A critical review of the literature on Maxillo-Facial Injuries, in support of the candidature of J.D. Macansh, for the degree of Master of Dental Surgery.

1959
The major portion of the literature under review comes from two books: one, "The Dental Treatment of Maxillo-Facial Injuries", by Sir William Kelsey Fry and Terence Ward, second edition; and the other, "Fractures of the Facial Skeleton", by N.L. Rowe and H.C. Killey.

Use is also made of other books and journals mentioned in the bibliography at the end.

J.D. Macansh

1959

Royal Newcastle Hospital,
Newcastle.
Figure 1

A patient with very severe maxillo-facial injuries following a motor accident in which she was thrown on to the steering wheel and into the windshield.
"The most important single factor in reaching a decision should always be commonsense, based upon fundamental principles".

Fry and Ward.

"Needless to say, it is a wounded human being, not a fractured jaw with a patient attached to it, that is under treatment".

Fry and Ward.
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HISTORY

In the study of any progressive science, the historical background to the growth and development of that science must be given its due attention; and it is to the credit of such men as Rowe and Killey, and Thoma that they have given time to study and write about the early treatments given to maxillo-facial injuries.

Rowe and Killey lead us to believe that even in the pre-Christian era, some effort at the treatment of maxillo-facial injuries was made at times. It was poor by our standards, but the principle idea of immobilisation was the aim. In the early Christian era, teeth adjacent to a fracture were ligated together with horsehair, gold wire, and such like substances; a type of Barton bandage was developed; and we find during this time, the appointment of the first military surgeons. During the middle ages there was a general improvement of existing techniques, but no new treatments for maxillo-facial injuries; the main discoveries being in general surgery.

With the advent of gun-shot wounds in the sixteenth and seventeenth centuries, a great deal of concern was directed towards aesthetics, and use was made of dry sutures, prostheses were manufactured, and the art of plastic surgery was born. In the eighteenth and nineteenth centuries the first dental splint was used; "supporting" bandages developed; anaesthesia was discovered; and skin and bone grafting attempted with some little success. Splints and prostheses were improved to a stage that the Gunning splint, as we know it, was used successfully;
and the first cast splints were made. X-rays were discovered during this period; the theory of antisepsis expounded; and Le Fort carried out his classical experiments on cadaver heads.

This growth and improvement in maxillo-facial surgery lead to the great use of Gunning and cast splints during the First World War. Thoma relates how during this war the first attention was directed to maxillo-facial surgery was a specialty. This was due to the vast number of facial gun-shot wounds received. In the trench-type warfare, with the upper part of the body exposed, this is not surprising.

This specialty fell to the lot of men with no previous experience, and therefore their skill and ingenuity was put to the test. It was soon realised that haemorrhage and infection were the principal dangers to be faced in gun-shot wounds: these wounds differing from civilian injuries by the loss of bone. However, by the observation of case histories, the following conclusions were attained:

1. Save all possible bone, even if held only by a thread of periosteum.

2. Control haemorrhage by pressure, packing, clamping, and ligating.

3. Infections mainly localised, produced little in the way of general symptoms and was treated by irrigation.

4. Most deaths were due to pulmonary foreign body inhalation.

5. The mechanical exposure and perfect cleaning of wounds was a supreme necessity in all cases.
6. Early immobility limited haemorrhage, sepsis, and necrosis.

7. Teeth in the line of fracture act as a foreign body, increasing the chances of non-union.

Kazanjian (per Thoma)\(^2\) based his treatment on a classification of fractures, and bone grafts were used in cases of non-union.

Between the wars, vehicular accidents increased the number of facio-maxillary injuries, and the percentage of female patients increased as shown\(^2\):

<table>
<thead>
<tr>
<th>Year</th>
<th>Brawls</th>
<th>Vehicular</th>
<th>Miscellaneous</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915</td>
<td>46.5%</td>
<td>0.2%</td>
<td>37.7%</td>
<td>7.0%</td>
</tr>
<tr>
<td>1926</td>
<td>49.4%</td>
<td>8.0%</td>
<td>21.0%</td>
<td>10%</td>
</tr>
<tr>
<td>1936</td>
<td>35%</td>
<td>60%</td>
<td>5%</td>
<td>29%</td>
</tr>
<tr>
<td>1940</td>
<td>47%</td>
<td>8%</td>
<td>17%</td>
<td>12%</td>
</tr>
</tbody>
</table>

In the between-war period, maxillo-facial treatment was
generally improved and simplified. Open reduction was condemned in this period due to the risk of infection. There was a gradual improvement in the accuracy of diagnosis, particularly with regard to fractures of the mandibular condyle, where previously there had been much confusion.

During World War II there was a rapid development of "team work", and a formulation of first-aid along the following lines:

a. Diagnosis (Parrott)(per Thoma)²
b. Haemorrhage control
c. Cleaning of the airway
d. Cleansing and irrigation
e. Removal of foreign bodies (including teeth)
f. Reduction of fractures
g. Temporary fixation
h. Wound suture

Despite the multiplicity of fractures, the following developments took place; sepsis was controlled by chemotherapeutic agents; and open reduction became commonplace. With open reduction, wire sutures (figure of '8' wiring, lower border wiring), Kirschner wires, and Clouston-Walker appliances were used.

Gillies (per Thoma)² proposed the early reduction of fractured maxillae, and later, penicillin was introduced as a routine drug.

Such has been the birth, growth, and development of the treatment of maxillo-facial injuries, almost to the present day.
ANATOMY

The surgical anatomy of the face may be divided into three parts, the area above the pupils is known as the upper third; the middle third consists of the area between the pupils and the mouth; and the area below the mouth is referred to as the lower third. Convenience is made of these three zones to describe various facial injuries.

According to Fry and Ward, a thorough knowledge of surgical anatomy of the facial area is essential for the diagnosis and treatment of maxillo-facial injuries. This includes not only the surface anatomy, but also the osseous, muscular, circulatory, lymphatic and nervous anatomy.

The Bony Structures

By palpating the face, the following hard structures may be felt: the orbits, the nasal complex, the zygomatic prominence, the zygomatic arch, and the mandible. In the oral cavity, the alveolar processes, the teeth, the palate, the zygomatic process of the maxilla, and the mylo-hyoid and external oblique ridges of the mandible may be palpated.

Rowe and Killey describe the mandible as a "floating" bone articulating with the cranium, being both prominent and exposed, and therefore liable to injury. The cortical layer is quite thick in the mental region and also along the external oblique ridge, but in the ramus it is comparatively thin, and hence a partial reason for the weakness of the angle of the mandible.

The mandible is composed anatomically of two sections; the
mandible proper, and the weaker alveolus which supports the teeth. A child’s mandible is considerably weakened by tooth crypts, but at the same time it is quite elastic. With age however, the bone becomes hard and brittle, and the vertical height is reduced.

The neck of the condyle, being quite thin is very liable to fracture. Rowe and Killey describe this as a safety mechanism to prevent the head of the condyle being driven up into the glenoid fossa. Hence, a blow to the body of the mandible on one side is liable to cause a fracture of the neck of the condyle on the opposite side.

The teeth are a source of weakness to the mandible; more particularly the canines and third molars. However, during treatment, these teeth may be a guide to the correct articulation for that particular patient.

Having briefly considered the bony anatomy of the mandible, which is the only bone in the lower third region of the face, we find that the bony anatomy of the middle third is rather complex. It consists of two maxillae, two palatine bones, two zygomatic bones with associated temporal processes, two zygomatic processes of temporal bones, two nasal bones, two lacrimal bones, one vomer, one ethmoid bone and associated conchae, two inferior conchae, and four pterygoid processes of the sphenoid bone.

Although this is a large number of bones for such a small region, to some extent they may be treated as a unit; or as
will be shown later on in the classification of middle third fractures, three units.

Whereas the mandible is a freely movable bone with inner and outer cortical plates, and a well developed central cancellous portion; the middle third complex consists of thin bones with very thin compacta which act as a shock absorber between the maxillary teeth and the base of the skull. However, such structures as the orbits, the nasal cavity, and the maxillary sinuses tend to weaken the facial bony architecture by cavitation.

Joining this facial complex to the base of the skull is the sphenoid bone, which may be termed the 'keystone' of the skull. The 'upper jaw' consists of the major portion of the facial skeleton, and includes the roof of the mouth, the floor and walls of the nose and maxillary sinuses, and the floor of the orbits.

The normal force of mastication is transmitted from the relatively strong upper alveolus up certain "pillars". These "pillars" are the zygomatic processes of the maxillae, the frontal processes of the maxillae and the palatal processes of the maxillae which distribute the force up the vomer to the sphenoid bone.

The facial skeleton is therefore designed to resist vertical (masticatory) stress, but not horizontal stress, and it will be shown later that the medial section of this "upper jaw" complex is more easily displaced than the lateral.
The Soft Tissues

The soft tissues of the face are not thick, and is the reason given by Fry and Ward\(^3\) for the rapid healing that takes place in the region, and the freedom from gas gangrene. The antral, nasal, and orbital cavities provide effective drainage for the middle third of the face by acting as temporary reservoirs for the collection of blood and occasionally pus.

Since the facial soft tissue covering is thin, it is the bony structures which control the facial contour, and any alteration of this bony architecture will alter the shape of the face. Unlike the mandible, the muscle attachments of the maxillary complex are not important in fracture displacement, since any displacement in this zone is due to the force and direction of the blow alone.

The mandible, on the other hand, is the attachment for some extremely powerful muscles. Of prime importance among these are the muscles of mastication which can be divided into two types: elevator and depressor. As a group the elevator muscles are extremely powerful, and the temporal and masseter muscles may be seen and palpated during contraction just anterior to the pinna, above and below the zygomatic arch. The internal pterygoid muscle is not seen in action, but it is more powerful than the masseter.

The temporal muscle arises from the temporal fossa and
the temporal fascia, and is inserted in the deep surface, anterior border, and the apex of the coronoid process. Its fibres pull upwards, backwards, and slightly forwards.

The masseter muscle originates on the inferior border and deep surface of the zygomatic arch, and is inserted on the lateral surface of the ramus. Its action is upwards, forwards, and slightly outwards.

The origin of the internal pterygoid muscle is the medial surface of the lateral pterygoid lamina and the tuberosity of the maxilla. It is inserted into the medial surface of the angle of the mandible below the mandibular foramen. Its action is upwards, inwards, and slightly forward.

The depressor muscles consist of the external pterygoid, a muscle of mastication, and the supra-hyoid group of muscles.

The external pterygoid muscle arises from the infra-temporal surface of the greater wing of the sphenoid bone and the lateral surface of the lateral pterygoid lamina, and is inserted into the anterior of the neck of the condyle and the meniscus and capsule of the temporo-mandibular joint. On contraction, its pull is forwards and inwards (rotation).

The other depressor muscles arise from the lower border of the mandible and the mylo-hyoid ridge and are inserted into the hyoid bone or the median raphe. These muscles
while acting as depressors of the mandible, also act as elevators of the hyoid bone.

There is thus a very close bond between the tongue, mandible, and the supra-hyoid muscles; and therefore, the loss of the anterior part of the mandible permits the falling back of the hyoid-tongue complex resulting in respiratory obstruction.

The mandible is maintained in its position by a joint, the temporo-mandibular joint, and surrounding ligaments. This joint is diarthroid, or double, as in the knee. On opening the mouth, the head of the condyle rotates at first, but then it and the meniscus move forwards on to the articular eminence. This movement is limited by the capsule, and the temporo-mandibular, sphenomandibular, and stylo-mandibular ligaments.

Posterior to the head of the condyle is the tympanic plate of the temporal bone, and according to Fry and Ward, a heavy blow to the mandible may cause its fracture.

The blood supply to the middle and lower thirds of the face and associated structures is mainly by the lingual, facial, and maxillary arteries. The lymphatic drainage is by way of the "collar" chain and the superior deep cervical lymph glands.

Developed from the first branchial arch, the sensory
nerves of the middle and lower thirds of the face are the second and third divisions of the fifth (trigeminal) cranial nerve. The nerves pass through bony canals, and are therefore liable to injury if the facial bones are fractured. The motor fibres of the third division of the fifth cranial nerve supply the muscles of mastication and the mylo-hyoid muscle. The facial muscles of expression, the buccinator muscle, and the lower eyelid are supplied by the seventh (facial) cranial nerve. As these motor nerves do not pass through bony canals they are not often injured.

Though the above anatomical outline is very basic, its understanding is essential for the diagnosis, assessment, and treatment of facial injuries.
THE CAUSES AND TYPES OF FACIAL FRACTURES

The choice of placing causes and types of facial fractures under the one heading is because the cause of the fracture often dictates the type of fracture expected.

Fractures may be either simple or complex. Simple fractures may be caused by minor accidents (including vehicular), falls, and brawls; and generally there is little displacement of the fragments. The general condition of the patient is good.

A fracture at the point of impact is called a direct fracture; while a fracture remote from the point of impact is called an indirect fracture. Frequently, simple fractures are indirect.

Complex fractures may be either crush type or gun-shot. The crush type fracture may be caused by a vehicular accident; and with this type there is a multiplicity of fractures, both direct and indirect. The displacement of the fragments is usually great, with surrounding soft tissue trauma. The general condition of the patient is poor, and a fracture of the base of the skull, or 'whip-lash' trauma to the central nervous system may be suspected.

Gunshot injuries are caused by missiles (primary—bullets, shell, or bomb fragments; secondary—masonry, teeth, or bone).
There is gross comminution and loss of bone and soft tissue, and strangely enough, the general condition of the patient is often good. Rowe and Killey\(^1\) however state that shock is usually severe.

The writer has attended 198 facial fracture patients at the Royal Newcastle Hospital, and the causes of these were: Vehicular accidents, 79; brawls, 59; falls, 22; sporting injuries, 18; industrial accidents, 12; rural accidents, 5; gunshot, 1; and unknown, 1.

It is interesting to compare these figures with those of Tebo\(^6\) in America and Rowe and Killey\(^1\) at Basingstoke:

<table>
<thead>
<tr>
<th></th>
<th>Tebo</th>
<th>Rowe and Killey</th>
<th>The Writer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicular</td>
<td>41%</td>
<td>47%</td>
<td>40%</td>
</tr>
<tr>
<td>Brawls</td>
<td>33%</td>
<td>19%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Tebo\(^6\) also states that 33\% of his patients had had alcoholic beverages shortly before injury. The writer has no figures on this, but it would seem to be much the same at the Royal Newcastle Hospital.

**Displacement**

The displacement of fragments is due to the direction and severity of the blow and/or muscular pull. As the maxilla is unaffected by muscular pull, displacement of this complex is by the fracturing force alone. The mandible, on the
other hand is readily displaced by strong muscles attached to it.

The direction of displacement of the fragments is due to the pull of the muscles. The areas of attachment of elevator muscles only, are displaced towards the origin of these muscles. The areas of attachment of the depressor muscles (except the external pterygoid muscle) are displaced towards the hyoid bone. The external pterygoid muscle has a rotation effect on the head of the condyle which tends to be displaced inwards and forwards. When two or more sets of muscles act on a fragment, which is most usual, the resulting displacement is the resultant of the forces acting and their direction of action.

The amount of displacement can be affected by the occlusion and the soft tissues, including the periosteum. As mentioned previously, simple fractures are usually displaced little, while complex fractures result in much displacement. Maxillary displacement is due to the blow along, and may be in any direction according to the direction of the force. It is usually displaced backwards, in which case it is held firm by impaction, but it may be displaced upwards or downwards. If the maxilla is displaced downwards it hangs quite loosely. Sometimes there is lateral displacement of the middle third complex, as with a fractured zygomatic bone.
Typical Fractures

Fry and Ward\textsuperscript{3} illustrate the preceding remarks by typical types of fractures.

The head of the condyle may be rotated inwards and forwards by either traumatic force or the external pterygoid muscle. Such displacement however, may be due to dislocation, and not to a fracture of the condylar neck. A fracture of the true head of the condyle is also possible, and is known as an intra-apatcular fracture.

When the neck of a condyle is fractured the main body of the mandible is displaced towards the injured condyle, and the adjacent ramus is pulled upwards. (See Figure 2). A fracture posterior to the last molar tooth is usually an indirect fracture caused by a blow in the region of the bicuspid teeth on the opposite side of the mandible. This is particularly so of fractures involving unerupted third molars.

With fractures of the angle of the mandible, the elevator muscles tend to pull the posterior fragment upwards, inwards, and forwards: inwards, because the internal pterygoid muscle is stronger than the masseter; upwards, because of the temporal muscle; and forwards, because of the masseter muscle. (See fig. 3). The anterior fragment is pulled downwards and rotated towards the injured side. Of course
Figure 2.

A postero-anterior x-ray of a fracture of the left condyle showing displacement.
the upward displacement of the posterior fragment is limited by the maxillary teeth, the tuberosity, or the upper buccal sulcus.

Fractures of the mandible may be assessed, with regard to displacement, as favourable or unfavourable in two planes, horizontal and vertical. If for example a mandible is fractured in the region of the third molar tooth the fracture line may lie at various angles. From a lateral or horizontal view, the fracture line can run from the inferior border of the mandible, superiorly, and either anteriorly or posteriorly.

If the line runs posteriorly, the elevator muscles will pull the posterior fragment into the anterior fragment, and little displacement will result. This is known as an horizontally favourable - H.F. - fracture. If however, the line runs anteriorly, the elevator muscles will pull the posterior fragment upwards and forwards away from the anterior fragment. This results in marked displacement, and is known as an horizontally unfavourable - H.U. - fracture. (See Fig. 3).

From a vertical, occlusal, or postero-anterior view, the fracture line will run from the inner surface to the outer surface at a posteriorly or anteriorly inclined angle. If the fracture line runs anteriorly, the inward displacement
Figure 3

A lateral x-ray picture of the left angle of a mandible showing fracture and displacement horizontally unfavourable.
of the posterior fragment caused by the internal pterygoid muscle is prevented by the anterior fragment; and little displacement results, and is known as a vertically favourable - V.F. - fracture. Should the fracture line run posteriorly the posterior fragment is no longer prevented from being pulled inwards, and displacement results. This is known as a vertically unfavourable - V.U. - fracture. (See fig. 4). According to Fry and Ward\(^3\), this later type is rather rare.

Obviously there are combinations of these fracture types. There may be an H.F. with a V.F., or an H.U. with a V.F. Should the fracture lines run at right angles to the surface, the resultant displacement will depend on the force of the blow.

Fractures through the main body of the mandible will involve teeth and their sockets. The posterior fragment will be displaced inwards and upwards, by the elevator muscle, while the anterior fragment is pulled down by the depressor muscles and rotated towards the injured side.

A fracture through the symphysis menti will result in little or no displacement if it is simple, since the displacing forces will be equal. If the fracture is comminuted, the fragments will overlap and roll in towards the tongue. This is caused by the depressor muscles, and results in loss of tongue control.
Figure 4.
A postero-anterior x-ray of bilateral fractures of the angles of the mandible showing a vertically unfavourable fracture on the right side. (Same patient as figure 3).
When both mandibular condylar necks are fractured, the main body of the mandible is pulled upwards and backwards by the elevator muscles. This results in gagging on the posterior molar teeth. The condylar heads may be rotated inwards and forwards.

If the neck of the condyle on one side and the body of the mandible on the opposite side are fractured, it would be expected that they were caused by a lateral blow; the body fracture being the result of direct trauma, and the condylar fracture, indirect. The condyle may be rotated in and forward; the middle or anterior fragment displaced down and back at the symphysis, and up, in the region of the ramus; and the posterior fragment may be pulled inwards and upwards.

Bilateral fractures of the body of the mandible at or near the angle present an anterior fragment attached to depressor muscles, and two posterior fragments attached to elevator muscles. In the resulting great displacement, (see figs. 3, 4, and 5), the posterior fragments are pulled up and in, while the anterior fragment is displaced downwards and backwards, gagging open the occlusion. In comminuted fractures of this type, the displacement is maximal with possible loss of tongue control.

Double fractures on the same side are rare; the middle fragment is pulled down and in; the anterior fragment down and back; and the posterior fragment up and in.
Figure 5
A lateral x-ray picture of a fractured mandibular right angle showing displacement. (Same patient as figs. 3 & 4).
In the edentulous mandible, according to Rowe and Killey, the mucoperiosteum is tightly bound down to bone, which limits displacement. A fracture in the region of the symphysis may allow the fragments to overlap, horizontally. A fracture of the body of the mandible may allow the posterior fragment to be pulled upwards and inwards, while the anterior fragment is displaced downwards and backwards. If the fracture is comminuted, the anterior fragment is displaced down and back, and the posterior fragment is pulled up, in, and forward. Large displacements usually result from bilateral fractures of the body, as the posterior fragments are pulled upwards and inwards, and the anterior fragment, downwards. A fracture of the condylar neck may not be detected clinically, but the head could be rotated in and forward.

Not all possible facial fractures are considered here. The foregoing is merely a correlation of the causes of facial fractures, the common types expected, and their possible displacements.
CLINICAL DIAGNOSIS

Fry and Ward\(^3\) claim that x-rays are no substitute for a careful clinical examination, in which a written record is kept with the aid of diagrams as the examination progresses. They further state that re-examination is essential in doubtful or difficult cases, and warn against handling patients too much.

Rowe and Killey\(^1\) are most systematic and follow a regular routine to which the writer also adheres -

(a) History
(b) General
(c) Extra-oral
(d) Intra-oral
(e) Radiographic

(a) The history of the injury is obtained from the patient, relatives, or witnesses, and must include the time, date, and place of injury, for three reasons -

(1) the probability of infection,
(11) the prognosis
(111) medico-legal inquiry.

Other questions to be answered include those regarding the mode of injury, the direction, and the force, pain, and the degree and duration of the loss of consciousness, if any. In prolonged and/or irritable unconsciousness, cerebral damage must be suspected. However, one should not overlook alcoholic intoxication, cardiovascular disorder, diabetic coma, or epilepsy. Some inquiry should be made into
intra-oral haemorrhage, if any, indicating an open fracture (open to infection) or a laceration. A most important question to be answered relates to previous first aid treatment, including drug administration.

(b) During the general examination, the medical report is perused to assess the state of shock, consciousness, blood loss, respiration, and other injuries to the skull, trunk, and appendages. For harmonious 'team-work' it is essential to know what the medical colleagues are doing and their difficulties.

(c) Turning to the patients face, notes should be made of oedema, ecchymosis, dribbling, exudation, deformity, asymmetry, soft tissue injury, nose, ears and eyes. Next, the face is palpated: starting at the condyles and feeling for functional movement, the hands move simultaneously towards the symphysis. It is essential that both sides of the face be examined simultaneously with both hands to detect asymmetry and deformity. The zygomatic arches, orbital rims, and nose are similarly palpated. Notes should also be made of areas of anaesthesia about the face, diplopia, and widening of the face (dish face).

(d) During the intra-oral examination, the functional movement of the mandible should be tested, and would include - opening, closing, protruding, and right and left lateral movements. Foetor oris, signs and areas of haemorrhage, and the type and quantity of saliva are noted.
In palpating the buccal and lingual sulci, particular attention should be paid to detecting the difference between an haematoma and a bony deformity. Buccal emphysema could mean only bruising or a fracture. A sub-lingual haematoma is an indication that the periosteum is torn, and therefore, a fracture is likely. Lacerations should be looked for, particularly of the muco-periosteum of the mandible, the hard palate, and the tongue. Abnormal or 'gagged' occlusion would suggest a fracture, as would loose teeth and mobility of normally stable bone. The percussion of the maxillary teeth in a large or small fracture of the maxilla will elicit a dull note ('cracked cup') from teeth in the fractured region.

(e) Following a most thorough examination along the lines suggested, a careful assessment of the information obtained, and a clinical diagnosis, a radiographic examination is carried out. Generally, two x-ray views of a fracture are enough for diagnostic confirmation.

The writer follows a routine as suggested by Rowe and Killey\(^1\). For suspected fractures of the mandible, a postero-anterior, two lateral oblique, dental intra-oral if possible, and for fractures in the anterior region, occlusal radiographs are taken. For fractures of the maxillae, a postero-anterior, a true lateral, and an occlusal radiographs are taken.

As Fry and Ward\(^3\) continually emphasize in their text, the examination of the patient should be carried out with
the utmost care, gentleness, consideration, and at times diplomacy. The patient should suffer no pain during the examination, as when first seen, most patients with facial fractures are suffering little pain. This is also the writer's experience.

Some points in the method of examination outlined may seem trivial, but each has its purpose. Foetor oris for example, may seem to have little significance in maxillo-facial injuries, but it is a sign of the suspension of certain functions such as deglutition and tongue movement.

The writer would have liked to have seen some strong point made in the literature regarding empty tooth sockets and foreign bodies in the oral cavity. There have been two cases at this hospital in which semi-conscious patients have seemingly had adequate airways, but on strong aspiration following general anaesthesia, teeth have emerged from the pharynx. Another motor vehicle accident case had glass removed from the oral cavity in the operating theatre. Glass is hard to see in the mouth, especially with haemorrhage, but had a thorough palpation been carried out, or possible, it could have been removed some hours earlier.
RADIOLOGY

It is not intended to review the actual techniques of oral and facial radiology; this has become fairly standardised throughout the literature\textsuperscript{3,7,8}. However, radiological interpretation and the various views of different regions of the facial skeleton will be discussed.

From the foregoing clinical diagnosis the surgeon will have a very good idea of where the fractures will be, except in multiple fracture cases, where the more serious injuries will mask the symptoms and signs of lesser traumatised areas. Fry and Ward\textsuperscript{3} make it quite clear that x-rays can be quite misleading, but they can be an aid, and they are medico-legal evidence.

They further appeal for systematic interpretations of radiographs by firstly appreciating the angle of projection of the rays; by recognising gross bony structures, and tracing out such structures as the orbits, the zygomatic bones, the nasal processes, the antral walls, the cervical vertebrae, the body and rami of the mandible the coronoid processes, and the condyles. Next, the bony outlines of each side should be compared. Having clinically established a fracture in a certain region, the bony outline of this area on the radiograph should be traced carefully to find a break or step.

Where x-rays are able to pass between the bone ends, a dark shadow on the radiograph will indicate a fracture. (see Fig. 5).
If the x-rays do not pass between the bone ends, no shadow will result. (see left angle of fig. 4). If the ends of the fragments overlap, a lighter shadow will be obtained on the radiograph (See fig. 3). Thus, it will be seen that the shadows, or fracture lines, will vary with the amount of bone destruction, the displacement, the angle of projection, and the stage of repair.

As will be shown later, a fracture line widens during the earlier stages of repair. The edges of a fracture are sharp and well defined, and change direction by angles, not curves. They may also cross arterial and other natural lines of the bony skeleton. Fracture lines usually show a step or interruption, but with very oblique fractures with little displacement, these may be difficult to see in one view only. In postero-anterior, P - A., x-rays, the rays will pass through a V.F. fracture of the angle of the mandible, but not through a V.U. fracture. The V.U. fracture remains invisible. (see Fig. 4).

Radiographs of fractured maxillae are difficult to interpret, as continuous fracture lines are never seen. Fracture lines can be seen however, at the inferior orbital margin, near the fronto-zygomatic suture, the fronto-nasal suture, and the zygomatic arch. Stereoscopic x-rays are of course ideal, but they are not always readily available.

The superimposed shadows of certain normal structures can simulate a fracture line, and therefore great care in
interpretation is needed, together with x-rays from other angles. In lateral x-rays of the mandible taken from certain angles, the intervertebral spaces may suggest a fracture of any of the following — coronoid process, ramus, angle, or condyle. In P. - A., x-rays, these spaces may suggest a fracture of the maxilla or through the lower bicuspid teeth, or suggest apical rarefaction of the lower anterior teeth. The hyoid bone may suggest an overlapping fracture in the region of the angle, or sequestration, in lateral x-rays of the mandible. X-ray shadows of the soft tissues of the neck in lateral views may be superimposed over the lower bicuspid region to simulate a fracture. Pharyngeal air spaces may or may not cause shadows on a lateral x-ray to suggest a fractured angle. The bony sutures vary in width in different individuals, but they are usually widened by trauma. With artery channels, the edges are smooth, they branch arboreally, and they become narrower.

The main x-ray shadows of a fractured mandible are caused by the buccal and lingual cortical plates, but with oblique x-rays or fractures, these may cause two fracture lines. The area between these lines may seem separated, and could be mistaken for a sequestrum.

Fry and Ward also suggest progress x-rays. The first, to check the position of the fragments after reduction. In the mandible, clinical union precedes bony union by several months, but any excess widening of the
fracture line may be caused by infection or traumatic movement. Here, however, it is well to remember that with a different angle, a different radiograph will be obtained. Six to twelve months must elapse before bony union is demonstrated.

Infection or movement of the fragments will cause resorption of bone, and thus a widening of the fracture line. X-ray evidence of infection will not be visible for at least seven days after infection. Sequestra, or dead bone, is often hard to diagnose, as initially there is no difference between it and healthy bone. Later, a dark shadow forms a separation, the healthy bone becomes slightly decalcified, while the sequestrum remains the same. The vital bone is decalcified, and hence the "fluffiness" at the edges. The sequestra remain sharp with clear cut edges.

Non-union is relatively simple in diagnosis as the bone ends become rounded and smooth (eburnated).

Various radiographs are taken to 'highlight' certain structures. Thus:
A P.-A. of the mandible will show clearly, the body, the rami, and the condyles (See fig. 4).
The maxillary P.-A. (occipito-mental) will identify the orbital margins, the antra, the nose, the coronoid processes and the zygomatic bones.
A 30° occipito mental x-ray will define the zygomatic arches, the orbital margins, and the zygomatic bones. A true lateral x-ray will produce a profile of the facial bones.

An x-ray of the ramus, a 30° lateral, will show clearly, the ramus, the angle, and perhaps the condyle. (See figs. 3 and 5).

A rotated 30° lateral view, or lateral of the body, will show the angle, and the body as far forward as the canine tooth. To radiologically view clearly the anterior region of the mandible, an occlusal film may be taken, or a 20° rotated P.-A.

Dental films will show the relationship of teeth to the fracture line.

An accurate x-ray of the condyle and the temporo-mandibular joint may also be obtained by a special method.

Thus, radiographs will confirm a clinically diagnosed fracture and demonstrate the amount of displacement of the fragments. It has been the writer's experience that to look at x-rays before the patient has only led to confusion because of a precognition.

In this atomic world, a word of warning regarding radiation may not be out of place. It would seem from various reports that radiation in our part of the world has not yet reached dangerous levels, but it behooves those
in whose power it is, to keep it so, or reduce it. Thus, only those x-rays considered necessary for the case should be obtained. Unnecessary radiographs may only add to the patient's discomfort; be a waste of time and money; and perhaps be a radiation hazard.
OBJECT OF TREATMENT

The most important object of maxillo-facial treatment is function. If function is restored to the patient, the result is good, no matter what else. So say Fry and Ward. Rowe and Killey add that the precise repositioning of fragments is very necessary to avoid malocclusion and impaired masticatory efficiency.

The value of the patient's appearance differs from patient to patient. It matters least with men; more so with married women; and most of all with girls.

The speed of treatment is also important. It could mean less cost to the patient, less cost to the hospital, less unemployment, and less psychic trauma.

Thus it would seem that a compromise between these three objects is essential for the majority of cases. A little deformity would be accepted in the interest of speed, since there is no point in striving over a long period for perfection. Aesthetics are not unimportant, and a surgeon must judge the patient's attitude to their appearance. With function, however, it is a different proposition, and the surgeon should strive for a perfect result; but, at the same time he should keep a sense of proportion.

Ambulant hospitalized patients with maxillo-facial injuries often present a problem if they have been a patient for very
long. Some tend to become a "professional" patient and like the hospital life. Their fear is to have to look after themselves when they leave, and one must be on the watch for malingers.

Fry and Ward\textsuperscript{3} suggest mental treatment as well as physical treatment for patients hospitalized for any lengthy period. Boredom saps the mind of energy, and therefore occupational therapy or light jobs are essential to keep patients occupied. Small daily tasks after a week will help to avoid a chronic attitude, and patients should be discharged to outpatient care as soon as possible.

Patients grossly disfigured for life should have vocational training as soon as possible to overcome the mental stress, and allay their anxiety. In such cases, aesthetics do matter, and particularly to the patient. A plan of treatment and prognosis should be given to the patient with discretion, together with the idea that everything humanly possible is being done for them.

In cases where their own or family welfare is a worry, the hospital almoners should be called.

There is no doubt that special maxillo-facial centres\textsuperscript{1,3} are the best hospitals for treatment, but in such places the surgeon should beware of the patient who "gains a little knowledge." No patient should have the opportunity of seeing their own records.
Post-treatment follow-up examinations should be made at appropriate intervals to check on the results of treatment, and to adjust any prostheses if necessary.

It will now be apparent that the treatment of maxillofacial injuries may call for the services of a number of ancillary workers, as well as medico-dental specialists.
ASSOCIATED INJURIES

It is not uncommon for a patient suffering maxillo-facial injuries to be admitted to hospital with other injuries, sometimes serious enough to delay maxillo-facial treatment. Although these other injuries may be outside dental treatment, they should be understood and appreciated. Particularly is this so of shock.

Although injury predisposes shock, the aetiology is a source of disagreement, but certain features are common always. According to Fry and Ward\(^3\), even the word "shock" suggests different ideas to different people. The patient may seem quite well, or they may have lost much blood and be in a state of collapse with Cheyne-Stokes respiration. Usually they are pale, cold with a sub-normal temperature, sweaty, and have a low blood pressure with a rapid pulse. There is usually nausea and even vomiting, and the mental state may be dulled, or clear and anxious.

Conditions that predispose these features include injury, crush or bone injury; haemorrhage, internal or external; cold, anaesthesia, and an emotional state before the accident.

Such cases are assessed and treated on their merits, which includes arresting haemorrhage, replacing lost fluid to restore the circulating blood volume, maintaining a normal body temperature, providing adequate oxygenation, and relieving pain and anxiety. The restoration of the circulating
blood volume is most important, and for this, whole blood, plasma, or dextran glucose-saline is used intravenously. Of these, whole blood is the best, but its use is usually reserved for the more serious cases, and haemoconcentration is no contra-indication for its use. However, the blood must be cross-typed, and this takes time. Plasma and dextran are retained in the vascular tree, whereas the glucose-saline is lost to the tissues. If the blood loss is not severe, one to two pints may be administered fairly rapidly, and then a pint of blood or plasma is given slowly. With a large blood loss and severe shock, a larger quantity should be given over a longer period. The best indications to restore the blood circulating volume are a rapid weak pulse, and a low systolic blood pressure.

A patient in a state of shock should not be over heated, as this will cause peripheral vasodilatation, and this in turn causes a loss of circulating fluid. Sweating only aids the fluid loss. On the other hand, the patient must not be chilled; natural (body) heat is the best, which is obtained by a light covering of bedding as suggested by Bradley. To relieve pain, patients should be given as a maximum, morphia (except with cerebral injuries) grains one quarter, pethidine milli-grams 50 to 100, or phenobarbitone grains three. These are best given parenterally.

As soon as possible after resuscitation the patient
should be taken to the operating theatre.

A blow on the face sufficient to fracture the facial bones often causes some degree of cerebral damage, from concussion or bruising to severe laceration of the cerebral substance. With concussion, the symptoms are transient and are caused by transient cerebral anaemia. This may be followed by oedema, causing headache, vomiting, and drowsiness. However, these symptoms have usually disappeared in 24 hours.

The symptoms of cerebral damage last longer than 24 hours; and are caused by the rupture of small cerebral veins and capillaries producing an extravasation of blood in the form of petechial haemorrhages throughout a large area, or larger haemorrhages at the point of impact or contre coup. These symptoms vary from occasional headaches, giddiness, nervousness, and loss of concentration to severe headaches, drowsiness, stupor, coma, or death. Severe cases may take a year or more to recover, and commonly recovery is incomplete. With these patients, pre-existing psychoneurotic trends are accentuated and inhibitions are released.

Further, Dandy (per Crowe and Kelly) states that three quarters of all internal carotid-cavernous sinus fistulas result from trauma. Raaf and Swan add that traumatic carotid-cavernous sinus aneurysm occurs in about one in 400 cases of head trauma. To diagnose such cases, Crowe and Kelly look for engorgement of the orbital contents and
eyelids with transmitted arterial pulsations; severe headaches with a buzzing noise in the head and ears, which varies from a slight buzz to a roar; projectile vomiting; and diplopia. The exophthalmos may be unilateral and the bruit may be heard. They further state that such lesions may result from trauma sufficient only to fracture the mandible.

In addition to cerebral damage a patient may have a fracture of the base of the skull. With severe maxillo-facial injuries this may not be easy to diagnose, and it could be missed.

A fracture of the anterior cranial fossa is indicated by cerebro-spinal rhinorrhoea. This may be tested for sugar to distinguish it from mucous. These fractures are usually relatively simple and the patients survive. Occasionally however, the second, third, fourth, opthalmic division of the fifth, and the sixth cranial nerves may be affected.

Cerebro-spinal fluid escaping from the ear would indicate a fracture of the middle cranial fossa. This could be accompanied by a continuous flow of dark coloured blood, which must be examined to confirm that it is not justameatal laceration. The maxillary and mandibular divisions of the fifth, the sixth, seventh, and eighth cranial nerves may be affected.

If the posterior cranial fossa is fractured, the head of the patient is held retracted. After two or three days
ecchymosis appears posterior to the mastoid process. The patient is deeply unconscious and the injury is likely to terminate in death. The ninth, tenth and eleventh cranial nerves may be affected.

As well as associated injuries, patients with maxillo-facial trauma may be suffering certain diseases such as syphilis, tuberculosis, anaemia, diabetes, or a vitamin deficiency. They should be diagnosed and treated.

A newly admitted patient must therefore receive a thorough examination by medical as well as dental specialists, and each consultant should advise his colleagues of his discoveries and proposed treatment.

At this hospital, all accident cases are admitted under "Accident Service" which is controlled by the Orthopaedic Department. Following their examination, the patient may be transferred to another service (dental, surgical, ophthalmic, etc.) for treatment, or consultants may be called to assist with treatment (dental, surgical, urological, E.N.T., medical, etc.).
PRELIMINARY TREATMENT.

The preliminary treatment varies with the amount of hard and soft tissue damage. The patients' general condition should be attended to first, and this includes maintaining the airway, arresting haemorrhage, controlling shock, preventing infection, and controlling pain. The early local treatment suggested by Rowe and Killey⁴ includes the removal of gross debris, wound cleansing, an examination, and first aid.

Should the tongue tend to fall back and occlude the pharynx, it may be held forward with the aid of a suture through the apex.

Intra-oral haemorrhage is not usually severe, and spontaneous arrest follows. Severed vessels in the soft tissues however, may need ligating. Resuscitation has been discussed earlier, and the control of infection will be discussed later.

The use of drugs to control pain and sedate the patient has also been mentioned. The writer has found that, but for exceptional cases, mist A.P.C. and codeine is most effective and well tolerated. The majority of cases dislike feeling drowsy or "funny". The pain, apart from being caused by the original injury, is sustained by mobile fragments. This can be controlled by a barrel crepe bandage.

The transportation of such patients is mainly of
military importance, but in transferring patients from one hospital to another, the clear airway and the general condition of the patient must be maintained. The patients should be quite comfortable and free of pain; preferably sedated.

Included in the removal of gross debris is the removal of dirt, and very loose teeth, portions of teeth, crowns, and restorations (dentures, loose bridges, and fillings), to prevent inhalation. Foreign bodies such as stones, glass, and metal are removed, as are blood clots and loose bone.

Here, Rowe and Killey¹ emphasize the importance of lubricating the lips with a cream or petroleum jelly. Dried blood and mucous can make the lips quite hard, and very liable to split during subsequent procedures. The lips should be kept moist at all times.

To cleanse the mouth, it may be syringed if the patient is incapable of rinsing with any or all of the usual agents. These agents, N. saline to remove food and other debris, 3% hydrogen peroxide to remove blood, and 4% sodium bicarbonate to remove mucous are used warm.

Following the oral toilet, the clinical and radiological examinations are carried out as outlined earlier. The results of those examinations will direct treatment along certain lines, and as a permanent form of treatment takes time to be implemented (e.g. cast splints), some temporary fixation is
indicated to help alleviate pain and discomfort.

The simplest form of temporary fixation is the barrel bandage. This is a bandage two inches wide which is placed around the head a few times just above the ears, and eyebrows, and far enough inferiorly posteriorly to engage the external occipital protuberance. It then changes direction to a coronal plane passing just anterior to the ears, under the mandible, and to the vertex of the head. It is safely secured at the two crossings. A four-tailed bandage should never be used as this only helps in displacing the mandible posteriorly.

The authors of both tomes\textsuperscript{1,3} insist that non-stretch material should be used, yet both suggest elasto-plast as an alternative. Rowe and Killey\textsuperscript{1} suggest the use of rubber dam under the mandible attached to a webbing head cap.

The writer still prefers a crepe bandage only slightly stretched for these reasons: 1. The section around the head can be placed more on the stretch, thus giving better retention. 2. The coronal section can be firm, but not tight: firm enough to fatigue displacing muscles. 3. In an emergency, e.g. vomiting, the patient can still open his mouth against the slight stretch.

Rowe and Killey\textsuperscript{1} in discussing bandages, state that the constant activity of the muscles of the floor of the mouth during deglutition necessitates absolute immobilization by
direct control of the fragments via the teeth or other means. External bandages are therefore only of limited supporting value as a first-aid measure, and quite useless as a permanent means of fixation.

If the patient is not going to the theatre in the immediate future, or has been, fluids may given orally or intra-venously to avoid dehydration.

In place of the barrel bandage, some form of inter-dental or arch wiring may be used as semi-permanent fixation. According to Fry and Ward, fractures may have to be treated under all sorts of different circumstances, and the choice of treatment available may be limited. However, if the basic principles are understood, some value will result, even if it only relieving discomfort. Even in ideal circumstances the best treatment is sometimes difficult to determine; but if common sense, based on fundamental principles, is used, a satisfactory result will be obtained.

The aim of the treatment is to reduce the displaced fracture, to immobilize the fragments, and to control infection.

The types of fixation available are:

1. Chin straps (for children)
2. Interdental, arch, and eyelet wiring
3. Cast and acrylic splints
4. Gunning splints
5. Wire sutures (figure of '8', lower border, alveolar
6. Clouston-Walker appliance\(^1,3,16,22\)
7. Circumferential wiring\(^1,3,16,\)
8. Kirschner wire\(^1,3,16,23\)
9. Metal plates\(^1,3,24\)
10. Plaster head-cap fixation\(^1,3,14,15,16\)

As to which type of fixation is the best, Fry and Ward\(^3\) propose each case be judged on its merits. Of course some methods are essentially for a particular type of fracture. Stoopack\(^25\) says: "In the majority of cases, mandibular fractures, including fractures of the condyles, can be reduced conservatively by closed reduction. The simplest method of treatment that results in anatomic alignment of the fragments, a normal healing process, and a functional mandible with functional occlusion is the method to be preferred."

In short, the aim is to provide a treatment that will result in perfect function, and good aesthetics in the shortest possible time.
FEEDING.

Fry and Ward\textsuperscript{3} give considerable attention to the dietary problem for patients with maxillo-facial injuries.

They assert that fixation does not interfere with feeding very seriously if the right food is properly prepared and presented, and the patient shown how to take it. Even the worst cases can be fed from a feeding cup with a rubber spout. External extensions may have to be overcome; it is difficult, but it can be managed.

The value of the calorific intake per patient must be 1700 calories per day. To this must be added six pints of fluid per day. A vitamin supplement should not be necessary if the food is of good quality and cooked properly. This includes vitamin C, which is essential for callus formation. Some roughage however, is essential for peristalsis and bulk.

The food should be appetising: liquid foods are monotonous and look alike. Therefore, they suggest the use of sauces, colour, and decoration; and dividing the meal into courses.

The time taken to consume a meal is a very real problem. With fixation, the intake is slow, and therefore the food becomes cold, and the patient tired of "eating". It is suggested therefore, that small meals be provided every few hours. Dietary aid should always be sought in the more difficult cases.
At the present time at the Royal Newcastle Hospital normal meals are being prepared for these patients, but each course is passed through a 'Vitamizer' or 'Blender-mix' type of mixer. This renders the meal capable of easy consumption. The resulting mix may not look very attractive, but it has colour and flavour.
SURGERY.

Since the bony skeleton of the face controls the aesthetic contours, it is of the greatest importance that bony surgery be completed before the soft tissues.

**Hard Tissues.**

The most important principle above all, according to Fry and Ward\(^3\), is the early, efficient, and continued immobilization until union is achieved. An haematoma, granulation tissue, and osteoid tissue are elastic, but the original blood clot must not be disturbed or dislodged, if at all possible. Hence immobilization. The better the immobilization - the less chance there is of bony infection, or indeed, soft tissue infection.

In uninfected regions, the fragments may be immobilized in their correct functional positions until they are united.

Drainage should be instituted in infected regions, but infection should never be anticipated, Starr and Arnott\(^{16}\) declare that external drainage is indicated by a high temperature together with gross sepsis and oedema, or an infected haematoma. They further state that such drainage is unwarranted in the presence of a healthy blood clot; in the absence of foetor oris; with soft oedematous swellings of soft tissues; in the absence of foreign bodies; or with a satisfactory temperature, pulse, and respiration of the patient.

According to Fry and Ward\(^3\), the body can overcome most infections, but if infection seems certain to occur, a drain may be placed at the time of suturing.
With comminuted gun-shot wounds, all possible bone should be left in place as a base for the establishment of osteoid tissue, and this bony union. If there is pus, then the area must be drained. Foreign bodies should be removed from between the fragments, but metallic objects may be left in the soft tissues. Wood should always be removed as it remains a harbour for organisms.

The writer treated a 13 year old boy who received a .22 calibre bullet wound to the left side of the face. The projectile entered the soft tissues of the cheek near the left commisure of the mouth, and travelled in the soft tissues without any other oral or external communication, fracturing the left angle of the mandible. Cast open ferrule coin silver splints were cemented over his erupted teeth; the displacement was reduced by elastic traction; fixation was applied for 83 days; and external drainage was established and maintained when necessary. For most of the period of fixation pus drained from the area. Progressive cultures of the pus showed that the organisms quickly became immune to the sulphonamide drugs and penicillin when used. No other antibiotics were used because the infected area was quite localised and the patient quite well. Following some bony union after 83 days a surgical debridement was carried out, suppuration then ceased, and all lesions healed. Debridement was delayed until after bony union, as it was considered that early surgery would delay osteogenesis by leaving a large bony defect. (See fig. 6)
Teeth in the line of fracture and infected teeth near the line of fracture should be removed, as they are a source of infection and act as a foreign body. Union is sometimes achieved with a tooth left in the line of fracture, but it is a risk which should be taken on rare occasions when it is required for reduction or fixation. Unerupted (impacted) lower third molar teeth are best left in situ when in the line of fracture, due to the trauma caused in their removal. However, a close watch should be maintained on these teeth. Teeth left in the line of fracture and becoming infected, are quite loose and more easily extracted in a week to ten days. Permanent tooth crypts are also best left in situ unless they become infected. Teeth near a line of fracture also have to be treated as suspect, as do infected teeth in other areas of the mouth. Such teeth may be essential for reduction and fixation.

Dead bone should be removed as it separates from the living bone. Removal before separation will help spread the infection, but during sequestration, the pus should be drained away or an abscess will form. Sequestra may be diagnosed clinically and radiologically. A sequestrum will feel quite rough to probe, whereas living bone is smooth. Radiographically a sequestrum is denser and has sharper margins than vital bone. Should a sinus be present, the cause should be found and removed if possible.

An abscess should be drained when fluctuant, from the most dependant point. Osteomyelitis is quite uncommon, but
Figure 6

A radiograph of the left angle of the mandible of a thirteen year old boy showing gunshot destruction and fixation. Two weeks after injury.
is the result of acute infection; perhaps from a tooth in the line of fracture.

In 198 cases of maxillo-facial injuries, the writer has seen one case of osteomyelitis. He was a young man who presented for treatment ten days after injury, with a tooth in the line of fracture. His dentition was very good, but his oral hygiene was poor. Chemotherapy and antibiotics had no effect, but after sequestrectomy, suppuration ceased and the lesion healed.

Since the presence of pus hinders repair, it is important that it be removed by drainage. Drainage is best established by Hilton's method, either beside or below the fracture, but never through it. Gauze should never be used as a drain: the finger of a rubber glove or corrugated rubber is the best. The drain should be firmly secured in position by sutures or strapping, but it must be moved daily to keep it free.

The drain should not be removed until the infection is under control, i.e., there is no swelling or discharge. Hypertrophic granulations may occlude sinuses quite commonly, and this hinders drainage. Such tissue should be removed to keep the sinuses patent and uncover any hidden sequestra. Fistulae are uncommon, (see fig. 9), but persistent sinuses, caused by prolonged suppuration and drainage, require surgical removal.

Secondary haemorrhage, seven to fourteen days after
injury, is caused by infection rupturing a related blood vessel. If the haemorrhage cannot be controlled by the usual methods (packs, pressure, sutures), a vessel may have to be ligated at a distance from the bleeding point. This is not uncommon in gun-shot wounds. Collateral circulation may be a further complication.

A high temperature is usually indicative of infection. Should this infected area be under pressure (an abscess), the temperature could swing three or four degrees. However, should the area be spreading (cellulitis), the temperature will continue to rise and swing. Once drainage is established the temperature will fall, but a small post-operative rise may occur. Diagnosis by chart signs is not infallible; judgment and other signs and symptoms are required to confirm any such diagnosis. For example, the absorption of an haematoma may cause a temperature rise. At the same time, a normal chart is not an indication that no infection is present: it merely signifies that the body is controlling any infection.

Maxillo-mandibular fixation is not deleterious to the temporo-mandibular joints. Some limitation of movement is experienced when fixation is first removed, but it does not last long. Immobilization produces better healing with hard and soft tissues; lessens the strain on the teeth where only a few are present; and lessens the strain on wire sutures or external appliances. Early functional movement is contraindicated until clinical union is achieved.
The disturbance of an haematoma or granulation tissue hinders repair, and if the lesion is open, it may lead to infection. Such disturbance may at times be unavoidable as with tooth extractions or a debridement. Particular care should be exercised during general anaesthesia that no excess trauma is caused. The extraction of teeth in the line of fracture is usually fairly easy if a little care and patience is exercised.

During the early stages of treatment patients require constant care by the nursing staff, and particular attention must be paid to the oral hygiene. Regular mouth washes or irrigations are essential, After splinting, the patients may use a child’s toothbrush to cleanse the accessible areas.

Only after clinical union is expected should a fracture be tested for union, and then with care. For a fracture of the angle, the hands are placed in the regions of the ramus and symphysis and mobility tested. Similarly for a fracture in the molar region. For fractures in the bicuspid and anterior region of the mandible, the hands are placed either side of the fracture area and mobility tested. Fractured condyles are tested by palpation during function; while the maxillary component may also be tested for mobility.

Radiological evidence of callus formation is seen quite early in fractures of the long bones, but in the jaws, evidence of healing is not seen for months.
Thus, bony trauma is treated by immobilization, aided by care and cleanliness.

**Soft Tissue**

In all facial injuries, the disimpaction, replacement, and immobilization of the hard tissues takes preference over the repair of soft tissues. Wound debridement, according to Fry and Ward\(^3\), as practised upon other parts of the body, has no place in maxillo-facial surgery. The blood supply of the face is so good that crushed and bruised tissues will survive, where elsewhere they would die.

According to the anatomists\(^{26}\): "The skin is the chief insertion of the facial muscles. Wounds of the face tend to gape, and require numerous stitches, for the fibres attached to the skin draw the margins of the wound apart."

Rowe and Killey\(^1\) state that with every fracture there is some soft tissue injury, and in five per centum there is skin laceration or abrasion. Such an injury becomes of major importance to the patient.

The hair surrounding a wound should be shaved, except for the eye-brows. Exposed tissues should be identified, and the lesion swabbed with soap and water away from the centre of the wound. Scrubbing with a brush may be necessary to remove all the dirt. Fry and Ward\(^3\) state that road dirt can tattoo a wound leaving a tragic cosmetic result. In the Newcastle district, the scars of coal miners' wounds are frequently tattooed.
If the wound is less than 48 hours old, primary suture, and healing by first intention is the aim. Bleeding vessels are clamped and ligated; and tissue that will not survive is removed. Ragged edges are trimmed to straighten the line of suture, and the skin is undermined. Soft tissues should not be drawn together under tension - they should be just held together. If approximation of the tissues is difficult, the area may be packed.

The sooner the tissues are sutured, the better the result will be. For a full thickness closure, the mucous membrane is closed by 2/0 gut, the intermediate tissue (muscles) by loose 3/0 gut, and the skin by 4/0 black silk to approximate the edges.

If the wounds are older than 48 hours, or if there is great loss of tissue, as in a gun-shot wound, the wounds may be packed, and healing by granulation will result. Skin may also be sutured to mucous membrane, and later, skin grafts and flaps can repair the defect.

Exposed bone will cause much pain and die if it cannot be covered. It is better therefore, to remove such bone to allow soft tissue coverage.

With this type of injury, co-operation with a plastic surgeon is of the utmost importance to avoid unnecessary disfigurement. (See figs. 7 and 8).
Figure 7.

Same patient as figs. 3, 4, and 5, in operating theatre, following removal of lower right third molar tooth, bony debridement, and cementation of cast open ferrule coin silver splints. The soft tissue debridement and closure is about to be carried out.
Figure 8

Same patient as figs 3, 4, 5, and 7, after four weeks immobilization. The left side healed well, but the major portion of the right side healed by granulation despite suturing; it was four days after accident before final closure. Note fistula present.
The avoidance of infection is one of the aims of the treatment of maxillo-facial injuries. This may be wholly or partially achieved by cleansing the wound, surgical efficiency (including drainage and immobilization), chemotherapy, and antibiotics. Wound toilet and surgical efficiency have been discussed, and will be discussed under other headings. This section will be restricted mainly to the use of antiseptic drugs.

Fry and Ward\(^3\) state that the sulphonamides interfere with the bacterial metabolism of para-aminobenzoic acid. The organisms require this substance and thus their growth is inhibited, but they are not killed. Penicillin interferes with the metabolism of glutamic acid, which is essential for the growth of the organisms. Other antibiotics interfere with other bacterial enzymes.

Which ever drug is used, it must contact the organisms by surface application or through the blood stream. To be effective, the sensitivity of drugs must be tested against cultured samples of collected pus, and only the inhibitory drugs used.

Drug allergy, (skin rashes and fever) is rare according to Fry and Ward\(^3\) and is controlled by the use of anti-histamine drugs. Drug allergy, and indeed, hyper-sensitivity, is not so rare now according to Lane\(^{27}\), Caldwell\(^{28}\), and Thomson\(^{29}\).

Fry and Ward\(^3\) do say however, that the use of antibiotics can
change the oral flora. Monilia (thrush) may appear, and is treated with a dye such as gentian violet. A change in the intestinal flora may be the cause of diarrhoea, and the drug should be changed.

The sulphonamide drugs can cause anuria because of the crystallization of the drug blocking the renal passages; or anaemia because of bone marrow damage. Penicillin can cause an allergy, or a hypersensitivity leading to collapse and death. Streptomycin is known to cause deafness, and other antibiotics may cause nausea, diarrhoea, or bone marrow damage.

The efficient penetration of drugs depends on the adequate concentration reaching the affected areas by way of the bloodstream if given for a long enough period. The administration of a large selection of drugs is no trouble. The sulphonamides, four to six grammes per day with an extra two grammes "loading dose", are given orally. Penicillin is given intramuscularly: 600,000 units of procaine penicillin per day, together with an initial dose of 600,000 units of crystalline penicillin. Other antibiotics are given orally.

Considering the oral flora, infection in the mouth is not common. Bjornesjo found that there is antagonism between the normal and the pathogenic oral flora; the former overcoming the latter and this constituting a valuable defence mechanism against oral infection.

In view of this, the excellent blood supply of the oral
region, and the numerous penicillin resistant strains of staphylococci, it seems that the prophylactic use of antibiotics is unnecessary, wasteful, and dangerous. Dangerous, because other resistant strains may be established.

During the years 1952, 1953, the writer used antibiotics prophylactically and obtained infection rates of 11% and 18% (including one case of osteomyelitis), respectively. For the years 1955, 1956, 1957, and 1958, not using antibiotics prophylactically, the infection rates were nil, 9% (including one gunshot wound), 18%, and nil respectively; the average for the six years being 9%. Prophylactic therapy is taken as meaning the routine use of antibiotics for all maxillo-facial injuries, commencing at the time of admission. Infection is taken as meaning the sight of pus.

It will be seen therefore that there is little difference between the prophylactic use and the non-prophylactic use of antibiotics at this hospital. Rowe and Killey\(^1\), Fry and Ward\(^3\), and the Americans Clarkson\(^31\), Kwapis\(^32\), and Howell\(^33\) favour prophylactic use of antibiotics for maxillo-facial injuries. Lane\(^27\) states that antibiotics should only be used to save a life. Their use at other times may cost a life, either directly or indirectly. Caldwell\(^28\) says: "Proper sterilization and care of instruments, good operative technique and surgical judgment have always been requisites in surgery; these requirements have not been altered by drug therapy." Thomson\(^29\) warns of the danger of the prophylactic use of antibiotics and calls for
aseptic surgical techniques. Where infection is present, pus should be cultured, organisms identified, and sensitivity tests carried out.

Fry and Ward⁴ warn than an infection may be actinomycosis or osteomyelitis. In seven years, over 350 cases of maxillofacial injuries have been treated by the Dental Department of the Royal Newcastle Hospital and there have been no cases of actinomycosis, and only one case of osteomyelitis.

Rowe and Killey¹ also advocate the prophylactic use of anti-tetanus serum.
FRACUTRES OF THE MANDIBLE

Rowe and Killey\(^1\) classify fractures of the mandible in a number of ways under various headings.

Causes - (1) Direct violence

(11) Indirect Violence

(111) Muscular contraction

Types - (a) Closed simple (no visible soft tissue damage).

(b) Open simple (tooth in line of fracture, torn mucosa).

(c) Comminuted - open or closed (more than one fracture in area due to severe violence, gunshot, or vehicular).

(d) Complicated (damaged facial vessels and nerves).

(e) Impacted (rare)

(f) Greenstick (in children in condyles).

(g) Pathological (muscular action following local or generalised skeletal disease).

Class - I (Teeth in both fragments

I11 (Teeth in one fragment only).

(A) (Short edentulous posterior fragment)

(B) (Long edentulous posterior fragment).

III (Edentulous Mandible)

The mandible may be fractured in any position, but there are certain common sites:

- neck of condyle
- angle
- through third molar tooth
- last standing molar tooth
- mental foramen
canine sympysis

Rare fractures are:
  intracapsular
coronoid process
sub-condylar (ramus).

These rare fractures usually show little displacement due to the splinting action of the insertions of the elevator muscles.

The signs and symptoms of a fracture of the mandible are a history of trauma, there may or may not be pain, but there is pain on movement, there is a functional disorder, mobility of the fragments, malocclusion, deformity, facial asymmetry, swelling, ecchymosis, crepitus, there may or may not be haemorrhage; and there is x-ray evidence. All signs and symptoms may not be present; but loss of function, mobility deformity, and swelling are the important points.

Reduction

In discussing methods of reduction of mandibular fractures, Fry and Ward warn against reducing and immobilizing fractures at the same time. That is, they deprecate the use of pre-arranged splints. Immediate reduction may be achieved by slow and careful tension applied by digital pressure or by tightening ligature wires. The use of elastic traction is probably the most common and popular method of reduction. The pull of the rubber ligatures gradually tires the muscles
and a most difficult reduction can be performed in a few hours.

Traction by weight on a Balkan beam, will deliver a greater pull over a period of days and so reduce a mal-uniting fracture, or a fracture in which soft tissue has intervened. (See fig. 9).

Under anaesthesia, a mandibular fracture may be reduced manually.

Maxillary fractures unite quicker, and therefore a faster reduction is required than that of the mandible. If a mandibular fracture is mobile it may be reduced by immediate methods or elastic traction. If the fragments are impacted or immobile, manual reduction under anaesthesia or Balkam beam traction is required. Early reduction however, cannot be over emphasised. With reduction, all early healing tissue is broken down and healing must recommence. The more consolidation that has taken place, the more difficult the fracture becomes to reduce. Even patients in a poor general condition are usually the better for early reduction and immobilization, even though the procedure does temporarily disturb them. It is seldom that something can't be done — even a barrel bandage.

Fixation

It is not intended to give a complete discussion on each and every method of fixation — it is almost a complete subject on its own — but some salient points will be mentioned
Wiring: Fry and Ward, Rowe and Killey suggest the use of wiring on occasions, such as when cast splints are not available. Wiring may be in the form of interdental wiring, arch wiring, eyelet wiring, or orthodontic wiring. Archer and Thoma prefer to use wiring where possible, while Perlow suggests the use of orthodontic bands and arch wires with hooks to obtain fixation. The actual techniques for the application of the wires are described in most books.

The disadvantages of wiring as pointed out by Starr and Arnott are:

(i) more difficult to maintain oral hygiene.
(ii) frequent adjustments of wires necessary.
(iii) jaws fixed together, therefore no mandibular function possible.
(iv) immobilization not possible if there are only a few teeth present.
(v) the wires may be loosened or removed by patients
(vi) uneven strain on one or more teeth may cause irreparable damage.
(vii) the short posterior fragments are not controlled by wiring.

The advantages are that wiring is quick to apply, and no elaborate equipment such as a furnace is required. Thus wiring is of great value in first aid.

Cast Splints: This type of fixation is used where there are teeth in one or all fragments, and where the number, shape and distribution of the teeth preclude wiring, according to
Figure 9

Same patient as figs. 3, 4, 5, 7, and 8, in Recovery Ward following operation. Balkan beam traction is applied to the mandible by means of a partial Clouston-Walker appliance in the anterior region. The head is held firm between sand bags.
Rowe and Killey\textsuperscript{1} Although arch wiring is a valuable method under emergency conditions, cap splints afford a more satisfactory and stable means of effecting immobilization. No rotation, or other tooth movement is possible, and therefore it is better as long term treatment, and better for gradual reduction with elastic traction on hooks. After removal of the splints some occlusal adjustment may be necessary, but usually slight discrepancies correct themselves.

Rowe and Killey\textsuperscript{1}, and Fry and Ward\textsuperscript{3} prefer cap splints, although the former gentlemen favour the open ferrule splints but they say they are weak and easily dislodged. Starr and Arnott\textsuperscript{16} prefer the open ferrule splints, but stress they extend right to the gingiva. The writer believes there are occasions when each type is preferred to the other.

The use of capped splints is condemned in many quarters as contributing to an "open bite". Fry and Ward\textsuperscript{3} explain and demonstrate that this is not so. The use and perfection of arch wiring of teeth in patients with fractured jaws resulted from the above belief or the mis-use of the capped splints. There is no doubt that Fry and Ward have perfected capped splinting as others have perfected wiring. A fair compromise between the two is the use of cast open ferrule splinting in which almost perfect occlusion is maintained during the period of fixation. However, there is no doubt that each method of fixation is ideal for different problems, and can be used with the greatest advantage.
Fry's and Ward's objection to cast open ferrule splints that they "come off too readily" is not correct if the splints are made accurately, and especially so if black copper cement is used.

Again, Rowe and Killey¹ and Fry and Ward³ believe compound is the best impression material. In the writer's hands this technique is most unsatisfactory due to distortion on each occasion. The writer prefers the use of an alginate hydrocolloid impression material, and the waxing-out of the unwanted undercuts on the models obtained.

For the cementation of cast splints, the patient should be premedicated with atropine grains 1/100 to decrease salivation, and morphia grains 1/4 or nembutal grains 3 (max). Local anaesthesia is preferred to general anaesthesia for ease of working and patient co-operation. The lips are lubricated and the teeth should be cleaned with hydrogen peroxide and dried with alcohol and warm air.

Black copper cement is the preferred cementing material, but no load should be placed on it for at least twelve hours. After this, the fracture may be reduced, preferably by rubber traction, and then fixation applied. Finally, the locking plates (fish plates) if any are placed in position.

The state of oral hygiene is checked at regular intervals, and a close watch is kept for any ulcers of the mucosa. These might be electrolytic or traumatic. Black gutta percha will protect any such areas.
Rowe and Killey\(^1\) give the approximate times of fixation as follows: Children - 4 weeks
Adults - 6 weeks
Elderly Patients - 8 weeks

Starr and Arnott\(^16\) say 4 weeks for a simple fracture of an adult. Of the elderly patients, Massler\(^3\) says: "Healing in the aged is typically fibrotic, often with scarring. The failure of fractures to heal is a common geriatric problem."

The writer's average treatment time for all fractures is 43 days.

At the time when clinical union is expected, the inter-maxillary fixation and the locking plates are removed, and the fracture site is tested. If there is no union, the fixation is replaced; but with clinical union, the splints may be removed.

Following removal of the splints the teeth are scaled cleaned, and polished. Minor occlusal unbalance will correct itself in a week or so. Sherr\(^35\) prefers to wait about two weeks until after physiological adjustments have taken place, and then carry out periodontal and equilibration treatment. Fry and Ward\(^3\) warn that balancing the splinted occlusion during splint manufacture will reduce much post-treatment grinding.

Of 188 cases of fractured mandibles that the writer has attended 122 were treated by cast splints. All 122 cases were successfully treated except one case of non-union in an alcoholic female, and one case of "open bite" from bilateral
fractured condyles.

Acrylic splints are not used very much, but they are an excellent substitute if casting facilities are not available.

Gunning Splints: These splints are old in origin, simple to manufacture, and effective in the treatment of edentulous fractured mandibles where there is little or no displacement. There is a trend at the present time towards open reduction and fixation. In the opinion of the writer, this is quite unnecessary unless there is much displacement, as new dentures, which will be necessary in any event, will correct any slight mal-alignment.

In difficult cases, a plaster barrel bandage may be used instead of the crepe bandage. Also, in the writer's opinion separate (two piece) Gunning splints are better than the one-piece, as any "bite" discrepancy is then more easily adjusted.

The writer has attended 52 patients treated by Gunning splints. Of these, there was one case of mal-union which should have had an external appliance; and one case of non-union in a very sick (pneumonia) and confused patient, with suppurative parotitis as complications.

Wire Sutures. The writer uses this term to include lower border wiring, figure of "8" wiring, and alveolar wiring.

Rowe and Killey¹ in giving the indications for lower border wiring mention excessive alveolar resorption and considerable displacement. Other authors using this technique are Fry and Ward³, Star and Arnott¹⁶, and Hyton - Williams²⁰. Rowe and
Killey\textsuperscript{1} advise placing the hole in the posterior fragment higher than in the anterior fragment, to obtain better control of the fragments.

The writer has attended three patients treated in this manner. All three patients had fractures of the angle of the mandible with much displacement, and all cases were successfully treated. This method of reduction and fixation was preferred because the thin ramus precludes the use of a Kirschner wire or a Clouston-Walker appliance.

Becker\textsuperscript{19} also uses wire sutures for fixation of fractured condylar necks. This is quite unnecessary in the writer's opinion as it subjects the patient to hazardous surgery.

Bradley and Hildreth\textsuperscript{18}, and Buck\textsuperscript{21} use wire, but in the alveolar bone instead of the lower border of the mandible. If this method is always as successful as it appears to be, it will simplify the surgical procedure on a number of occasions.

**Clouston - Walker Appliance.** This type of fixation is an adaption by Clouston and Walker\textsuperscript{22} of the Roger Anderson orthopaedic appliance to the mandible. Rowe and Killey\textsuperscript{1}, Fry and Ward\textsuperscript{3} Starr and Arnott\textsuperscript{16}, and many other writers now advocate this type of fixation for certain fractures; particularly of the edentulous mandible.

The indications for its use are listed by Rowe and Killey\textsuperscript{1}:

A. For grossly displaced edentulous posterior fragments which are not controlled by intra-oral means.
B. For grossly displaced edentulous mandibles which are orally open or infected.

C. To control edentulous fragments during bone grafting.

The disadvantages are:

(i) Absolute stability is difficult to achieve
(ii) The pins loosen in the bone as a result of stress.
(iii) Infection around the pins is likely.
(iv) The appliance is unsightly and awkward.
(v) Hospitalisation is necessary.

Some complications that may arise are:

1. Neuritis of the inferior dental nerve may be due to a pin in the canal.
2. Infection of the fracture may be due to a pin in the fracture line.
3. Damage to the facial nerve and vessels - rare.
4. Over penetration of the pins.
5. Damage to adjacent structures.
6. Loosening of the pins due to excess movement or infection
7. Cellulitis due to track infection.
8. Traumatic injury from lack of care with apparatus such as lying on it, bumping it, or sitting in the hot sun for a lengthy period.
9. Salivary fistula - not serious
10. Post-removal cellulitis - rare
11. Bone necrosis due to infection, heat (pins inserted too fast), or electrolytic action.
According to Fry and Ward, infection is rare, and adequate fixation may be expected for up to two months. The writer has attended to five patients treated by Clouston-Walker immobilization. (See fig. 10). In four cases, the appliance was removed after three to four weeks with excellent results. In the remaining case, the pins had to be removed after four days because of severe pain and necrosis. The reason for this was not discovered, but it affected all four pins; and after removal, pain ceased, and after a little bone sequestration, the lesions healed. This could have been due to infection, heat, or electrolytic action. In any case, Gunning splints helped complete treatment successfully.

As the reduction of these fractures is by the closed manual method, it is advisable to obtain radiographs after fixation to confirm the repositioning of the fragments.

**Circumferential Wiring.** This type of wiring is used in conjunction with Gunning splints, and Rowe and Killey discuss complications:

A. Wires cutting the alveolar bone is rare, but is avoided by keeping all wires tight.

B. Broken wires are avoided by not twisting the wires too much.

C. Infection must receive early attention.

As with the Clouston-Walker pins, anaesthesia is not required for the removal of the wires.
Figure 10

A Clouston-Walker appliance immobilizing the fragments of an edentulous mandible fractured in the left molar region.
Kirschner Wires. Rowe and Killey, Fry and Ward, and Starr and Arnott mention the use of Kirschner wires, but do not discuss it very fully. Delk and Lettermann discuss its use a little more fully and give case reports. Its use is restricted mainly to closed fractured edentulous mandibles where there is gross displacement.

The writer has attended six patients treated by the use of Kirschner wires, four of whom had bilateral fractures. (See figs. 11 and 12). All patients were successfully treated. Six to twelve months after treatment the wires may be withdrawn from the chin without anaesthesia if the patient so desires.

Metal Plates. This type of fixation is also mentioned by Rowe and Killey, and Fry and Ward, while Kleitsch and Smith describe its use. Finger plates of an inert metal such as tantalum, with similar screws, and screw-drivers are used. This avoids any electrolytic action between dis-similar metals.

The writer is of the opinion that if too many methods of fixation are used, efficiency in the use of any of them will suffer. Naturally a wide selection is necessary for all contingencies, but the selection should be limited by that. Knowledge of other methods is essential, but not necessarily a practical knowledge. This opinion is supported by eminent authors who in mentioning a large number of methods of immobilisation, only describe some fully.
The writer has practical knowledge of arch and interdental wiring, cast splints, Gunning splints, lower border wiring, Clouston-Walker fixation, and Kirschner wires.

**Treatment**

**Teeth Bearing Fragments.** Patients suffering from this type of fracture will usually present with a history of trauma, usually little pain, anaesthesia of lower lip on affected side; there will be some swelling varying from little to much; there may or may not be loss of function; and the occlusion may or may not be disturbed depending on the amount of displacement. If the fracture is open, through a tooth socket, there will be some haemorrhage; if it is a closed fracture, a haematoma will be present either immediately or later. Mobility will certainly be present but crepitus may not, and authors1,3, warn against trying to elicit crepitus because of the discomfort to the patient. Finally, there will be radiological evidence.

Teeth in the line of fracture are extracted, and immobilization achieved by cast splints or wiring. Early reduction is obtained by rubber traction, and late reduction by manual means or with the aid of Balkan beam traction.

If cast splints are not available, then fixation may be maintained by wiring (eyelet, interdental, arch) or acrylic splints.

For tooth bearing fragments, separate cast splints are preferable to prearranged splints. Fry and Ward3 point
Figure 11
A case of bilateral fracture of the mandible in the bicuspide regions with gross displacement. Picture shows Kirschner wire driven along anterior fragment and out the chin on the right side.
Figure 12

Same patient as fig. 11. The displacement has been reduced, and the Kirschner wire driven back along the anterior fragment, across the line of fracture, and along the posterior fragments. The excess wire was cut off at the chin.
out the dangers of prearranged splints:

(a) Difficult to articulate models correctly.
(b) Fracture surfaces hard to reposition exactly.
(c) Splint likely to spring off before the cement is properly set.

Separate mandibular splints and maxillary splint are cast and cemented in position. Reduction is obtained by rubber traction between the maxillary splint and the mandibular splints. When reduction is complete, locking plates (fish plates) are soldered together and screwed into position. If fixation of the fragments is secure enough, intermaxillary fixation may be dispensed with and the maxillary splint removed.

Clinical union may be expected in four to five weeks when the fractures may be tested for mobility. Intermaxillary fixation (usually wire) is removed, if it is still in use, and the locking plates unscrewed. If clinical union is present the splints are removed by the use of old extraction forceps. If there is still excess mobility, fixation is reapplied.

Following a prophylaxis, the patient returns in about two weeks for occlusal equilibration; and later in about three months for a follow-up examination.

The Short Edentulous Posterior Fragment. These fractures include fractures of the condyle, which will be considered next, fractures of the coronoid process, ramus, and the difficult fractured angle.
Fractures of the coronoid process and the ramus are rare, and as these regions are well 'splinted' by muscles, little displacement results. Thus, intermaxillary fixation for five weeks by cast splints, acrylic splints or wiring is the treatment of choice.

With a fracture of the angle however, the position is a little more complex. When there is no displacement, intermaxillary fixation is sufficient treatment for four to five weeks.

If there is vertical displacement, i.e. it is H.U.; it may be controlled by a small acrylic extension to a cast splint and intermaxillary fixation; or some displacement may be accepted, and allow it to be controlled by the tuberosity or the upper third molar tooth. (See figure 13) If the fracture is a closed one, lower border wiring may be performed. If it is open, then a Clouston-Walker appliance can be used.

If a lower third molar is present, the line of fracture is almost certain to pass through this socket, and the tooth may be retained (at a risk) to help reduction and fixation. With horizontal displacement, V.U., an open reduction and lower border wiring can be carried out if it is a closed fracture. If it is an open fracture, then manual reduction with a Clouston-Walker appliance for fixation is the treatment of choice.

Fractures in the region of the angle may be direct:
or indirect fractures; there is usually some pain with movement; there is swelling, and some loss of function; the occlusion is deranged; and there is mobility in the region. Radiographs should be studied carefully to avoid mistaking a shadow of a pharyngeal air space as a fracture.

Four to five weeks fixation should result in clinical union.

Fractures of the Condyles. A fracture of the condyle is usually the result of indirect trauma; the zygomatic arch gives some protection from direct trauma, although such fractures can be open on occasions such as a gunshot wound.

The diagnosis of a fractured condyle is the result of pain on mandibular movement; swelling; lack of condylar function on opening and closing the mouth; a swing of the mandible towards the injured side on opening; there is a "gagged bite" in bilateral fractures; and radiographic confirmation.

Condylar fractures, according to Rowe and Killey\(^1\) are a difficult problem in a complex anatomical region. Fractures in other joints usually lead to serious complications, but this is seldom with condyle. Their treatment is influenced by the following factors:

(1) Soft diet - to lessen strain on the temporo-mandibular joint

(2) Anatomical arrangement - one condyle can do the work of two
Figure 13

Same patient as figs 3, 4, 5, 7, 8, and 9.

Right angle of mandible (see fig 5), following removal of third molar, partial (acceptable) reduction by Balkan beam traction, and fixation. The upper third molar helped control the posterior fragment.
(3) Pseudoarthrosis - false joint

(4) Muscular balance - mandibular muscles act as a sling.

(5) Joint is non-stress-bearing in nature.

They classify the fractures on anatomical structures:

i Intracapsular - rare - no displacement

ii Extracapsular & neck - simple antero-medial deviation - 60% of all condylar fractures

iii Fractures with associated injuries - capsule, ligaments, meniscus - lateral overlapping displacement.

iv Fractures involving the adjacent bone - unusual - fracture of middle cranial fossa.

v Comminuted - severe accidents or gun-shot

(a) Open to external auditory meatus

(b) Open to the middle ear.

(c) Open externally - gun-shot.

Rowe and Killey also say that damage to the growth centre is rare; and base their treatment on the general idea that if there is no displacement they immobilize the mandible; if there is displacement, they aim for pseudoarthrosis.

With simple unilateral condylar fractures with no displacement, the jaws are immobilized for four weeks if there are natural teeth present: there is no immobilization for edentulous cases. If there is displacement, the jaws are immobilized for ten days until the pain subsides, and then movement is encouraged with or without the aid of a guide plane. An open reduction is not usually performed. The early treatment for bilateral fractures is six weeks immobilization.
For late treatment or gross displacement, the fracture is over reduced for four weeks by means of elastics anteriorly and bite blocks posteriorly. This is followed by two weeks passive fixation in normal occlusion.

Open fractures are liable to infection leading to ankylosis. The early treatment is therefore debridement and immobilization, but if infection is present, movement is encouraged to prevent ankylosis. This is no indication for condylectomy.

Post-treatment complications such as 'clicking,' are treated by an injection of a sclerosing solution or condylectomy.

With fractures of one condylar neck Fry and Ward\(^3\) aim for a fibrous joint with full function, if the head is dislocated. They say that reduction and union of the head is unimportant. However, the reduction of the displacement of the body (the swing to the injured side) is important, and is obtained by fixation in normal occlusion for one week, followed by three weeks active movement with the aid of a guide plane.

Intracapsular fractures are treated by fixation.

To confuse the issue a little, Fry and Ward\(^3\) illustrate two cases of fractures of the condylar neck; one case received treatment, the other didn't but both results were satisfactory.

For bilateral fractures, these authors like Rowe and Killey\(^1\) stress the importance of early reduction because of the rapid healing that takes place. The mandible is immobilized in a slightly over compensated position for two
weeks, and then some movement with elastic traction is encouraged for three weeks. There is no late treatment for a fracture of one condyle as no deformity results, but for old bilateral fractures, over reduction and fixation is continued for four to five weeks. In some cases the posterior teeth may have to be ground or extracted. Tam\(^4\) presents a case of open bite resulting from untreated bilateral fractured condyles five weeks after injury, in which reduction was obtained by strong elastic traction.

Fry and Ward\(^3\) also mention injuries to the condyles at birth by forceps delivery. This can produce crush-type fractures with a poor prognosis leading to ankylosis. Condylectomy will aid these patients.

Starr and Arnott\(^16\) immobilize the mandible for four weeks if there is no displacement of the head of the condyle following a fracture of the neck. With displacement, immobilization is applied for two weeks, and thence controlled movement by the aid of a guide plane is encouraged. For bilateral fractures, reduction is by rubber traction, then fixation for two weeks, movement with weak elastic traction for one week, and finally movement without traction between guide planes for one week. Old fractures are treated by condylectomy.

Mac Gregor and Fordyce\(^36\) in their studies of this problem believe there is confusion in the method of treatment of fractures of the condyle, and list known treatments:
(1) Complete fixation.
(2) no fixation – just rest.
(3) fixation in open bite position.
(4) primary fixation (one to two weeks), then active movement.
(5) no treatment.
(6) elastic traction.
(7) fixation with posterior "bite wedges" (over reduction).
(8) open reduction (as suggested by Becker 19).
(9) condylectomy.

They point out that fractures of the condyles are not easy to reduce, and that local fixation (open reduction) such as wiring and plating, is not an easy procedure. They also state that the muscles of the heads, the external pterygoids, act together with other muscles of the mandible in movement, and therefore, if there is no mobility, union will occur. Even in the absence of fixation, bony union takes place.

Their treatment is based on signs and symptoms:
(a) If there are other fractures present, as is usual, fixation is used.
(b) Pain is seldom severe enough to warrant immobilization.
(c) If the patient can control a gagged bite themselves, no fixation is required. If they can't control it, then fixation is used. Old fractures are treated by fixation with overcorrection for two to three weeks.
(d) Patients can control deviation under instruction.

Having treated 250 patients, their conclusions are:

1) Bony union does occur.
2) There are no false joints or fibrous union.
3) Bony remodelling takes place.
4) There is no pain.
5) There is normal function.
6) There is no interference with growth.
7) There are no arthritic changes.
8) Fixation is not necessary.
9) No surgery is required.

From the list of methods of treatment given by Mac Gregor and Fordyce\textsuperscript{36}, it seems to the writer that there is either no treatment certain of success, or that all treatments if properly applied are successful.

The writer believes all bilateral fractures should be immobilized for four weeks, but that guide planes are seldom necessary. Where there is much displacement some over-reduction is necessary for the first ten days. Immobilization for three to four weeks is also the writer's choice of treatment for unilateral fractures where teeth are present. (See fig. 14) Again, guide planes are seldom necessary. For unilateral fractures in an edentulous mouth, the writer believes fixation is only necessary for comfort, or if the patient cannot control any deviation of the mandible during opening.
The Long Edentulous Posterior Fragment. The treatment of this type of fracture is not nearly so difficult as that of the short posterior fragment. Such injuries are usually the result of a direct blow, and the usual signs of swelling, deformity, mobility, and crepitus are present; together with the symptoms of pain.

If there is no displacement of the fragments, Rowe and Killey\(^1\) believe intermaxillary fixation of the anterior fragment alone will be sufficient treatment. The writer believes a saddle extension over the posterior fragment is necessary however, to avoid later displacement during deglutition particularly, in a V.U. fracture. This can happen - to the writer's disappointment.

With vertical displacement however, they suggest the saddle extension in addition to the anterior intermaxillary fixation. The displacement is reduced by manual means.

Open, infected, or medially displaced posterior fragments may be treated as above. If closed and non-infected with gross displacement, the fracture may be openly reduced and wire suture fixation employed. If the fracture is open or infected with gross displacement, the Clouston-Walker appliance is to be preferred.

Fractures of the Edentulous Mandible. Rowe and Killey\(^1\) in discussing these fractures state that with age, the mandible becomes thin and brittle and more liable to fracture.
Figure 14

A P.A. radiograph of fractured left neck of condyle following four weeks fixation. Same patient as figure 2.
However, there is usually little displacement, as the mucoperiosteum acts as a splint; but, if the fracture is open, there is usually considerable displacement because of the muscular pull and the absence of teeth. Precise realignment however, is not essential.

Fry and Ward agree, and explain that since no natural occlusion can be lost, no reduction is necessary unless:

a) the displacement interferes with function.
b) causes facial deformity
c) prevents or delays union.

The fractures are usually simple and closed, with less mobility than other fractures of the mandible. They further state that the fractures heal rapidly, and therefore early treatment is essential.

This may be so for the younger, patient, but not for the older one according to Massler.

Reduction of these fractures is by manual means or open reduction.

Fixation may be by:

(a) Gunning splints and barrel crepe or plaster bandage (with little or no displacement).

(b) Gunning splints and circumferential wiring (with little displacement)

(c) Wire suture (gross displacement)

(d) Clouston-Walker appliance (with open fractures).
(e) Kirschner wire (closed, gross displacement)
Rowe and Killey\(^1\) point out that the best first aid treatment here is a 'just firm' barrel bandage without any dentures in position.

**Special Cases.** Rowe and Killey\(^1\) discuss fractures of the mandible where one jaw is edentulous. If the maxillae are edentulous, and upper Gunning splint with circumferential wiring may be wired to a lower\(^*\) cast splint; an upper Gunning splint may be fixed to a plaster head cap by cheek wires or external bars and wired to a lower cast splint; or a lower cast splint may be fixed directly to a plaster head cap by external bars. The last method being preferable. If the mandible is edentulous, cast splints are cemented on the maxillary teeth, and wired to a Gunning lower\(^*\) splint which is held in position by circumferential wires.

Multiple fractures of the mandible, according to Fry and Ward\(^3\) are treated by a combination of methods previously discussed, thinking of one fracture at a time. Fractures of a body and a condyle are treated as a fracture of the body alone. A fractured ramus is treated by intermaxillary fixation, as is a fracture of the coronoid process.

A double fracture with an edentulous middle fragment seldom needs reduction, just fixation; the edentulous fragment being immobilized by circumferential wires. A small fragment of a fractured alveolus may be removed, but a larger fragment may be splinted or immobilized by arch wiring.
In combined maxillary and mandibular fractures, one jaw is immobilized first, usually the maxillae to a plaster head cap, and the other jaw immobilized to the first.

With comminuted fractures of the mandible, there is no method of immobilizing the comminuted fragments, only the main fragments. If there is no loss of bone, fixation in normal occlusion is maintained until clinical union has occurred. With loss of bone, the main fragments are immobilized in occlusion and a bone graft is added to the defect. If only a small loss of bone has taken place, fixation and treatment is effected as if there was no bone loss for four to six weeks. If this is not successful, a bone graft will have to be considered.

In the writer's view, the sooner treatment is commenced, the better; and to be effective, with speed; the treatment must be simple.
MANDIBULAR FRACTURES
IN CHILDREN

Rowe and Killey\textsuperscript{1} devote a chapter of their book to describing mandibular fractures in children, and Georgiade, Masters, Metzger and Pickrell\textsuperscript{13} have also devoted time and study to this problem. A problem it is, when first confronted by a shocked and frightened child in pain. Children however, respond quickly to kindness, and once they realise that they are "being made better" and relieved of pain, they co-operate very well. Patients under 12 to 14 years of age may be termed children, as their permanent dentition has not yet reached complete eruption.

In general, according to Rowe and Killey\textsuperscript{1} the aetiology, diagnosis, and treatment of children is much the same as for adults. However, certain problems such as anatomical development of the mandible, incomplete tooth eruption, immature mental development, and poor co-operation have to be, and can be overcome. Fractures of the mandible in children is not common, because of the resiliency of the bone. A "greenstick" (incomplete) fracture of the condylar neck is the most common type of fracture. These heal rapidly with minimal treatment. With severe fractures of the condylar neck and dislocation of the condyle, the growth centre may be damaged leading to facial deformity.

Child patients are usually quite well behaved during the examination if they are seen soon after the accident, as they
are quite often still dazed. Sedation is not often necessary, but when it is the appropriate dose should be given. The dosage at the Royal Newcastle Hospital for "nembutal" is grains one half for each stone (nearest stone) of body weight, up to a maximum dose of grains three.

Radiographic examination can be difficult because of pain, fright, and lack of co-operation. The interpretation likewise can be difficult because of the lack of density of the bone, tooth crypts, and erupting teeth.

The rate of union is very rapid in children; usually about three weeks. Some occlusal derangement is accepted in the deciduous dentition following a fracture, as bony remoulding will soon correct any mal-union.

If fractures of the mandible in children is rare, then injuries to the teeth and alveoli is most common. With these injuries, the aim is to save all possible tissue, hard and soft, by splinting of some kind.

Mandibular fractures in children should be treated by the simplest means possible, as children always interfere with any apparatus, and any simple means of fixation is easily replaced. This of course, depends upon the age and co-operation of the child. Rowe and Killey suggest eyelet wiring if the teeth are sound and the roots are well formed. The writer believes such cases cannot be classed as child fractures.
Impressions may be obtained in compound or an alginate hydrocolloid, and a little displacement need not be reduced. If cast splints will not remain in position, the cement may be reinforced by circumferential wiring around the splints. In some cases where there is lack of teeth a type of Gunning splint, covering teeth as well as alveoli, may be held in position by circumferential wires.

A simple method of fixation the writer found useful for two young patients, was to reduce a theatre cap in size to fit the patients' heads and sew small hooks on to them in the temporal regions, and use rubber dam as chin slings. This was easily removed by the patients, but persistence by the nursing staff in replacing it soon won the patients' co-operation.

Rowe and Killey\(^1\) state that children hate having their mouths shut for long, and therefore any rigid fixation is often dislodged. Patient co-operation should be sought together with persistence on the part of the operator. These two points together with a simple appliance will succeed.

The writer has attended thirteen child patients with mandibular fractures. All were successfully treated, two by rubber dam slings and linen head caps; two by Gunning splints and circumferential wiring; one by a cast splint and circumferential wires; and the rest by cemented cast splints.
FRACTURES OF THE MIDDLE
THIRD OF THE FACE

In discussing fractures of the middle third of the face, one becomes aware of the complexity of the possible bony injuries as compared to those of the lower third or mandible. It is all the more remarkable therefore, that the classification of lines of fracture of the middle third, and their treatment, should be more simple than those of the mandible.

Facial middle third injuries are the result of a crushing force, and in this modern age of speed, vehicular (automobile, motor cycle, aeroplane) accidents provide the necessary forces. Practically all middle third injuries to civilians are the result of fast moving vehicles coming to an abrupt halt, and the patients' faces striking a projecting object (steering wheel, dash board, seat back) when the patients have been thrown forward.

Such trauma may require the collaboration of oral surgeon, ophthalmic surgeon, neuro-surgeon, and otorhinolaryngological surgeon. This collaboration of 'team work' must function smoothly if patients are to receive the full benefits of each specialty.

As has been mentioned previously, the facial skeleton can resist considerable vertical force, but with horizontal force, it will shear off. Anterior force will drive the maxillary complex down and back, giving the face the so
called 'dish-face' appearance.

Whereas impacted fractures of the mandible are extremely rare, the vast majority of middle third fractures are impacted and comminuted. As a result of maxillary involvement, the normal occlusion of the teeth is deranged. Involvement of the nasal complex can lead to infected sinuses, and impede nasal respiration by blood clots. Orbital involvement can lead to diplopia; while ethmoidal involvement may include a fracture of the cribiform plate, thus resulting in a fracture of the anterior cranial fossa and the escape of cerebro-spinal fluid from the nose.

According to Rowe and Killey¹ the displacements of middle third fractures depend upon:

1. The degree of force - the mass of the body or bodies, and the velocity.
2. The resistance - facial bones, movement of the head on impact.
3. Direction - lateral or frontal.
4. Point of application - nose or premaxilla.
5. Cross section area of object struck - iron bar, brick wall.
6. Attached muscles - of little import except for the orbits.

The soft tissues tend to hold the fractured facial bones together, and lacerations are rare, while intra-oral lacerations are even rarer.
The mid-line suture of the maxillae is weak, and therefore its fracture is not uncommon with middle third fractures of all types, although it is more common if there is a deep overbite and in Le Fort Class III fractures. The displacement is usually not very severe, and although the upper central incisor teeth may be separated widely at times, their extraction is not always necessary. The healing powers (drainage and blood supply) is so very good in the maxillae.

Facial fractures act as a "shock absorber" for the cranium, but extreme trauma may cause fractures of the frontal and parietal bones, and the base of the skull.

**Diagnosis.** According to Fry and Ward\(^3\) middle third fractures are palpable soon after injury and before any gross swelling takes place. Later, such fractures are marked by orbital haematomas, sub-conjunctival haemorrhage, oedema of eyelids, flat or crooked nose, a swollen (football) face and a 'dish face.'

Naturally, it depends on the severity of the trauma which of the above diagnostic features are present, and to what extent. These features may be confined to one side of the face indicating a fracture of the lateral middle third, and there is usually less swelling.

Signs which may be present for a diagnosis of central middle third injury are: a flattened nasal arch, a widened
inter-zygomatic distance, sunken upper lip, flattened profile ('dish face'), mobility of the teeth bearing segment, and mal-occlusion.

Bony injuries to the lateral middle third of the face present signs of: facial asymmetry, one zygomatic bone above the level of the other, diplopia and one eye above the level of the other.

Middle third fractures may be confirmed by palpating the orbital margins, the zygomatic arches, the zygomatic prominences, testing the occlusion, testing the mobility of the teeth bearing segment and noting displacements.

**Classification.**

Le Fort (per James and Fickling)\textsuperscript{37} first published his reports of his cadaver experiments in Paris in 1901. In these experiments, Le Fort subjected cadaver heads to varying forces from different directions, and following maceration, he found that the bones of the face fractured along certain fairly constant lines. Great force is needed to produce fractures of the face, as the face resists injury chiefly on account of the elasticity resulting from the arrangement of bone, periosteum and soft tissues. The extreme thinness of certain portions, far from decreasing its resistance, adds to its elasticity. When the limit of elasticity is passed fracture occurs.

Le Fort (per James and Fickling)\textsuperscript{37} says: "In spite of
its multiple attachments to the base of the cranium, the upper jaw possesses a considerable degree of independence." The upper jaw is designed to distribute stresses to the base of the skull over a large area by means of bony columns, and thus dissipate the force.

Le Fort I (Guerin's fracture) is a horizontal fracture through the lower part of the face, above the floor of the nose and below the zygomatic bones. It runs from the lower part of nasal cavity, around and above the alveolus, and divides the pterygoid processes in their lower third. It may be incomplete or unilateral.

Le Fort II fracture involves the middle part of the face, through the orbits and medial to and below the zygomatic bones. It runs from the nasal bones, across the frontal processes of the maxillae, across the lacrimal bones and orbital floors, down below the zygomatic bones, across the infra-temporal surfaces of the maxillae, across the pterygo-maxillary fissures and divides the pterygoid processes in their middle thirds.

Le Fort III fracture separates the face from the cranium. It passes through the nasal bones, the orbits, and above the zygomatic bones. (See fig. 15). The line of fracture runs through the nasal bones, across the frontal processes of the maxillae, across the lacrimal bones, through the ethmoid bone
and the greater wing of the sphenoid bone just below the optic foramina, across the orbital processes of the palatine bones, just below the superior orbital fissures, through the inferior orbital fissures, across the pterygo-palatine fossae, across the pterygo-maxillary fissures and divides the pterygoid processes in their upper thirds.

Of course, there may be combinations of these fractures:

I and II;  I, II and III;  I and III;  II and III.

Le Fort (per James and Fickling)\(^3\) found from his experiments that:

1. Antero-posterior blows to the upper lip caused a Le Fort I or Guerin type fracture.
2. Lateral blows to the inferior part of the maxilla caused an unilateral Le Fort I fracture.
3. Blows from below upwards on the superior alveolar margin, the mouth being open, caused a Le Fort II.
4. Antero-posterior blows upon the middle part of the face caused a Le Fort II.
5. Blows to the nasion from above caused a fracture of the nasal complex and/or a Le Fort II.
6. Blows from below upwards upon the mandible were experimentally unsuccessful, but clinical cases are known. An unilateral or bilateral Le Fort I with maxillary midline separation is the usual result, but a Le Fort II can occur.
7. Various types of blows to the zygomatic bones produced
Figure 15.

The typical appearance of a patient on admission with a Le Fort III fracture of the middle third of the face. There is also a fracture of the left body of the mandible.
little to severe injury, with little to gross displacement, with or without involving associated bones. Antero-posterior blows upon the entire anterior part of the face produced I, II, and III or II and III Le Fort fractures with maxillary separation.  

8. Blows upon the face and the cranium at the same time produced Le Fort I, II and III fractures. This type of accident is not rare and the lesions do appear to influence each other greatly.  

9. Heavy multiple traumata in various directions upon different parts of the face caused Le Fort I, II and III fractures with maxillary separation.  

Le Fort (per James and Fickling)\(^3\)\(^7\) shows that fractures of the face, far from presenting complex pictures, can be grouped into a small number of characteristic types.  

Rowe and Killey\(^1\) and Fry and Ward\(^3\) classify middle third fractures a little more precisely by dividing the region into central and lateral areas. Each of these areas or regions is then subdivided into three degrees of trauma.  

Fractures in the central region consist of:  
I. Fractures of the nasal complex.  
II. Fractures of the maxillae.  
III. Fractures combining I and II and involving the ethmoid bone (cribriform lamina.)  

Fractures of the lateral region consist of:  
I. Fractures of the zygomatic bones without displacement.
II. Depressed fractures of the zygomatic bones.

III. Depressed fractures of the zygomatic bones involving the frontal bone (anterior cranial fossa) and/or the temporal bones (middle cranial fossa).

Rowe and Killey\(^1\) also relate their classification to the Le Fort classification, and illustrate combined central and lateral region fractures. Of course, there may be separation of the maxillae. They state however, that a rigid classification of the middle third fractures is impossible with the complex composition of the area.

The writer believes the Le Fort classification is to be preferred, but with certain qualifications appended. For example, a fracture of the middle third area may be described as follows: Le Fort III, with midline separation and depression of the right zygomatic bone; or right Le Fort III, left Le Fort II and midline separation. The latter description is probably the better.

**Treatment.**

The medical condition of a patient is the prime concern, and no medical risks should be taken to achieve early reduction unless it is to control severe haemorrhage, alleviate shock or eliminate respiratory embarrassment. According to Rowe and Killey\(^1\), reduction and fixation is not life saving, and therefore there should be no rush for surgical intervention,
even with cerebro-spinal rhinorrhoea. When the general condition has improved, treatment may commence.

Severe haemorrhage is rare, except with gun-shot wounds. Respiratory embarrassment may be eliminated by aspirating blood clots (see fig.1), and reducing by hand any maximum displacement. In maxillo-facial injuries, shock is usually not severe. With suspected head injury, medical advice should be sought, regarding the prophylactic use of drugs to prevent meningitis, and for the alleviation of pain.

The oral cavity and the face should be cleaned of all debris and blood clots with dilute hydrogen peroxide or warm saline. The eyes should be cleaned with warm saline only. Facial lacerations are sutured, and the ears are examined for cerebro-spinal fluid. The nasal cavity should not be cleaned as haemorrhage will usually recommence.

If the patient's general condition is good, then impressions for splints may be taken. The writer prefers to use an alginate hydrocolloid as the impression material.

Rowe and Killey doubt any benefit of first aid, and suggest that it may be even dangerous. In all cases, treatment should commence as soon as possible. If for some reason treatment is delayed, a temporary splint may be constructed from an impression tray with a little impression compound in it, and some external fixation (head caps.). If the maxillae
are separated, arch wiring may be used.

Fry and Ward\textsuperscript{3} state that fixation to the mandible is quite adequate in a great proportion of cases. Rowe and Killey\textsuperscript{1} on the other hand, state that intermaxillary fixation is bad if such fixation is not anchored to the cranium, as the mandible could pump infection into the cranial cavity. They further state that a barrel bandage is not effective for fixation. The writer believes a fracture of the middle third region alone, is best left until treatment commences. If a fractured mandible is associated with it however, a barrel bandage is of some use as temporary fixation to alleviate pain and eliminate dribbling.

The aim of treatment according to Rowe and Killey\textsuperscript{1}, is to reduce displacement and thus replace the various components in their correct positions and immobilize them until clinical union is achieved. Fry and Ward\textsuperscript{3} state that because of the rapid healing that takes place in the maxillary complex, rapid reduction is necessary to avoid mal-union. Manual reduction is preferable, but slow traction (elastics or Balkan beam) may be used if a general anaesthetic is contra-indicated. Any delay must be avoided, so that reduction is complete within two or three days.

With a partial or incomplete or unilateral Le Fort I (Guerin's) fracture, reduction may be performed under local anaesthesia by moulding the alveolus with the fingers or
rubber covered forceps. Less risk will be run than in the mandible by retaining teeth in the line of fracture. Where teeth are present, the fragment need only be immobilised to the rest of the maxillary teeth. In edentulous cases, reduction only should be necessary.

If a teeth bearing fragment is displaced medially, intermaxillary elastic traction will effect reduction and maxillary locking (fish) plates may then be used. With lateral displacement, intra-maxillary elastic traction may be used for reduction and fixation maintained by locking plates.

Rowe and Killey\(^1\) point out that due to the comminution of maxillary fractures and the interposing of soft tissues, perfect reduction and accurate apposition is unlikely to be achieved.

A transverse fracture of the maxillae, or complete Le Fort I, is usually a 'floater.' That is, it is not impacted and reduction is relatively simple, either manually or by elastic traction to a mandibular splint. After fixation by external connecting bars to a plaster head cap, intermaxillary fixation and the mandibular splint may be removed. If the maxillae are edentulous, a Gunning splint may be retained in position by means of trans-buccal cheek wires or circumferential (perialveolar) wiring.

For the application of a plaster head cap, the hair
must be cut short for a male, or collected at the vertex for a female. The area to be plastered is covered with stockinette and/or a couple of layers of crepe bandage. The plaster should 'grip' the frontal protuberances and be above the eye brows; 'grip' the temporal regions; be above the ears; and 'grip' the mastoid regions and the external occipital protuberance. (See fig. 16.) During the application of the plaster bandages, the retaining rods are incorporated in appropriate positions. Complete head coverage is not necessary for retention, and only causes the patient discomfort by itching.

There will always be some movement of the head cap since the scalp moves on the skull, and as the plaster sets it will expand.

Le Fort II and III fractures are usually impacted, and sometimes great force is required to reduce these fractures. This is best achieved by manual reduction using lion or maxillary forceps with general anaesthesia; having already cemented the splint or splints in position, and applied a head cap at least twelve hours previously. Connecting rods are then placed in position joining the head cap to the maxillary splint and locked in position. If possible, the occlusion is then tested by closing the teeth together. The writer believes caps splints are a disadvantage here as the operator cannot then see the occlusion. If it is not
Cranio-maxillary fixation for a bilateral Le Fort III fracture. There is also an open comminuted fracture of the symphysis of the mandible. The dry dressings covered infected Clouston-Walker pin holes as this appliance was used for early fixation of the mandible.
correct, the connecting bars are unlocked and the necessary adjustment to the reduction is made. If no test is possible, a mandibular splint, previously cemented in position, is later used with elastic traction for small adjustments.

Where the maxillae are edentulous and there are teeth in the mandible, Rowe and Killey\(^1\) suggest cranio-mandibular fixation. That is, a mandibular splint is fixed to a plaster head cap and a maxillary Gunning splint is 'sandwiched' between them.

Rowe and Killey\(^1\) use one connecting bar with the aid of trans-buccal cheek wires in cranio-maxillary fixation. The writer prefers to use two connecting bars only for stabilization. (See fig. 16) Placed lateral to the pupils, they are no more annoying than one bar over the nose. Cheek wires cannot be used if there is mid-line separation as the wires pull up and laterally, thus increasing displacement.

Rowe and Killey\(^1\) also emphasize that replacing the maxillae to the mandible by rubber traction alone is fraught with danger, as the vertical and lateral positions can be distorted. Gagging on the posterior teeth should be watched for, as the mandible is freely mobile and can be immobilized in an abnormal position. The maxillary-mandibular traction should not be applied while the patient is anaesthetized as respiration may be difficult (blood clots in nares), and any vomitus may be inhaled.
With Le Fort I and II fractures, the maxillary splint may be immobilized by stainless steel wires to the inferior orbital margin or the zygomatic process of the frontal bone, thus eliminating the use of a head cap. Trans-osseous wiring is another alternative method of fixation. The fractured facial bones are repositioned and stainless steel wire sutures are placed across the fracture lines at certain convenient areas such as: zygomatico-frontal area, inferior orbital margin, and nasal cavity margin. The reduced fractured facial bones may also be threaded on to a Kirschner wire if there are no open wounds, and fixed to a head cap.

Rowe and Killey\(^1\) advise three to four weeks maxillary immobilization for middle third fractures. Starr and Arnott\(^16\) advise four weeks immobilization.

Fry and Ward\(^3\) state that a fracture of the middle third of the face should be immobilized within two days if possible, as after fourteen days reduction is very difficult, and impossible after six weeks. Early reduction is achieved by manual manipulation, while later reduction is best obtained by weight traction. The upper splint is connected by a cord through pulleys on a Balkan beam to a weight. The weight should be applied a half pound at a time to four or five pounds. Very late treatment may require six pounds to reduce the impaction over a period of some days. Over reduction should be avoided, although there is a tendency
for the backward displacement to recur if fixation is not immediately applied.

Where the maxillae are edentulous, a small displacement is unimportant as new dentures will correct any discrepancy.

Fractures of the Nasal Complex.

Although the nose is included in the middle third of the face, fractures in this region should be seen by an E.N.T. surgeon; but fixation by external connecting rods to a head cap, with or without maxillary fixation, may be necessary. The aim is to reduce any nasal impaction; that is, obstruction by the use of nasal forceps and the fingers. The nose may be packed for a few days or a butterfly plaster may be used, as suggested by Starr and Arnott\textsuperscript{16}. Fry and Ward\textsuperscript{3} suggest an impression compound splint, rubber tubes in the nares, or lead plates sutured on either side.

Zygomatic Fractures.

Fractures of the zygomatic bones or lateral middle third fractures should always be reduced before maxillary fractures so that maxillary fixation will aid the zygomatic fixation and because reduction is easier at this stage.

A displaced zygomatic bone will produce a marked deformity by a flattened cheek. The bone is usually displaced downwards, inwards and posteriorly by the impacting force alone. There is no muscular displacing force. Such displacement
usually results in diplopia as a result of the floor of the orbit dropping.

According to Rowe and Killey\(^1\), the flattened cheek deformity is usually masked by gross oedema two to three hours after injury. Epistaxis indicates a torn antral membrane, while there may be orbital ecchymosis, sub-conjunctival ecchymosis and diplopia present.

Interruptions to the bony continuity may be palpated in the inferior and lateral orbital margins, and the zygomatic arch. Surgical emphysema and traumatic anaesthesia may also be present. Intra-orally there may be ecchymosis of the buccal sulcus; anaesthesia of the teeth and gingiva on the affected side; and an intra-oral palpable defect of the zygomatic process of the maxilla. If the zygomatic bone is depressed very far it will prevent full mandibular function by 'snagging' the coronoid process.

In a radiographic examination particular attention should be paid to the areas of the zygomatico-frontal suture, zygomatico-temporal suture of the arch and the zygomatico-maxillary suture of the inferior orbital margin. Radiopacity of a maxillary sinus usually indicates haemorrhage.

Fry and Ward\(^3\) point out that a Le Fort I fracture may leave the teeth bearing alveolus in quite good position, but the antral component may be in retro-position.
Reduction of the displaced fracture may be achieved by:

i) Gillies temporal approach and elevation.

ii) Intra-oral tuberosity approach and elevation.

iii) Caldwell-Luc approach and elevation.

iv) Nasal approach and elevation.

For simple disimpaction, the Gillies method is preferred, but with comminution, the Caldwell-Luc approach with digital moulding is better.

Fixation for a fractured zygomatic bone is seldom necessary, but when it is required the antrum may be packed with petrolatum gauze; the fracture lines may be crossed by wire sutures; or external fixation applied by a wire loop or a Clouston-Walker pin to a plaster head cap as suggested by Gross.39

The writer has attended 24 patients with fractures of the middle third of the face. The result of treatment in each case was satisfactory.
MIDDLE THIRD FRACTURES
IN CHILDREN

According to Rowe and Killey and Georgiade et al, fractures of the middle third of the face in children are rare. The Le Fort lines of fractures in children are even rarer, because the face is small in area compared to the head, and the elasticity of the face absorbs considerable distortion before fracture occurs.

The bones usually fractured, in order: the nasal bones, the frontal process of the maxillae, and the zygomatic bones. As with all middle third fractures, treatment should be commenced at the earliest possible time. Following reduction, only temporary, if any, fixation is required for young children. For older children, fixation as discussed in the previous section may be required.
GUN-SHOT WOUNDS

With gun-shot wounds, "team work" or specialty co-operation is essential for a satisfactory functional and aesthetic result. Bradley\(^{12}\) lists general surgeon, plastic surgeon, otorhinolaryngologist, neuro-surgeon, orthopaedic surgeon, oral surgeon, and ophthalmic surgeon as specialists that may be required to attend a case of gun-shot wound to the face.

Undoubtedly, this is a major problem in war time, but isolated cases also occur in civilian life. During the static or trench warfare of the First World war, maxillo-facial gun-shot wounds were most numerous. World War II produced less maxillo-facial gun-shot wounds, but more crush type middle third fractures as the result of vehicular (cars, trucks, and aeroplanes) trauma.

During these wars, the benefit of treatment was often delayed because of transport difficulties and severe debridement was essential in these cases. During the Korean War, Kwapis\(^{32}\) and Howell\(^{33}\) found that with faster transport (helicopters), conservative debridement only was necessary.

Rowe and Killey\(^{1}\) emphasize that the traumatizing missile must not be forgotten. Facts to be considered are: was the missile fast, slow, large, or small; the point of entry and exit; and did it strike hard tissue early after penetrating the skin, or later on. Emphasis is placed on the early diagnosis, evaluation, and treatment of every case.
Primary, or first aid treatment should be life-saving. In Korea, tracheotomy became almost routine for such injuries. There is usually little pain so that drugs are seldom necessary. Haemorrhage should be arrested and the area covered by a dressing. If a tracheotomy has not been performed the air-way must be maintained clear by having the face downwards, and the pharynx clear of blood clots and foreign bodies. The tongue is best held in position by a suture from the apex. Oedema of the soft palate and the larynx must be watched for, but tracheotomy will reduce the danger resulting from this. Rowe and Killey suggest the use of a barrel bandage to aid comfort, hold dressings in place, and help with the intake of fluids.

Usually there is little shock, but if there is, it may be neurogenic or oligaemic. With neurogenic shock there may be facial pallor, but the colour of the lips remains good. The extremities are cold, but there is no dyspnoea or restlessness. There is a low blood pressure and a slow pulse. Sighing respirations may be present together with sweating, nausea, and even vomiting.

Oligaemic (blood loss) shock will present facial pallor, pale lips, thirst, cold extremities, pronounced restlessness, a very low blood pressure, a fast pulse, sweating, dyspnoea, and vomiting. To treat shock, Rowe and Killey advise raising the foot of the bed above the level of the head, body warmth, morphia, and fluids, orally and/or intravenously.
Local, pulmonary, and meningeal infection should be prevented by a thorough wound toilet, and according to Rowe and Killey,\textsuperscript{1} the prophylactic use of antibiotics and chemotherapy, and anti-tetanus serum.

Pain may be alleviated by the use of tongue fixation (suture), a barrel bandage, and seeing that the patient is as comfortable as possible.

The dental treatment suggested, is the use of wire and plaster fixation to help keep the air-way patent and arrest haemorrhage. Loose teeth are extracted, but remnants and teeth in the line of fracture are left in situ. A thorough toilet is carried out, and temporary fixation may be obtained by the use of inter-dental wiring, inter- and intra-alveolar wiring, and external skeletal fixation (Clouston-Walker). Mobile short edentulous posterior fragments and fractured maxillae are best left alone.

Soft tissue trauma if clean and of recent origin should be sutured with wound approximation following toilet, debridement, and skin undermining. If the wounds are older than 48 hours or grossly soiled, they should be cleaned of foreign bodies with the aid of forceps, and scrubbed with soap and water. Devitalised and infected tissue should be excised, and the wounds loosely sutured with drainage present. Later, a plastic surgeon should be consulted.
The intermediate treatment is directed towards permanent bony fixation by wire, pins, and splints. The intake of food and fluids is managed, and adequate oral hygiene maintained. Infection control is still of paramount importance. As an aid to convalescence, saliva shields may be necessary for the patients' comfort.

Secondary treatment is directed towards restoring function and aesthetics to the patient. Bone and soft tissue grafts may be required, so that further fixation may be necessary. Later, the elimination of microstoma is carried out if necessary, and function restored by the use of exercisers.

Looking to the future, Rowe and Killey suggest that if atomic warfare develops, crush-type injuries, burns, and radiation may be expected. This will present a great problem in controlling shock, necessitating transfusions. Muscle destruction could be severe, producing acute blood loss, and so taxing the availability of blood transfusion to the utmost. By the use of routine tracheotomy and wide-spectrum antibiotics, all bone may be saved and restored to position.

The treatment of residual traumatic deformities requires the close collaboration of plastic surgeon, oral surgeon, and
prosthethist. Each case must be examined thoroughly, a diagnosis reached, and a treatment plan carefully considered. The great problem will always remain; whether a graft or a prosthetic appliance will benefit the patient most.
POST-OPERATIVE CARE.

Following the application of fixation, aimed towards bony and soft tissue repair, patients still require constant treatment for their physical and mental well being. This is stressed by Rowe and Killey who devote a chapter of their book to this aspect of treatment.

Following general anaesthesia, the maintenance of the patients' air-way is still of major importance, and remains so until the cough reflex returns. Following any operative procedure in the mouth, an oral toilet is necessary, and all blood aspirated and debris (note chips of dry cement) removed. As the pharyngeal pack is removed further aspirating should be carried out in the mouth and pharynx. It is now easy to see that all haemorrhage has been controlled. Finally, the lips are once more lubricated.

Until consciousness returns, patients require constant supervision, preferably in a special recovery-resuscitation ward. Immediate post-anaesthetic sedation is dangerous, and should not be administered by anyone except the anaesthetist for that case when it is considered necessary. The writer remembers one young female who tried to commit suicide during a deranged mental state following post-anaesthetic sedation.

. For the next seven days a close watch should be maintained on the temperature chart. A pronounced rise in temperature may be due to oral infection or respiratory infection (pneumonia).
Respiratory infection is usually indicated by a six to eight hour temperature rise within the first two days. This is caused by a blockage of a bronchus or a bronchiole by inspissated mucus or blood, or inhaled clot, calculus, teeth, bone, or dentures. Such blockage will cause lung collapse and later, a lung abscess. Such a complication may be controlled or prevented by the use of antibiotics and physiotherapy (post-anaesthesia breathing exercises).

Oral infection may arise three to five days post-operatively, and is marked by some soft tissue oedema. To help avoid oral infection, frequent mouth-washes or irrigations are essential to keep the oral cavity clean. When infection occurs hot saline irrigations at frequent intervals will help keep the infection localised. Pus is cultured, identified, and antibiotic sensitivity tests are carried out. The appropriate antibiotic need not necessarily be given immediately, as the writer believes that clinical bony union can be achieved in the presence of pus, provided adequate drainage and frequent irrigations are maintained.

Urinary tract infection is sometimes a post-operative problem, and a urologist should be consulted. Following fixation, pain is usually of a minor nature and is readily eliminated by A.P.C. and codeine. All types of fixation require regular inspections so that minor adjustments can be made, and any feeding problems should be investigated with
the aim of keeping the patient as contented as possible. With less intake of food and less bulk, bowel movements will naturally be lessened, so that there is no need for alarm at probable constipation.

Early ambulation is to be encouraged, and patients discharged from hospital as soon as possible. The time of return to employment depends very much on the type of work. A clerk could return to work with fixation still applied, but a miner should not work for six to eight weeks. Heavy work demands a large intake of food, which, with fixation, is not possible. This is apart from the risk of further injury to the part.

The writer has all maxillo-facial injury patients that have been discharged from hospital, return as an out-patient at intervals of no longer than seven days. Thus a check is kept on progress, and encouragement or praise is given to those who require such psychological aid.
HEALING

Rowe and Killey\(^1\) state: "Bone is a specialised form of connective tissue, derived as a direct result of differentiation of certain embryonic mesenchymal cells whose function is primarily to provide a supporting framework for the body." Mature bone consists of two permanent elements, osteocytes and an organic matrix. During activity, osteoblasts (bone formers) and osteoclasts (bone resorbers) appear.

During formation, the primitive fibroblast hyalinises and ossein is formed. Further condensation leads to the formation of osteoid, which is subsequently calcified by the activity of osteoblasts, which later become osteocytes. Thus membranous bone is formed. Endochondral bone is similarly formed except that the primitive fibroblasts are followed by chondrocytes.

Further growth and development takes place by osteoblastic and osteoclastic activity. Factors which have a controlling influence on bone-growth are diet and hormones.

Fry and Ward\(^3\) stress that the process of repair must be known in order to understand the treatment. Bone healing is complicated by movement and/or infection which delay or prevent union. Bony union is the complete union of a fracture with bone; while non-union is the interposition of fibrous tissue between fragments. Bone repair is similar
to soft tissue repair.

**Soft tissue Repair.** In wounds which heal by first intention blood vessels are severed and cells are damaged. The escaping blood washes the wound, then clots and protects the raw surfaces, preventing infection. The resulting inflammation is due to cell damage caused by the trauma and the disturbed blood supply. With vascular dilatation, lymph and leucocytes migrate into the tissues. Endothelial cells from the neighbouring capillaries invade the blood clot, and are followed by proliferating fibroblasts and phagocytic cells. These cells take up and remove blood pigment, fibrin and dead cells. The endothelial sprouts continue to grow from each side of the wound until they unite, when they canalise and become new capillaries. With these young capillaries come the proliferating fibroblasts, phagocytes, and inflammatory cells to build up granulation tissue. The fibroblasts lay down collagen fibres which unite the wound, producing healing and scaring.

The healing of wounds by second intention is similar, but instead of the granulation tissue growing from the sides of the wound to meet in the centre, it grows from the base up. This results in greater scaring.

**Bone Repair.**

Rowe and Killey\(^1\) name four types of tissue closely
associated with the repair of bone. They are the periosteum, blood vessels, cortical bone, and cancellous bone. The periosteum which is a connective tissue, has fibroblasts on the inner layer, and these become osteoblasts when bone formation becomes necessary. The blood vessels are derived from the periosteum and the centre of the bone (e.g. the inferior dental artery and nutrient arteries of the facial bones). If the cortical bone is thick, necrosis may be severe; but if it is thin, better healing is achieved. The cancellous bone aids with the early formation of callus or osteoid.

Physiology and Biochemistry. When tissue is injured histamine and acetylcholine is released in the area. This causes a vasodilatation of the surrounding vessels, thus increasing the blood supply to the region, causing hyperaemia and bone resorption. The normal pH of 7.4 falls to about 5.4 in about seven days because of peptones, lactic acid, and anoxaemia in the region of the haematoma. This is called the "acid tide". The Ca$^{++}$ and (PO$_4$)$^{3-}$ concentration falls and bone resorption takes place. The phosphatase concentration increases from the fourth to the twenty-first day after injury. All the calcium, phosphorus, and phosphatase necessary for repair is obtained from the fragment ends, and therefore a dietary supplement is unnecessary.

Histology The histology is concerned with the
microscopic study of the clot formation, the organisation of the haematoma, and the building of the fibrin network. The localised acidity causes a vaso-dilatation which in turn causes a local capillary stasis. The permeable vessel walls permit the protein exudate to enter the tissues, a fibrin network to be built up, and high oxygenation of the area. Phagocytosis continues and canalisation is complete after ten days. The next period, up to three weeks is vital for the laying down of collagen, and no movement (tissue damage) should be allowed. Following this fibrous union, osteoblasts appear and lay down primary bone (osteoid) in from three to six weeks. This osteoid is resorbed and replaced by osteoclastic and osteoblastic activity to mature bone in anything up to eighteen months.

**Clinical Features.** An haematoma, diagnosed by swelling, oedema, ecchymosis, and inflammation will remain for four or five days with complete fixation, and all pain ceases. After ten to fourteen days, no signs remain. In three to four weeks, with fibrous union, there is still mobility of the fragments, but consolidation has taken place, and there is no crepitus. In four to six weeks, only slight mobility remains, and clinical union may be said to have occurred.

**Movement.** Fry and Ward\(^3\) give a warning that granulation tissue is very delicate, and any movement that damages granulation tissue is traumatic. Movement that does not damage granulation tissue is termed sub-traumatic.
Traumatic movement repeats the haematoma - granulation tissue cycle, and continued movement will lead to fibrous non-union. Shearing movement tears the granulation tissue along its whole length, and the resulting fibrous non-union leads to fibrous scar tissue between the eburnated fragments. With angular movement, there is both traumatic and sub-traumatic movement. Callus formation proceeds in the zone of sub-traumatic movement and acts as a splint, allowing bony union.

**Abnormal Growth and Development** A few conditions likely to affect the growth, development, and repair of the jaws are discussed by Rowe and Killey. Osteogenesis imperfecta is a congenital disease or of early childhood, in which the cortical bone is very thin, and fractures are common followed by incomplete repair. Osteopetrosis is another congenital disease or of early childhood in which there is bony sclerosis, and fracture occurs easily due to the brittleness of the bone. The bones also fracture easily with the Vitamin D deficiency disease, osteomalacia. A cystic disease of bone is hyperparathyroidism, and fractures easily occur. Pathological fractures can occur with osteomyelitis, cysts, neoplasms, and osteoradionecrosis.

**Bone Grafts** Three types of bone are used in bone grafting. Homograft is bone used from another human, while autograft is bone used from the patient. A recent development
is the use of enorganic bone\textsuperscript{38} as a graft material.

Homografts are not always successful, possibly due to protein antagonism. When it is successful, it "takes" in the same manner as an autograft which dies, resorbs and new bone is built up in its place. The harder the bone (cortical) therefore, the longer the time for the graft to "take", and so cancellous bone is used in chip form to increase the surface area. It is interesting that autografts implanted in soft tissues, with or without periosteum, will not survive if there is no functional use for it.

Early reports\textsuperscript{38} indicate that anorganic bone will be most successful in its use as a grafting material, and has the great advantage that a donor area is unnecessary and a bone bank will always be at hand.

**Infection** Infection may be a reason for non-union according to Fry and Ward\textsuperscript{3}. Movement likewise, will cause an inflammatory response that will delay union, and lead to non-union. The sources of infection for a fracture are the oral cavity, the skin, already infected bone, the lymphatics, and the blood stream.

Infection from the oral cavity will enter an intra-oral open fracture. More serious however, is the infection derived from the skin with an extra-oral open fracture. Dental apical pathological conditions, teeth in the line of fracture
and denuded cementum will aid the infection of a fracture. During a bacteraemic state, infection may reach a fracture site by way of the lymphatics and blood vessels.

Cell damage causes inflammation, and if bacteria enter, the area is infected. Into this infected site migrate polymorphonuclear leucocytes; some of which are broken down forming pus. This pus collects under pressure and tracks along the planes of least resistance. The adjacent tissues are marked by inflammation; swelling, pain, redness, and heat. Areas of suppuration should be drained.

Secondary haemorrhage is caused by infection spreading, causing tissue damage, and so weakening a blood vessel that it ruptures. This can occur any time after twenty-four hours and may also be due to infected clot breakdown.

Bone resorbs only where it contacts healthy soft tissue; if there is no adjacent healthy tissue, no resorption takes place, but it becomes necrotic. Dead bone is separated from live bone by the action of osteoclasts, and the separated bone is called a sequestrum and tends to be exfoliated with associated pus. Osteoid never forms with sequestration (or pus), but it may form a short distance away (e.g. involucrum).

Comminuted fractures are usually open and infected. Uninfected bone fragments deprived of their blood supply undergo "aseptic necrosis". Instrumentation (curettage) before sequestrum separation will spread the infection.
Judicious probing however, will aid the diagnosis of sequestration, as viable fragments feel soft, and change shape and density in the area. Dead bone feels hard to the probe, and doesn't change shape or density.

A bacterial or mechanical irritant may be a repair stimulant if it is weak. The result however, varies with the types of cells: the highly differentiated cells may be irreparably damaged, but fibroblasts are damaged less easily. In any event, movement of any magnitude is a risk that can result in non-union.
COMPLICATIONS.

Soft Tissues

Complications in the treatment of soft tissue injuries are rare according to Rowe and Killey\(^1\), but they may be due either to continued trauma or infection. The lips and buccal tissues are commonly lacerated by teeth, and sometimes portions of fractured teeth will remain in the wounds. A radiographic examination will discover this, but it will not reveal the presence of glass, acrylic resin, or porcelain. Wounds in which foreign bodies are suspected should be explored with a probe.

A post-healing complication, not uncommon, is the obliteration of the labial or buccal sulci by cicatricial tissue. This may be treated by excision and an epithelial inlay. Another rare complication following healing is the development of cervico-facial antinomycosis. This is treated by drainage, antibiotic therapy, and possibly radiation.

External scar tissue becomes less conspicuous and more supple during the first six months after injury. Fry and Ward\(^3\) state that scarring is reduced if movement is limited following soft tissue injuries. Should scarring occur however, it may be reduced by massaging it with a vegetable oil. Rowe and Killey\(^1\) state that no plastic repair to scar tissue should be attempted within six months of injury.

Infection is treated by drainage; and antibiotics are no
substitute for surgery. When fluctuation occurs, the skin or mucous membrane is incised at the most dependant point of the area to be drained. Hilton's method is used: closed artery forceps are plunged into the fluctuant area through the incision until pus is reached; the forceps are then opened and withdrawn. Continuous drainage is obtained by suturing a rubber drain into the area for two days.

MANDIBLE

According to Fry and Ward an unbalanced occlusion is not unusual following removal of capped splints, but the malocclusion disappears without treatment in a week or two. Delayed union is a relative term as there is no normal. Normal union may vary from two to eight weeks; being quicker in children and slower in dentate elderly adults. Union that is achieved in two to six months may be said to be delayed. Delayed union or non-union will result from poor apposition, caused by incomplete or over reduction. Widening of the fracture line by bone resorption at the fractured surfaces normally occurs for two or three weeks. If the widening continues for a longer period, movement, sequestration, or infection may be the cause, and lead to non-union.

Malunion. Malunion is the result of poor or no treatment, leading to union in such a position that function and/or aesthetics is impaired. The treatment is to refracture, and retreat the lesion or perform a bone graft. The longer correction is delayed the more difficult it becomes. Mallett
and Federspiel\textsuperscript{41} give illustrations of malunion treatment.

**Non-Union.** Fry and Ward\textsuperscript{3} define non-union as a fibrous union with eburnated fragments (rounded smooth bone ends). This non-union may be loose or firm, but the nearer it is to the symphysis, the worse the disability. Non-union of a fracture of the neck of a condyle causes little worry; it may be even the treatment of choice. The treatment is to freshen the bone ends, and approximate the fragments or insert a bone graft.

Rowe and Killey\textsuperscript{1} state that complications of maxillofacial injuries are now quite uncommon. Teeth left in the line of fracture for a purpose, may need extraction later; but provided the bone ends are accurately opposed, the fragments adequately immobilized, and infection prevented, union should result. Failure of union in six to eight weeks may be because of delayed union; malunion, leading to ankylosis; or non-union leading to pseudoarthrosis.

The local aetiology of such complications may be due to infection; inadequate immobilization, which is the most common cause of complications; and imperfect reduction, which is the next most common cause of complications. Complications can arise from the excessive separation of the fragments by bone loss or over-reduction; the interposition of tissue or foreign substances between the bone ends, which inhibits osteoid
formation mechanically, or by ionic disintegration through the pH upset; and because of certain pathological conditions of the bone such as tumours, osteomyelitis, osteoradionecrosis, and fibrous dysplasias.

The general aetiology of fracture complications is old age and general debility, and diseases such as syphilis, diabetes mellitus, chronic renal disease, and tuberculosis. These diseases require treatment which can complicate maxillo-facial treatment.

**Bone Grafts.** With acute injury, skeletal fixation takes precedence over soft tissue repair; but with secondary deformity soft tissue restoration often precedes skeletal repair, according to Rowe and Killey. A bone graft should not be contemplated with in three months of injury, if infection is present, or if there is any communication of the area with the oral cavity. A good blood supply is essential, so that any badly scared tissue is excised and replaced by healthy tissue.

Before a graft is placed in position, the fibrous tissue between the fragments is removed, and the eburnated ends removed. Bleeding is encouraged by placing bur holes in the adjacent bone, and the fragments are approximated if not already so. A block of cortico-cancellous bone, usually from the anterior superior iliac spine, is placed in the defect together with cancellous chips. A minor bone loss is acceptable at the angle, but if restoration is required, a portion of the eighth rib may be used.

Rigid fixation is essential for six weeks.
Usually an external approach is used, but Shira and Frank\textsuperscript{43} reported on an intraoral approach.

**Temporo-Mandibular Joint Injuries.** Fry and Ward\textsuperscript{3} discuss temporo-mandibular joint injuries as a complication, not following treatment or non-treatment, but before and during treatment. A contused joint may be due to a blow causing a laceration of the associated soft tissues. This results in swelling and pain. Treatment is fixation in the rest position for a short period. Condylar neck fractures are often associated with dislocation of the condylar head; diagnosis being from radiographs. No attempt is made at reduction, but a false joint (pseudoarthrosis) is established. Recurrent dislocation is due to damaged capsule or ligaments and is not uncommon or serious. The condition is treated by maxillo-mandibular fixation for three or four weeks. Penetrating wounds of the temporo-mandibular joint are rare, and infection control is the main concern. These injuries are treated by condylectomy, or fixation followed by movement.

**Abnormal Movement.** Limitation of mandibular movement may be due to inflammation of the soft tissues, joint injury, depressed zygomatic complex, or neurosis. Joint injury may lead to ankylosis which can vary from slight to complete. Ankylosis is treated by condylectomy. Lewis\textsuperscript{44} treated zygomatic interference by removal of the coronoid process.

**Middle Third.**

**Delayed treatment.** Fractured nasal complex, frontal
processes of the maxillae, and zygomatic bones consolidate in about three weeks according to Rowe and Killey\textsuperscript{1}, while the dento-alveolar component may be still mobile. Up to two weeks after injury the nasal complex, the frontal processes of the maxillae, and the zygomatic bones may be reduced by the usual manual methods, but with a greater degree of controlled force. The teeth bearing component may be manually reduced up to three weeks after injury.

Delayed reduction is best achieved by slow traction such as weights from a Balkan beam. This traction may be applied to an upper splint up to six weeks following injury; four pounds weight should be tried for three days to start with. Strong elastic traction can also be applied to trans-buccal cheek wires from upper splints to a plaster head cap.

If reduction is not possible, there are three means of correction. With little displacement, posterior gagging of the teeth may be corrected by grinding, selective extractions, or alveolectomies. If the displacement is more extensive, onlay bone or cartilage grafting may be used to build out the face, and if there is tissue loss as well, a prosthetic appliance may be worn.

When mal-union is incomplete, the old fracture lines may be refractured by exposing them and separating the fragments by chisels and osteomes. The displacement is then
reduced and immobilized by connecting rods to previously
applied splints and a head cap. However, further
surgery may be needed if union is complete, and maxillary
osteotomy required at Le Fort I, II, or III levels as
outlined by Federspiel,14 and Rowe and Killey.1

With prompt efficient diagnosis and treatment, Rowe and
Killey expect few complications to arise. Poor treatment
can result in disfigurement, respiratory difficulty,
interference with mastication, or ocular inefficiency.
"The great majority of complications are preventable, but
certain of the post-traumatic sequela may fairly be
regarded as unavoidable, and justly related to the severity
of the injury rather than neglect or ignorance."

Post-traumatic headaches are caused by cerebral
irritation, and may be due to trauma, which may lead to
meningitis or to personality changes. Cranial nerves are
seldom damaged: the most common is the olfactory (I),
resulting in anosmia (no sense of smell).

Displacement of the medial or lateral walls of the
orbits can result in diplopia. Nasal deformity may be
corrected by refracturing, but a graft will be needed for
the correction of a 'saddle nose' caused by infection.
APPENDIX

The figures to be presented refer only to patients attended to by the writer. They do not include all patients with maxillo-facial injuries treated at the Royal Newcastle Hospital.

The figures for 1958 are incomplete, and only include those patients whose treatment was completed by about October.

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<td>Female 32 32 46 29 28 33 33</td>
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<td>11 (33%)</td>
<td>10 (48%)</td>
<td>17 (32%)</td>
<td>15 (53%)</td>
<td>13 (50%)</td>
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<td>Fights</td>
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<td>13 (36%)</td>
<td>3 (14%)</td>
<td>19 (36%)</td>
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Of the miscellaneous causes; one was unknown, and one was a gun-shot maxillo-facial injury.

It was found that on an average, vehicular accident cases tended to be unconscious for an hour or more; while patients from other causes either did not lose consciousness, or were unconscious for a short period. This would indicate that maxillo-facial patients of vehicular accidents suffered some cerebral damage, and it would be wise to watch these patients closely.

On an average, patients complained of little pain; it was more a "numb feeling".

Types of Fractures:

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**Treatment:**

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<td>-</td>
<td>-</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td>52</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>186</td>
</tr>
</tbody>
</table>

**Infection Rate (visible pus):**

<table>
<thead>
<tr>
<th>Year</th>
<th>1952</th>
<th>1953</th>
<th>1955</th>
<th>1956</th>
<th>1957</th>
<th>1958</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>11%</td>
<td>18%</td>
<td></td>
<td>9%</td>
<td>18%</td>
<td></td>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>

In the years 1952 and 1953, penicillin was administered prophylactically to all patients routinely with maxillofacial injuries. In 1953, there was one case of osteomyelitis: the patient did not seek treatment for ten days after injury, and a bicuspid tooth was in the line of fracture. Antibiotics were not administered prophylactically in the years 1955, 1956, 1957, and 1958. In fact, antibiotics were only given when the general condition, not the local condition, required them.

**Period of Treatment in days:**

<table>
<thead>
<tr>
<th>Year</th>
<th>1952</th>
<th>1953</th>
<th>1955</th>
<th>1956</th>
<th>1957</th>
<th>1958</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31-80</td>
<td>17-126</td>
<td>25-90</td>
<td>7-105</td>
<td>19-127</td>
<td>7-107</td>
<td>7-127</td>
</tr>
</tbody>
</table>
145 Treatment Success.

<table>
<thead>
<tr>
<th>Year</th>
<th>1952</th>
<th>1953</th>
<th>1954</th>
<th>1955</th>
<th>1956</th>
<th>1957</th>
<th>1958</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>100%</td>
<td>95%</td>
<td>100%</td>
<td>96%</td>
<td>100%</td>
<td>96%</td>
<td>97%</td>
<td></td>
</tr>
</tbody>
</table>

In 1953 there was one case of non-union in an alcoholic female who refused to co-operate. There were two cases of malunion in 1956: one was due to incomplete reduction of bilateral fractured condyles; and the other was a fractured body of an edentulous mandible with much displacement, which would have benefitted by open reduction. The case of non-union in 1958 occurred in a confused elderly miner who developed pneumonia following admission to hospital with bilateral fractures of the mandible in the bicuspid regions. The left fracture healed well, but he developed acute suppurative parotitis on the right side, and the fracture refused to heal, although the fragments were in good position and immobilized.

The alcoholic female of 1953 refused to have a bone graft and was discharged. The malunited fractured condyles were treated by posterior occlusal grinding to obtain fair occlusion and reduce the gagged bite. Later the occlusion corrected itself, giving a satisfactory result. The case of malunion of the body was not corrected as function and aesthetics were quite satisfactory. The ununited fracture of the miner will be corrected by an anorganic bone graft at a later date.
In the following table of individual fractures treated (less 1958), fractures of the middle third are counted as two fractures, except partial or unilateral Le Fort I. Thus there may be a Le Fort II on one side, and a Le Fort III on the other side. Fractured zygomatic bones do not include those of Le Fort III fractures, but fractures involving that middle third bone alone. Fractures of the nose include those associated with Le Fort II and III fractures.

<table>
<thead>
<tr>
<th></th>
<th>1952</th>
<th>1953</th>
<th>1955</th>
<th>1956</th>
<th>1957</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Le Fort I</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Le Fort II</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Le Fort III</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nose</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zygomatic Bone</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Condyle</td>
<td>16</td>
<td>9</td>
<td>10</td>
<td>14</td>
<td>10</td>
<td>59</td>
</tr>
<tr>
<td>Ramus</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Angle</td>
<td>11</td>
<td>6</td>
<td>6</td>
<td>16</td>
<td>12</td>
<td>51</td>
</tr>
<tr>
<td>Molar</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Bicuspid</td>
<td>14</td>
<td>19</td>
<td>12</td>
<td>19</td>
<td>5</td>
<td>69</td>
</tr>
<tr>
<td>Canine</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Symphysis</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>50</td>
<td>40</td>
<td>87</td>
<td>46</td>
<td>291</td>
</tr>
</tbody>
</table>

Thus the writer has attended 291 fractures in 171 patients at the Royal Newcastle Hospital in 1952, 1953, 1955, 1956, and 1957.

It is interesting to compare some of the figures with those of Rowe and Killey1.
<table>
<thead>
<tr>
<th>Description</th>
<th>Rowe and Killey</th>
<th>The Writer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Patients</td>
<td>73%</td>
<td>77%</td>
</tr>
<tr>
<td>Female Patients</td>
<td>27%</td>
<td>23%</td>
</tr>
<tr>
<td>Middle Third</td>
<td>33%</td>
<td>13%</td>
</tr>
<tr>
<td>Mandible</td>
<td>76%</td>
<td>95%</td>
</tr>
<tr>
<td>Age Bracket</td>
<td>14/12 - 91</td>
<td>2 - 81</td>
</tr>
<tr>
<td>Vehicular</td>
<td>47%</td>
<td>40%</td>
</tr>
<tr>
<td>Brawls</td>
<td>19%</td>
<td>30%</td>
</tr>
<tr>
<td>Single Fractures</td>
<td>44%</td>
<td>53%</td>
</tr>
<tr>
<td>Double Fractures</td>
<td>41%</td>
<td>33%</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY


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36. A. B. MacGregor and G. L. Fordyce — "The Treatment of Fractures of the Neck of the Mandibular Condyle"


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