importance, as any slight discrepancies of reduction may be later accommodated for by the construction of new dentures. Under these circumstances, the middle face fracture can usually be immobilised either by an internal wiring technique, a transfixation method by means of Steinmann pins, or by skeletal pin fixation methods. The total immobilisation of both jaws can then be gained with the use of a Gunning dental splint, combined with rigid cranio-mandibular fixation by means of a Barton bandage reinforced with elastics.

Where secondary fractures of the bony skeleton of the face occur in association with multiple fractures of the jaws, the secondary fracture fragments may be reduced and immobilised by internal wiring methods, or, in the case of fracture involving the maxillary sinus, by packing the sinus with gauze in combination with transosseous wiring of the fragments. Fractures
of the zygomatic bones, the inferior margin of the orbit, and the outer wall of the maxillary sinus, can be treated in this manner.

It is also to be remembered that where a fracture involves the angle, ramus or the condyloid process of the mandible, total immobilisation of the mandible is necessary, complementary to the use of internal wiring or skeletal methods of fixation of the fracture.

In the treatment of patients presenting multiple fractures of the jaws, a good reduction of the fragments depends a great deal on unhampered manipulation, and this can only be carried out if no pain is experienced and complete muscular relaxation is obtained. It is seldom possible to reduce all the fractures present at one operation, and two or more operations may be required. The success of any treatment undertaken will depend thus upon a thorough examination of the patient, a good surgical technique, and finally a basic understanding of the established methods of fixation of fractures of the jaws so that a combination of methods may be chosen to suit the individual case.
From the clinical aspect of a healing fracture, the early phase of haematoma formation and fracture repair is characterised by swelling and oedema, together with oedema and the clinical signs of inflammation. Provided that the early immobilisation of the fragments is carried out and infection controlled, these aspects should cease after four to five days, and at the same time the pain will subside. The persistence of pain or swelling of the tissues should always arouse suspicion that either the fixation is inadequate or that infection has not been controlled. Some degree of oedema may persist until the fourteenth day. From this stage until the final bony repair has occurred, the only alteration in the normal contour of the face should be due to the slight excess of callus formation about the fracture site.

Routine post-operative sedation is not usually necessary or desirable, and any drug which depresses the cough reflex or the respiration is best avoided, or used with caution. Restlessness due to pain, however, may be alleviated by the subcutaneous injection of 100 mgm. of pethidine. During the post-operative period a temperature chart for the patient should be kept and carefully observed. An elevation of temperature sometimes may occur from the development of infection within the oral cavity. This infection may be localised firstly within the soft tissues if an open wound is present or, secondly, within the fracture haematoma, which may be associated with the presence of teeth in a line of fracture, or by sequestration formation, or by the presence of a foreign body in the tissues.
The control of infection post-operatively should be:

1. **Prophylactic in nature:**
   Good oral hygiene must be maintained by careful irrigation of the mouth after each feed, preventing the retention of any food debris.

2. **By the use of chemotherapy and anti-biotic treatment:**
   In order to apply chemotherapy or anti-biotic treatment in a scientific or rational manner, a swab of the tissues should be taken, the organisms cultured, identified and their sensitivity to sulphonamides, penicillin, streptomycin, chloromycetin, aureomycin, and terramycin determined. The appropriate treatment may then be selected, but bearing in mind any toxicity or side reactions that these drugs may possess and their methods of control. Anti-biotic therapy should be continued until all swelling has disappeared and extraction wounds or oral lacerations have healed.

In cases of maxillary fracture, the patient should be so positioned in bed that mucus or blood may easily escape from the mouth or nose, or, alternately, these secretions should be removed by means of an aspirator. Drainage tubes or gauze wicks emerging from the maxillary sinus, if not needed to support its bony walls, are usually removed on the second or third post-operative days.

If the patient has undergone a long operation, the intravenous infusion of saline with 5% dextrose is indicated to replace lost fluid and to counteract acidosis resulting from vomiting. If a great volume of blood has been lost before or during the operation,
or if the patient is anaemic, a blood transfusion would be indicated instead of the intravenous infusion of saline solution. Later, cold applications may be placed on the injured side to control any inflammatory reactions.

On the second post-operative day, all bandages and dressing should be changed. The occlusion of the teeth and the position of any splints used should be checked. The patient’s cheeks and lips should be examined to make sure that any wires which have been used for the fixation of the fracture are not lacerating the soft tissues. The patient’s temperature should be observed also—any rise in the temperature may indicate that infection has set in.

As we have already stated, the patient’s oral hygiene is most important. A mouth wash should be prescribed and used frequently, depending upon the status of oral health, and the presence or absence of lacerations of the gingiva or oral mucosa. A power spray should be used also during the post-operative period to remove all remnants of food lodged between the teeth. Negligence in these simple hygienic measures is often the cause of subsequent gingivitis of the oral tissues and extensive caries of the teeth.

The Feeding of the Patient:

It should be appreciated that there is a limit to the amount of a fluid or semi-fluid diet which can comfortably be digested at any one meal. Therefore, in order to maintain a sufficient intake of the necessary calories, one must give a little food at frequent intervals. It has never been found necessary to remove anterior teeth
in order to provide a gap for feeding purposes. There is always adequate space behind the last molar teeth to allow the passage of fluid or semi-fluid feed, even in a mouth with a full complement of teeth. Thus, the food intake must be capable of passing through a feeding tube and so, of necessity, is of fluid or semi-fluid nature. Even the worst case of jaw injury can be fed by the mouth usually, if a feeding cup is provided with a rubber tube extension about four inches long. In this regard a teapot is ideal, drinking from the spout. It is necessary that an adult patient resting in bed should receive five pints of fluid daily with a minimum calorific value of 1700 calories. Every effort should be made to provide roughage in a basic diet in order to maintain normal peristalsis and so body function. Whilst concentrated foods provide the necessary calorific intake, they do not provide a satisfactory feeling of repletion, and sufficient bulk foods to provide this should always be included in the diet as soon as possible.

This fluid or semi-fluid basic diet should also be relatively high in proteins and low in carbyhydrates, because the latter are dependent upon mastication. The admixture of ptyalin is necessary for digestion. Minerals are very important and the diet must include calcium, phosphorus and iron. The necessary intake of vitamins is also important, particularly from the point of view of wound infection, wound healing, and the calcification of newly formed bone. Vitamin A, B₂ complex, C and D should, therefore, be added to the diet. The deficiencies of vitamin A, niacin, and riboflavin are important predisposing causes of mouth infection. Vitamin C is necessary for the conversion of procollagen to collagen and vitamin D plays an important part in bone formation.
The patient's food intake should, therefore, be carefully supervised, and the patient should be given sample menus. An example of a sample balanced diet for one day is as follows:

<table>
<thead>
<tr>
<th>Breakfast:</th>
<th>Calories:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange juice</td>
<td>1 glass</td>
</tr>
<tr>
<td>Cream of wheat</td>
<td>3/4 cup</td>
</tr>
<tr>
<td>Cream</td>
<td>40 grms.</td>
</tr>
<tr>
<td>Cocoa</td>
<td>1 cup</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
</tr>
</tbody>
</table>

10.00 a.m.

| Egg nog            | 1 glass   | 200       |

Dinner:

| Cream of celery soup | 1 cup     | 160       |
| Beef, finely ground  | 1 tablespoon | 130       |
| Purée of sweet potato| 1 potato  | 135       |
| Purée of spinach     | 1/4 cup   | 25        |
| Milk to thin potatoes & spinach | 80 grms. | 55        |
| Boiled custard       | 1 cup     | 300       |
| Tea with 40 grms. of cream | 1 cup | 25        |
| **Total:**           |           | **880**   |

Supper:

| Chicken broth       | 1 cup     | 100       |
| Mashed potatoes     | 1/2 cup   | 50        |
| Purée of carrots    | 2 carrots | 45        |
| Milk to thin potatoes & carrots | 80 grms. | 55        |
| Purée of fresh peaches | 3 med. peaches | 100    |
| Cocoa               | 1 cup     | 300       |
| **Total:**          |           | **650**   |

8.00 p.m.

| Grape juice        | 1 glass   | 200       |

**Grand Total:** 2,505
In the exceptional case of a patient who cannot produce suction because of the loss of the continuity of the lips, cheek or palate, the use of a drinking tube may not be adequate. In these cases spoon feeding, feeding by means of a catheter, or rectal feeding may be used in conjunction with the feeding tube.

Hospitalisation of the patient should be limited to the time necessary for the welfare of the patient, but no longer. Early ambulation is always to be encouraged since the incidence of pulmonary and vascular complications is thereby reduced to a minimum. Patients with complicated fractures, however, should not be allowed to proceed home or to work until all danger of infection has subsided. Later, bi-weekly visits to the clinic should be planned for the adjustment of the splints or appliances, and for mouth irrigation and dressings.

The healing time for the clinical union of uncomplicated fractures which have been completely immobilised may be expected within four to six weeks in the average adult. This period may extend to eight weeks in the case of an elderly patient. When completely mobilised, the patient often finds that he is unable to open the jaws to any extent due to muscular trismus. Exercise is the best treatment in this case, but it must be gradual in intensity. Physiotherapy, by means of radiant heat therapy, active and passive stretching of the jaws, muscle exercise, are also beneficial at times in cases of muscular trismus.

The final occlusion of the teeth should also be checked and spot ground if necessary. Judicious spot grinding of the teeth should always be a feature of post-operative care of the patient, establishing equilibrium in centric, protrusive and lateral movements of the mandible.
Malposition of the mandible due to occlusal disharmony may later produce many secondary conditions, such as attrition of the teeth, hypercementosis, root resorptions, and pulpal hyperaemia. Periodontitis would also be a feature, as well as the disturbance of the function of the temporo-mandibular joint. Sherr expresses this well by stating:

"That the intricate relationships between the muscles, ligaments, temporo-mandibular joints and teeth, must not be overlooked, as the integrity of each depends on its proper relationship to the others."
THE COMPLICATIONS OF TRAUMATIC INJURIES OF THE JAWS.

Traumatic injuries of the jaws may present the following complications:

1. Acute infection of adjacent tissues.
2. Chronic infection with an active fistula.
3. Maxillary sinus infection.
4. Osteomyelitis of the jaws.
5. Delayed and/or non-union of fracture fragments.

1. Acute Infection of Adjacent Tissue:

All compound fractures have infection as a complication. The open wound creates a path to deep infection and the more sepsis about the teeth and the gingival crevices, the greater the danger. The muco-periosteum covering the jaws is tightly bound down to the underlying bone, and it is continuous with the periodontal membrane attaching the teeth to the bone. As a result of this, when teeth are present fractures of the jaws involving the teeth bearing area are almost invariably compound, and therefore the fracture is in communication with a cavity, which cannot be maintained in a sterile condition. From this it follows that a tooth deprived of the periodontal membrane on some aspect of its root, as a result of bone fracture, constitutes a portal of entry whereby infection may be introduced into the bone at the site of the fracture.

Teeth whose roots are involved in the line of fracture are liable to lose their blood supply as a result of the severing of the blood vessels at their apex. Teeth thus affected constitute a further source of infection, when necrotic changes occur in the pulpal tissues. Accordingly, where a fracture line passes
through a tooth socket and the tooth is involved, the death of the pulpal tissues, for the purposes of treatment, should be presumed certain. The effect of a dead necrotic pulp in a tooth with its apex close to, or actually in, a fracture line can be so disastrous that there should seldom be any compromise. However, in certain cases, as when a tooth involved in a line of fracture may be advantageously utilised in the immobilisation of a distal mandibular fragment, a compromise may be made. Atterbury and \(52\) Vazinsein maintain that the retention of these strategic teeth involved in a line of fracture can obviate the need for more complicated methods of fixation of the fragments. They stress that with the use of adequate chemotherapy and dependent drainage, the infection and the delayed healing of the fracture can be minimised. Kromer is also of this opinion and in a review of 690 cases of jaw fractures, his deduction was:

"That all teeth involved in a line of fracture must be individually evaluated, and that in certain cases it is justifiable to retain a tooth in a line of fracture for fourteen days if it is needed for the immobilisation of the fragments, provided that the appropriate antibiotic therapy is used in conjunction."

Thus we may say that the retention of these strategic teeth in a line of bone fracture is a calculated risk. With today's effectiveness of anti-biotic therapy, this risk may be taken for a short period to facilitate treatment. However, it is advisable to remove these teeth as soon as practicable, as they are a potential source of trouble, leading to delayed or non-union of the fracture fragments.
In compound fractures of the jaws, foreign bodies may also be present, which may initiate infection. Infection is common in mandibular fractures. It usually starts in a haematoma, forming at the inferior border of the mandible, following the injury. Swelling of the face occurs and sub-periosteal, intra-oral, or facial abscesses may form. These may lead to osteomyelitis of the jaw, or spreading by the facial planes may present a cellulitis complication. More serious still, are phlegmons or abscesses forming in the retrobulbar space and temporal fossa. Through involvement of the pterygoid space, cavernous sinus thrombosis may develop via the pterygoid venous plexus, with a fatal result. Swelling of the eyelids result in closure of the eyes is here a danger sign, and its terminal stage is indicated by deepening stupor, stiffness of the neck, a rising pulse, temperature and respiration, together with delirium.

In all such cases, full appropriate anti-biotic therapy and early prophylactic incision and drainage are necessary. Routinely this should be established in all cases of fracture with external wounds, infected haematomata or, again, in cases where a tooth in a line of fracture has created swelling. The following regions may be involved - the sub-maxillary space, the sub-mental area, the sub-lingual space, the pterygo-mandibular space or the infra-temporal fossa. The incision for drainage should be so made that organisms from the mouth will not be carried into the external wound. In cases of deep sub-maxillary swelling, an incision can be made at least 1 cm. below the inferior border of the jaw at the site of the fracture. A rubber drainage tube or a Dakin tube can then be
sutured into the wound to effect drainage. The appropriate anti-biotic therapy is commenced and the wound covered by sterile dressing. If the abscess formation occurs before the immobilisation of the fracture fragments, treatment should be delayed until the infection is controlled. Supportive general treatment should also be rendered to the patient, building up resistance by administering vitamins, especially ascorbic acid, any patient dehydration should be counteracted and, especially if the patient is anaemic, a blood transfusion may be beneficial.

2. The Presence of Chronic Infection:

The presence of chronic infection denotes the presence of a focus of infection, such as a nonviable tooth which was not removed or the presence of a small sequestrum. The infection is generally of a low grade nature, not preventing union but creating a fistula, discharging a small amount of pus and delaying the union of the fragments. The removal of the cause of the low grade infection should always be the primary consideration. Then, under appropriate anti-biotic therapy, primary closure of the fistula can be attempted.

3. Maxillary Sinus Infection:
The maxillary sinus is involved in all fractures of the zygomatic bone and in fractures of the maxillae along the lines of Le Fort I and Le Fort II types - in other words in depressed, horizontal and pyramidal fractures of the maxillae. Consequently, maxillary sinus infection is not an uncommon complication of middle face fractures. Pickering points out in an analysis carried out by Dawson and Fordyce in 1953 with fractures of the zygomatic bone, that in 2% of cases only, did acute infection develop in the sinus.
They showed, however, that an oro-antral fistula with a low grade infection persisted in 22% of cases in which the antrum was packed for the immobilisation of the fracture after reduction. This is a measure of the recuperative resources of the maxillary sinus.

In early cases of maxillary sinus infection, present at the time of reduction of the fracture, a window should be cut in the naso-antral wall for drainage. In addition, by way of a Caldwell-Luc antrum operation, the diseased antral membrane together with all polypoid formations should be removed. In cases of acute infection which occur after the reduction and fixation of the fractures, drainage may be established by opening into the antrum by means of a trocar and cannula inserted from the nose under the inferior turbinate bone, in order to irrigate the cavity. This procedure will remove any broken down and infected remnants of a haematoma, provide drainage, and allow irrigation of the sinus to be carried out until the returns are clear and infection has subsided.

4. Osteomyelitis:

Osteomyelitis is a fracture complication and is more serious than the others. It is usually localised and affects the region of the fracture only. The loss of bone by sequestration can cause great deformity. Its most frequent etiological factor is a retained tooth through which the fracture is compounded. Osteomyelitis and the subsequent sequestration of bone may occur also, especially in comminuted fractures, if foreign bodies have been incorporated.

In cases of osteomyelitis, the removal of the sequestra and infected tissue is of paramount importance,
together with any fibrous tissue that may have formed between the fragments. In old cases, fibrous union of fragments may have developed because, in the presence of infection, fibrous tissue forms instead of bone. The ends of the fracture fragments are then made raw and freshened before renewed reduction. A bleeding surface is necessary for callus formation and bone healing to take place. From the bleeding bone surfaces, new osteoblasts are formed. These, together with young fibroblasts, lay down extra-cellular collagen fibres, which form the callus and in which the calcium is deposited, until a lacy network of bone has been produced. The fracture will then generally heal if it is properly immobilised, and all of the infected dead bone and any non-vascular tooth present in the fracture line, removed.

If a sizable piece of bone has been lost at the site of the fracture, which involves the whole depth of the jaw, the treatment should include also the preservation of the gap for future bridging with a bone graft. The choice of a method of fixation of the fracture in these cases can then present a problem. Intermaxillary fixation of the fracture, if it is used, may result in the prolonged immobilisation of the mandible with the final result of muscular trismus and stiffness of the temporo-mandibular joint. Skeletal fixation methods should be employed here. They will provide rigid fixation of the fragments without immobilisation of the joint. At the same time, they will preserve a gap between the fragments for future bridging by means of a bone graft, in those cases of considerable bone loss due to sequestration. A method of skeletal fixation would also facilitate the irrigation of the wound, and the application of dressings. It would also promote a good blood circulation to the jaws and
prevent loss of calcium from the bones.

After the removal of the sequestra and the reduction and fixation of the fragments, the surface wound may be then sutured. A drainage tube is inserted for a few days until all drainage is completed.

Under modern prophylactic anti-biotic therapy, these procedures can be carried out today with safety, shortening the time necessary for treatment, and eliminating one of the most common causes of non-union of fracture fragments; namely, long continued suppuration, sequestration, and the formation of scar tissue between the fragments.

5. Fracture Complications of Delayed Union and Non-union of Fragments:

The complication of non-union is rare in fractures of the middle third of the facial skeleton, but it is not an uncommon complication of mandibular fractures. Simple fractures usually heal in five to six weeks, if there is close adaptation of the fragments, and if their fixation is adequate. There are, however, a number of conditions which prolong the healing time, causing delayed union, whilst other conditions may prevent it altogether, so that non-union results. These conditions are mainly of a local, but rarely of a systemic, nature. Among the general diseases, syphilis has been considered in the past to be an important cause of non-union, but today it is not believed to be an important contributory cause of non-union of the fracture. Other diseases which interfere with the normal process of healing of bone are: rickets, osteo-malacia and scurvy.

Among the local causes, the improper reduction and ineffective fixation of the fracture fragments are the most important causes of non-union. Displacement
of fracture fragments, or their distraction, is sure to delay union, and these conditions may finally result in non-union of fragments if not corrected. Non-union is also often seen in cases of untreated fractures, as may occur in mandibular condylar fractures that may have remained undetected and where a pseudarthrosis is formed at the site of the fracture. The presence of infection is another very important cause of delayed union and non-union. It may be due to a tooth in the line of fracture or to osteomyelitis. Infection, if mild, prevents the formation of osteoblasts and, instead of bony union, fibrous union will result. In active suppurring processes, the vitality of the bone is destroyed. Bone absorption causes large excavations in the ends of fragments in which may be found pieces of dead bone of various sizes which become necrotic. Thus, a large defect is produced which cannot be bridged over with bone, and thus the fracture remains ununited, although the fragments may be pulled together by scar tissue.

Delayed union of a fracture should be treated by freshening the ends of the fracture fragments, or by bone drilling across the site of fracture, to be followed by proper impaction of the fragments and their effective fixation for the immobilization of the fracture. Open reduction is indicated, and the displacement or distraction, which may be due to a foreign body, the root of a tooth, or muscle tissue, reduced by their removal. Any infected tissue, sequestra or inflammatory granulation must also be removed. The ends of the bone fragments are then made raw, and bleeding obtained with the aid of a sharp bone file, but without any appreciable shortening of the fragments through loss of bony
tissue. Reduction and fixation of the fracture may then be proceeded with and the method chosen for fixation must give absolute immobilisation of the fracture. Alternately, if it becomes evident during the treatment that union will be delayed, bone drilling has been recommended. In this case, the fracture site is exposed with as little dissection as possible, and holes are drilled in the bone fragments with a slowly rotating drill. These holes are drilled from the outer surface of the bone through each fragment in an oblique manner, those near the fracture line passing across the fracture, and a number of holes are drilled in each part. These drilled holes will open up the spongiosa of the bone and secure the formation of small blood clots in the interposed scar tissue, and new granulation tissue will form, from which young osteoblasts may lay down bone to bridge the fracture. It is imperative that the fracture should be completely immobilised, and the choice of appliances in these cases generally consists of skeletal fixation of the fragments, together with a form of cranio-mandibular fixation for rigidity. The use of bone plates is often useful in these cases if the intermaxillary fixation of the fracture, for one reason or another, does not completely immobilise the jaw.

Non-union of a fracture is characterised by osteoporosis and varying amounts of resorption of the bone fragments, together with cburnation of the bone ends and the interposition of fibrous tissue between the fragments. These conditions bring about a loss of osseous tissue and prevent bone regeneration. The most common cause
of non-union, as already stated, is a localised osteomyelitis producing sequestration of bone in the line of fracture. The correction of non-union of fracture fragments, therefore, will always require surgical exposure of the fracture site to permit the removal of sufficient bone from the ends of the fragments to obtain fresh bleeding. The continuity of the outline of the bone must then be re-established and in these cases the only satisfactory treatment which will produce good results is the bridging of the gap by means of a bone graft, or by filling this gap with bone chips.

In cases presenting moderate bone loss between the fragments, Shira and Frank advocate the intra-oral insertion of homogeneous bone chips, if this bone loss occurs in the tooth bearing region of the jaw. Direct apposition of the fragments would result in the collapse of the arch with the resultant disruption of the occlusion of the teeth and, so, function. These men stress, however, that the use of these bone chips should be reserved for those cases in which the bone defect is relatively small. This method of treatment is not indicated for large bone defects with gross displacement of the fragments or, again, in those cases where sufficient intra-oral access cannot be obtained. Thus the use of bone chips grafts is indicated in cases of non-union, where the space between the bone fragments is narrow and the surface wide, as is often seen in cases of oblique fractures in the anterior region of the mandible. These bone chips are packed between the freshened bone ends, and bone chips, which are obtained from the ilium, are best suited. A vitallium plate is fitted to the inferior border of the mandible secured by screws,
to maintain the fragments and the bone chips in their correct position. The fixation is reinforced by the immobilisation of the mandible by means of intermaxillary fixation.

In order to bridge larger spaces, especially in the horizontal region of the mandible, rib bone grafts are used. In these cases, both fragments are decorticated at the fracture end, after which the outline for the graft is cut in the bone fragments to create a graft bed with a raw bleeding surface. A piece of rib, generally from the sixth rib, is then cut, shaped, and fitted like an inlay into the prepared area in each fragment. Holes are then drilled and it is wired into place, providing autofixation of the graft. The wound is then closed in layers and sutured, and further immobilisation of the fragments is obtained, either by skeletal pin or intermaxillary fixation methods. The immobilisation of the jaw in cases of bone grafting must be positive and stable. To ensure success of treatment in these cases, a fresh autogenous bone graft must be used, and on insertion its bed must be healthy, free from infected tissue, and well fitting.

A non-union complication of a condylar fracture can readily occur, as these fractures are frequently overlooked at the time of injury. The condylar fragment may be considerably displaced. The resultant union of the fragments is a fibrous one with the establishment of a false joint at the site of the fracture. Whether subsequent treatment of the non-union of the condylar fracture is indicated, will depend upon the severity of any symptoms complained of by the patient, and the degree of functional debility. If, because of these factors, an operative procedure is indicated
by way of an open operation, a conservative or a radical approach to the problem may be undertaken. The conservative treatment would consist hereof exposing the fracture site, the removal of all interposed fibrous tissue, the freshening of the bone ends to obtain bleeding, and the renewed reduction and impaction of the fragments. This procedure should be combined with an osteo-periosteal graft and immobilisation of the mandible, if possible. The radical treatment in these cases would consist of the operation of condylectomy, and the establishment of a permanent fibrous false joint. Condylectomy would be indicated in those cases where union of the fracture cannot readily be effected, or in cases where union is undesirable because of the condition of the temporo-mandibular joint. For example, in cases in which ankylosis of the joint has resulted due to comminution of the condyle, or, again, in cases where the temporo-mandibular joint would be unlikely to function normally due to fracture dislocation of the condyle.

6. Mal-united Fractures:
These will often cause deformity and asymmetry of the face. The mal-union of a fracture is usually an aftermath of improper reduction and ineffective fixation, resulting in displacement of the fragments. Loss of bone due to comminution of fragments, or the occurrence of osteomyelitis is another contributing factor in cases of mal-union. This is readily seen where the loss of bone would result in the fragments being pulled together in fractures of the horizontal ramus of the mandible, whilst, with a fracture at the angle of the mandible, bone loss would result in
the elevation of the ascending ramus. In both cases
defor mity would occur because the space produced by
the loss of bone is not maintained, and subsequent
fibrous scar contraction develops. Mal-occlusion of
the teeth is a serious complication in cases of mal-
union, and often open bite relationships may exist.
Traumatic arthritis may also be a feature, produced
by the dis-alignment of the vertical rams of the
mandible. This latter may not be serious if the con-
dylar displacement occurs in the direction of the
normal movement of the jaw. It may create, however,
a considerable disturbance, if the condylar head is
rotated and displaced in a lateral or medial direction,
either as a result of a displaced condylar fracture,
or a displaced fracture at the angle of the jaw.
Neurological signs are also common in cases of mal-
union, especially in relation to mandibular fractures.
The inferior dental nerve may be injured, resulting in
numbness of the lower lip, and sometimes paraesthesia,
when an amputation neuroma has formed.

Thus, the treatment of mal-union of a fracture of the
jaw must be symptomatic in nature and directed towards:
1. The adjustment of the occlusion.
2. The treatment of the neurological/complaints.
3. The correction of any deformity by means of
   osteotomy, the renewed reduction, and fixation
   of the bone fragments.

The adjustment of the occlusion may be corrected by
judicious spot grinding of the teeth. In the edent-
ulous patient, new dentures may be constructed, not
only to restore the correct occlusion, but also to
supply any necessary bulge to support the soft tissues
which may have lost their underlying framework.

The neurological symptoms may be self-correcting, but if impingement or section of the mandibular nerve has occurred, surgical intervention designed to de-compress the nerve or to re-establish its continuity in the mandibular canal is necessary.

For the cases presenting gross deformity which affects the facial appearance, as in excessive protrusion or retraction of the mandible, and in patients presenting an excessive overbite, then correction by open operation is necessary. This entails osteotomy, followed by renewed reduction and fixation of the fracture. The bone is generally divided at the site of the healed or partly healed fracture. In most cases this causes no great difficulty, since the new callus and the union between the cortical tissues can readily be severed by a sharp osteotome. In some cases surgical access may be obtained intra- orally, whilst in other cases an external incision is needed. The most important part of the operation is the renewed reduction and impaction of the severed fragments in their correct anatomical relationship, followed by their rigid fixation and immobilisation in order to prevent a recurrence of the deformity. Skeletal pin fixation combined with intermaxillary fixation and transosseous wiring of the fragments, may be employed. In cases where there is a space between the bone fragments when they are placed into a corrected position, a bone graft would be indicated.

Mal-union of condylar fractures is not, however, as easily corrected because of the technical difficulties of such an operation. Conservative treatment by means of physiotherapy should always be tried, but if
this fails to give a reasonable result, a good functional result can be obtained by condylectomy and the establishment of a fibrous false joint. Condylectomy would, therefore, be indicated for those cases presenting:

1. Partial or complete ankylosis of the temporo-mandibular joint.

2. Signs of traumatic arthritis.

3. Synarthrosis, due to blocking of the joint in comminuted condylar fractures, resulting in deformity.

No matter what specific treatment is instigated in the treatment of fracture complications, be it due to infection or otherwise, pre-operative anti-biotic medication should be commenced. A careful bacteriological study should be made of the infectious organisms, and one should test the action of several anti-biotics to find the one to which the organisms are most sensitive. The appropriate anti-biotic may then be employed. It should be continued during the treatment until all evidence of sepsis has subsided and, if possible, until a firm callus formation holds the fractured fragments, thus allowing the fixation appliance to be removed.
CONCLUSION

The treatment of traumatic injuries of the jaws demands of the oral surgeon a sound surgical procedure based upon a detailed knowledge of the surgical anatomy of the regions concerned, an understanding of the pathology of bone and tissue repair, a mechanical knowledge of the wide varieties of appliances which are used in the reduction and fixation of fractures of the jaws and, finally, attention to detail.

For successful therapy the following points are emphasised:

1. The necessity of a full examination of the patient:
   This examination must be both general and regional in nature and accompanied by a history of the patient. If there are any apparent signs of intra-cranial damage present, such as the occurrence of cerebro-spinal rhinorrhoea, an early consultation with a neurosurgeon is essential before any treatment is instigated. The presence of any debilitating disease such as diabetes, which has a profound impact on the healing of damaged tissues, must be recognised, and the patient's lowered tissue resistance built up by means of appropriate therapy. A patient's history may also bring to light any known allergy to one of the anti-biotic drugs, thus precluding its use.

Adequate radiography in association with the regional clinical examination of the patient is imperative. At any suspected fracture site, two radiographs at right angles to each other are necessary for the definite location of a fracture and for the direction in which the line of fracture runs.
2. The establishment of a definite plan of treatment:
   Respiratory embarrassment, and shock due to traumatic injuries may require immediate attention. Thus, the general treatment of the patient is as vital as the local treatment of traumatic injuries of the jaws.

3. The treatment of the soft tissue injuries:
   The infection of soft tissue injuries can present greater complications than the bone injuries themselves.

4. The control of infection of the injuries:
   All compound fractures of the jaws are complicated by infection. Unless this infection is controlled, delayed union of the bone fracture is always the rule. Teeth involved in a line of bone fracture should be extracted as they are a great potential source of infection. Strategic teeth, which are involved in a line of bone fracture and whose retention may facilitate the immobilization of the fracture, must be individually evaluated. Their retention is only considered safe for a maximum period of fourteen days if a full prophylactic anti-biotic control is employed. The anti-biotics are today regarded as the panacea for successful therapy in the control of infection. These drugs can, however, be used unintelligently and, consequently, ineffectively. It is emphasised that a bacteriological examination of traumatic injuries should be a routine procedure for the selection of the appropriate anti-biotic. One must also be conversant with the side reactions of the specific anti-biotic chosen. The use of these anti-biotic drugs is to be combined with the full asepsis of operation, together with prophylactic incision and drainage when indicated.
5. The early reduction of the fracture by the simplest and most conservative method which will provide the best functional and anatomical result:

The method of choice must depend upon the type and location of the fracture, that is its classification, upon the presence or absence of teeth in the dental arches, and upon the amount of displacement of the fractured fragments to be overcome, especially in relation to the muscular tension exerted upon these fragments.

6. The early fixation of the fragments in their correct anatomical position and the rigid immobilisation of the fracture for the time necessary for healing:

The fixation of fracture fragments is directly related to the method of reduction employed. Movement in a line of bone fracture, be it sub-traumatic or traumatic, will delay the union at best whilst, on the other hand, non-union of the fracture may result. The inadequate immobilisation of a fracture of the jaws for the time necessary for healing, is the greatest single local cause of mal-union of a fracture.

The methods of skeletal pin fixation and transosseous wiring of fracture fragments are popular today. These methods will afford the exact approximation and fixation of fracture fragments. They are particularly indicated in the control of fragments subjected to strong muscular tension. Skeletal pin fixation methods are ideal in the treatment of cases presenting non-union of the fracture due to considerable bone loss, whether it be due to comminution of the fragment or infection. This method will retain the fragments in their correct anatomical position and, at the same time, retain the space created by bone loss, for the future bridging by means of a bone graft. These two methods of fracture fixation can be carried out safely today since the advent of
anti-biotic therapy.

It is pointed out that the lack of success generally in the treatment of fracture and fracture dislocations of the mandibular condyle head, is attributed to the lack of adequate and correct coaptation and fixation of the fragments. Conservative treatment should only be used in cases with a very favourable prognosis. In cases of marked displacement of the condylar fragment and in cases of fracture dislocation, open reduction of the fracture is indicated. Finally, the immobilisation of the mandible, for a period of from four to six weeks, must be secured in all cases of transosseous wiring fixation of fracture fragments.

7. The adequate post-operative care of the patient:

This care must be a feature of the treatment employed in cases of traumatic injuries of the jaws.

If the above points are kept in mind when undertaking treatment for traumatic injuries of the jaws, I consider that the individuality of each case presented will be respected. Treatment by any one or a combination of the established methods, varied to suit each case, can then be undertaken with a favourable prognosis.
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