MAXILLO-FACIAL FRACTURES

M. J. Addison, B.D.S. (S.U.)

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Department of Oral Surgery

Faculty of Dentistry

University of Sydney

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INTRODUCTION

This review covers all of the available journal and textbook literature of the last ten years, as well as many important references from previous years.

The field covered is maxillo-facial traumatic injuries, excluding gunshot wounds. Although an understanding of soft tissue injuries and nasal fractures is necessary for this subject, these sections have not been covered in great detail, as they come more within the province of the plastic surgeon.

Many references have not been included, either because they were repeating what had been said before, or did not contribute anything to knowledge in this field.

Details of treatment techniques have not been given unless they were unusual, or were necessary for discussion of that technique. Some techniques have not been mentioned, where a similar technique has been discussed sufficiently to demonstrate a particular principle (e.g. Jelenko arch bars have not been specifically treated, but arch bars in general have been).

References have been listed at the end of each major section in the order in which they have been discussed.

Abbreviations which have been used are: cerebro-spinal fluid - CSF; temporomandibular joint - TMJ; stainless steel - SS.

Several photographs have been included to illustrate various principles and techniques.
Where possible, any important reference in a text book has been traced back to the original work, but in several cases this has not been available - e.g., Stevenson per Thoma (1963) on page 161.

Rowe and Killey's text (1955) is still the only comprehensive book available in this field, although the last edition was published in 1955 and it is becoming a little out of date. Two excellent works by Killey (1965 and 1967) have helped to fill the need for a more up to date reference; these are in the form of handbooks which give the practitioner a wealth of information in an easily digestible form.
INDEX

HISTORY OF FRACTURE TREATMENT 1

AETIOLOGY, INCIDENCE AND TYPES OF FRACTURES 7

Causes of Injury 8

Fracture sites, Frequency, and the Age Groups Affected 9

Relation of Mandibular Fracture Sites to:

   Site of Trauma 11
   Age 12
   State of Dentition 12

Mechanics in the Production of Mandibular Fractures 14

Sites and Frequency of Fractures of the Middle Third of the Face 16

Types of Fracture 17

DIAGNOSIS AND TREATMENT PLANNING 20

Diagnosis:

   Preliminary Examination and Emergency Treatment 21
   History of the Injury 30
   General Examination 31
   Local Examination - Extra-oral 40
      Intra-oral 41
      Radiographic 42
   Treatment Planning - Anaesthesia 47
      Tooth in the Line of Fracture 48
      Use of Functional Treatment 48
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotic Therapy</td>
<td>49</td>
</tr>
<tr>
<td>Facial Lacerations</td>
<td>51</td>
</tr>
<tr>
<td>First-aid Immobilisation of the Jaws</td>
<td>53</td>
</tr>
<tr>
<td><strong>FRACTURES OF THE MANDIBLE</strong></td>
<td>57</td>
</tr>
<tr>
<td>Surgical Anatomy</td>
<td>58</td>
</tr>
<tr>
<td>Classification</td>
<td>65</td>
</tr>
<tr>
<td>Signs and Symptoms</td>
<td>68</td>
</tr>
<tr>
<td>Treatment — Reduction and Fixation Methods:</td>
<td>70</td>
</tr>
<tr>
<td>Wiring Methods</td>
<td>74</td>
</tr>
<tr>
<td>Cast Metal and Acrylic Splints</td>
<td>78</td>
</tr>
<tr>
<td>Open and Extra-skeletal Methods</td>
<td>83</td>
</tr>
<tr>
<td>Treatment of the Edentulous Mandible</td>
<td>96</td>
</tr>
<tr>
<td>The Edentulous Posterior Fragment</td>
<td>104</td>
</tr>
<tr>
<td>Fractures of the Mandibular Condyle</td>
<td>108</td>
</tr>
<tr>
<td>Fractures of the Coronoid Process</td>
<td>123</td>
</tr>
<tr>
<td>Fractures of the Mandible in Children</td>
<td>124</td>
</tr>
<tr>
<td><strong>FRACTURES OF THE MIDDLE THIRD OF THE FACIAL SKELETON</strong></td>
<td>135</td>
</tr>
<tr>
<td>Surgical Anatomy</td>
<td>136</td>
</tr>
<tr>
<td>Classification</td>
<td>143</td>
</tr>
<tr>
<td>Signs and Symptoms</td>
<td>148</td>
</tr>
<tr>
<td>Treatment —</td>
<td></td>
</tr>
<tr>
<td>Treatment of Dento-alveolar Fractures</td>
<td>154</td>
</tr>
<tr>
<td>Reduction of Le Fort I, II and II Fractures by:</td>
<td></td>
</tr>
<tr>
<td>Manipulation</td>
<td>156</td>
</tr>
</tbody>
</table>
Traction 159
Open Reduction 162

Immobilisation of Le Fort I, II and III Fractures by:

External Skeletal Methods 165
Immobilisation Within the Tissues 173
Intra-oral Methods 177

Fractures of the Zygomatic Bone and Arch:
Classification 180
Signs and Symptoms 184
Fractures of the Orbital Floor 188
Treatment 192

Fractures of the Nasal Region, Frontal Sinus and Paranasal Air Sinuses 199
Fractures of the Styloid Process 204
Delayed Treatment 205
Middle Third Fractures in Children 208

POST-OPERATIVE CARE 213
Immediate Phase - Post-anaesthetic 214
Intermediate Phase - Hospitalisation, Diet 215
Late Phase - Occlusal Adjustments 218

COMPLICATIONS 221
The Pathology of Bone Healing 222
Factors which Affect Healing: Local Factors 225
General Physiological Factors 227
Delayed and Non Union 229
Mandibular Complications 231
Middle Third Complications 234
Other Complications 237
HISTORY OF FACIAL FRACTURES
An understanding of the history of facial fracture treatment is a necessary background to any attempt to evaluate present day methods and approaches to treatment. This subject has been treated by Rowe and Killey (1955), and Thoma (1959); while the more recent developments have been covered by Dingman and Natvig (1964).

The history of jaw fractures has been traced back to the earliest civilisations, including the Sumerians, Egyptians and Etruscans, who practised the crudest methods of bone setting as early as 2200 B.C. At about the same time in India, use was being made of pedicle flaps from the cheek or forehead to repair defects of the nose or lips. Most of the advances of knowledge in this field took place in times of conflict. Wars throughout the ages have provided such a number of facial injuries that the surgeons have been forced to use their ingenuity to devise methods of treatment.

William of Saliceto (about 1270) was the first to apply the obvious treatment of ligating the teeth to effect immobilisation.

The first person to refine the treatment of jaw fractures into a definite science was Ambroise Pare in the sixteenth century. He revived the use of ligatures and instituted proper drainage; among his many ideas were 'dry sutures', and some original facial prostheses.

In the late eighteenth and early nineteenth centuries, the dental science had begun to develop; the first splints were introduced by Chopart and Desault in 1780. The appliance which
they devised for the treatment of mandibular body fractures consisted of a shallow trough of iron inverted over the occlusal surface of the lower teeth which were protected by cork or lead plates. A bar projected from the trough in the incisor region, being bent at right angles and fastened by thumbscrews to a submandibular plate of sheet iron. Movement of the fragments was thus prevented by compression between the occlusal surface of the teeth and the lower border of the mandible. Variations of this principle were developed in the subsequent hundred years. Barton (1816) devised the bandage named after him. An early form of cap splint was developed by Nasmyth and Lister (1835), using gold to construct a metal splint to fit over the teeth.

The discovery of anaesthesia in 1846 by Morton (United States) was to prove a great advance in the treatment of jaw injuries. At about the same time Fauchard (France) and Buck (United States) began to use inter-osseous wiring with variable results due to infection, and subsequent sequestration.

The American Civil War (1861-65) and the Franco-Prussian War (1870-71) marked many advances in this field: Gunning developed his vulcanite splint; Bean was the first to treat fractures by sectioning the model of the fractured lower jaw, and carefully articulating this with the upper jaw before making a Gunning splint in vulcanite. Various types of splints were developed — swaged and cast — cementation was by gutta-percha or wire ligatures were passed between the teeth and around the splint.
In 1890 Angle applied some of his orthodontic ideas to fracture treatment, using arch wires attached to orthodontic bands which were cemented to the teeth. This principle is still in use today.

These advances in the latter half of the nineteenth century went hand in hand with the increasing use of anaesthesia, antiseptic and aseptic techniques of surgery. In 1895 the discovery of the x-ray by Roentgen was to open the way for accurate diagnosis of fractures.

In 1901, Le Fort described his famous middle third classification, placing on a firm foundation the treatment of these fractures.

The First World War saw the development of the art of prosthetic replacement of facial and oral tissues. Soft tissue debridement and bone grafting were improved; the use of bone grafts from the iliac crest was developed; tissue defects were repaired by the tube pedicle technique, which was pioneered by Gillies (United Kingdom) and Filatov (Russia).

The main advances between the Wars were an improved form of eyelet wiring described by Eby in 1920, and the temporal fossa approach for the elevation of the depressed zygomatic bone described by Gillies, Kilner and Stone in 1927.

During the Second World War, the locking-plate technique of joining splinted fragments was developed by Fry et al. Clouston and Walker introduced their two-pinning technique in 1943. Fleming's discovery in 1929 of penicillin lead to a ready supply
of this drug by 1944. The subsequent development of antibiotics has enabled many treatments to be used which would otherwise have been impossible.

The need for a team approach to the treatment of maxillofacial injuries was recognised and units were set up which inclu ded ophthalmic surgeons, neurosurgeons as well as maxillo-facial surgeons. This approach has been carried into the present day hospital treatment, where the use of oral surgeon, general surgeon, neurosurgeon, ophthalmic surgeon and anaesthetist may be combined.

After the War, open reduction and internal fixation was developed; previous attempts had often failed because of poor metals causing tissue irritation and the development of sepsis in many cases. The use of antibiotics and superior metals such as tantalum and vitallium has reduced these complications and this approach is very popular in the United States. Techniques such as circumferential wiring, transosseous wiring, metal bone plates, internal wiring fixation, bone pinning, which were once doubtful procedures have now become commonplace.

REFERENCES


(3) R. Dingman and D. Natvig - "Surgery of Facial Fractures", 
AETIOLOGY, INCIDENCE, AND TYPES OF FRACTURES
CAUSES OF INJURY

This section was mentioned by most authors, but the only comprehensive coverage was given by Rowe and Killey (1955) and in a series of articles by Hagan and Heulke. Both of these surveys agree as to the cause and proportions of different types of fractures; as well, Hagan and Heulke contribute a survey correlating fracture site with site of impact, age, and the state of dentition.

In a survey of 500 cases of fractures of the jaws carried out by Rowe and Killey, the cause of fractures was found to be:

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fights</td>
<td>93</td>
<td>18.6</td>
</tr>
<tr>
<td>Motor cyclists</td>
<td>79</td>
<td>15.8</td>
</tr>
<tr>
<td>Pedal cyclists</td>
<td>74</td>
<td>14.8</td>
</tr>
<tr>
<td>Falls</td>
<td>60</td>
<td>12</td>
</tr>
<tr>
<td>Motorists</td>
<td>58</td>
<td>11.8</td>
</tr>
<tr>
<td>Sports</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>23</td>
<td>4.6</td>
</tr>
<tr>
<td>Faints</td>
<td>17</td>
<td>3.4</td>
</tr>
<tr>
<td>Epileptic fits</td>
<td>9</td>
<td>1.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>47</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Road traffic accidents accounted for 234 cases or 46.8% of the total. Of the 500 cases, 73.4% were male and 26.6% were female, which agrees with a survey by Hagan and Heulke (1961) in which 73.4% of those injured were male. Dingman and Natvig (1964)
state that the sex ratio of 3 males : 1 female injured is due to the greater activity and exposure to trauma of males. Hagan and Heulke (1961) list the causes of injury as:

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto accident</td>
<td>55.8</td>
</tr>
<tr>
<td>Fights</td>
<td>17</td>
</tr>
<tr>
<td>Falls</td>
<td>10</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>14.4</td>
</tr>
<tr>
<td>Unknown</td>
<td>2.8</td>
</tr>
</tbody>
</table>

The American Dental Association in 1962 estimated that 72.3% of all persons injured in motor car accidents received head injuries. From the results of several surveys carried out concerning motor car accidents, the Association recommended legislation for the compulsory fitting of properly constructed seat belts on all new cars.

**FRACTURE SITES, FREQUENCY, AND THE AGE GROUPS AFFECTED**

Rowe and Killey (1955) and Hagan and Heulke (1961) agree that the greatest number of fractures occur in the 20 - 30 age group. In the study of Hagan and Heulke, 49.5% of the patients were between the ages of 14 and 26. The figures of Rowe and Killey are:

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>6</td>
<td>1.2</td>
</tr>
<tr>
<td>6 - 11</td>
<td>18</td>
<td>3.6</td>
</tr>
<tr>
<td>12 - 19</td>
<td>81</td>
<td>16.2</td>
</tr>
</tbody>
</table>
The relative frequency of single and double fractures was observed by Rowe and Killey to be almost equal; double fractures were mostly bilateral, it being a rare occurrence to find two or more fractures on the same side of the mandible.

The occurrence of single and multiple fractures was found to be in similar proportion by both surveys:

<table>
<thead>
<tr>
<th></th>
<th>Rowe and Killey</th>
<th>Hagan and Heulke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single fracture</td>
<td>43.7%</td>
<td>46.4%</td>
</tr>
<tr>
<td>Double fracture</td>
<td>41.1%</td>
<td>31.9%</td>
</tr>
<tr>
<td>Triple fracture</td>
<td>13.3%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Quadruple fracture</td>
<td>0.3%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

According to Rowe and Killey, 76.4% of all cases involved the mandible and 32.8% involved the middle third of the face.

THE SITE AND FREQUENCY OF MANDIBULAR FRACTURES

Rowe and Killey (638 fractures)

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condyle</td>
<td>25.6</td>
</tr>
<tr>
<td>Angle</td>
<td>19.9</td>
</tr>
<tr>
<td>Molar region</td>
<td>19.7</td>
</tr>
<tr>
<td>Incisor region</td>
<td>12.8</td>
</tr>
<tr>
<td>Canine region</td>
<td>12</td>
</tr>
</tbody>
</table>
The coronoid process was fractured in 9 cases, and the hyoid bone and styloid process were each fractured on one occasion.

Hagan and Heulke (576 fractures)

<table>
<thead>
<tr>
<th>Location</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcondyle</td>
<td>36.3</td>
</tr>
<tr>
<td>Body</td>
<td>21.2</td>
</tr>
<tr>
<td>Angle</td>
<td>20.5</td>
</tr>
<tr>
<td>Lateral chin</td>
<td>13.5</td>
</tr>
<tr>
<td>Alveolar process</td>
<td>2.8</td>
</tr>
<tr>
<td>Ramus</td>
<td>2.2</td>
</tr>
<tr>
<td>Coronoid process</td>
<td>2.1</td>
</tr>
<tr>
<td>Midline</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**RELATION OF MANDIBULAR FRACTURE SITES TO SITE OF TRAUMA, AGE, AND STATE OF DENTITION**

**Site of Trauma**

According to Hagan and Heulke (1961), the majority of subcondylar fractures resulted from a blow to the chin region, most often to the chin point. More often the body of the mandible was fractured by a direct blow to the region of the fracture. Approximately two-thirds of the angle fractures were caused by a blow to the body or angle of the mandible. Frequently fractures between the midline and the mental foramen were caused by blows to the anterior part of the jaw, as were most fractures of the alveolar process.
Age

In younger persons, subcondylar and lateral chin fractures were the most common; fractures of this region decreased in frequency with age. Angle and body fractures were more frequent in older patients.

State of Dentition

Edentulous persons have a higher frequency of body and angle fractures than subcondylar fractures. Subcondylar fractures were more common in persons with posterior mandibular teeth missing. The presence of a mixed dentition did not have a notable effect on fractures, although the incidence of alveolar fractures was higher.

This was confirmed by a statistical analysis of the above study by Heulke et al (1961).

In a further statistical analysis of the above study, Heulke et al (1962) found a high incidence of fractures where individual teeth were missing; thus pointing out a weakness in short edentulous spaces.

In a subsequent study, Heulke and Burdi (1964) confirmed this weakness. They also pointed out the relation of fracture site to the third molar and canine teeth regions, although they concluded that the high incidence of fractures in these sites may have as much to do with the lessened cross-sectional area of the mandible in these areas as the weakening effect of the teeth.

They also found that more fractures were produced by impacts to the body of the left side of the mandible or to the chin than
were produced by impacts to the body of the right side of the mandible. Anatomic characteristics of the state of the mandibular dentition, edentulous regions, the mental foramen and the long root of the canine tooth were considered in determining predisposing or directive factors in the location of mandibular fractures.

They summarised as follows: impacts cause fractures in the region of contact to the mandible more often than in other regions. When there is an edentulous space mesial or distal to the fracture site, or only distal to it, the fracture passed through a space more often than through an alveolus. Conversely, patients with complete dentition around the fracture site had the fracture passing through the alveolus more often. More fractures passed through the third molars or cuspids than through any other single region. It is an assumption, however, to conclude that the teeth alone are the only influence on the fracture location; other factors - specifically the site of impact and the cross-sectional area of the bone - must also be considered when assessing the reasons fractures are located in specific regions.
MECHANICS IN THE PRODUCTION OF MANDIBULAR FRACTURES

Heulke (1961) carried out an experiment, subjecting 27 human mandibles to varying forces at the symphysis. The stresses and strains created in the mandible were recorded by a "Stresscoat" technique. With this technique, the mandible is covered by a coat of varnish; any stresses show as lines or cracks in the varnish. His results were as follows:

Forces and impacts to the symphysis of the mandible cause deformations which are specific in their location. Most frequently these impacts cause a deformation of the subcondylar region of the mandible, the type of deformation depending on the method of condylar fixation. This deformation may be a medial or lateral bending of the condyle or a vibration of the subcondylar region itself. In addition, the lingual aspect of the chin tends to flatten because of the application of the force to the opposite side of the bone. Tensile stresses and strains tend to concentrate about the mental foramen, buccal alveolar walls, lingula and lingual tuberosity, oblique line, buccal shelf, and inferior margin of the mandible. However, following chin impacts, these areas are not so frequently involved either clinically or experimentally. The coronoid process also tends to vibrate because of chin impacts when the condyles are firmly fixed. Clinical data have shown that any area of the mandible may be fractured by impacts to the chin region, with the subcondylar region being the most frequently involved. The experimental results of this study also indicate that all areas of the
mandible may develop high tensile stresses and strains due to impacts to the chin, and that the subcondylar region is most frequently involved.

Heulke and Patrick (1964) carried out further experiments: subjecting 6 specimen skulls to impacts to the point of the chin. The strains produced were measured by strain gauges in the lateral subcondylar regions and lingual cortical plates. The results indicated that the subcondylar region exhibits higher tensile strains than the lingual cortical plate. The results confirmed the results of the previous survey.
The sites and frequency of fractures of the middle third of the face

The only comprehensive study available on the incidence of middle third fractures was presented by Rowe and Killey (1955). The site and distribution of 164 cases were as follows:

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractures of the zygomatic bone alone</td>
<td>39.6</td>
</tr>
<tr>
<td>Fractures of the zygomatic arch alone</td>
<td>2.5</td>
</tr>
<tr>
<td>Fractures of the premaxilla</td>
<td>8.0</td>
</tr>
<tr>
<td>Unilateral Le Fort type I fractures</td>
<td>8.0</td>
</tr>
<tr>
<td>Unilateral Le Fort type II fractures</td>
<td>1.2</td>
</tr>
<tr>
<td>Le Fort type I fractures</td>
<td>8.5</td>
</tr>
<tr>
<td>Le Fort type II fractures</td>
<td>18.8</td>
</tr>
<tr>
<td>Le Fort type III fractures</td>
<td>1.2</td>
</tr>
<tr>
<td>Le Fort type I and III fractures</td>
<td>6.7</td>
</tr>
<tr>
<td>Le Fort type I, II, and III fractures</td>
<td>1.2</td>
</tr>
</tbody>
</table>
TYPES OF FRACTURE

Fracture may be defined as a sudden violent solution of continuity of bone and may be incomplete in nature. The fracture may result from:

1. direct violence;
2. indirect violence;
3. excessive muscular contraction (e.g., fracture of the coronoid process).

Rowe and Killey (1955) classify the different types of fracture as follows:

**Simple fracture** - this is a linear fracture not in communication with the exterior, and is usually found in the region of the condyle, coronoid process, ascending ramus, angle posterior to the last molar tooth and often in fractures of the edentulous mandible.

**Compound fracture** - any fracture involving the tooth-bearing area of the mandible, or where an extra-oral or intra-oral wound is present involving the fracture line, is termed compound fracture. Fracture of the condyle will become compounded when there is an associated laceration of the anterior wall of the external auditory meatus.

**Comminuted fracture** - this type of fracture is generally caused by a greater degree of violence, often occurring in middle third fractures.

**Complicated fracture** - complications may be damage to the inferior dental nerve or branches of the facial nerves or vessels;
certain fractures of the condylar region will involve the meniscus or articular surface.

**Impacted fracture** - this type of fracture is very rare in the mandible, but is frequent in the middle third of the face.

**Greenstick fracture** - this type of fracture is usually found in children; fractures of the condylar process in children are usually greenstick in type.

**Pathological fracture** - this generally follows minimal trauma or muscular contraction with the following conditions:

(a) generalised skeletal disease such as osteogenesis imperfecta, Paget's disease, etc.;

(b) localised skeletal disease such as cysts, osteomyelitis, osteoradionecrosis, neoplasm.

**Distracted fracture** - the fragments of bone may be held apart by bone, tooth or soft tissue.

**Displaced fracture** - displacement occurs when one or both fragments are drawn out of alignment by muscle pull.

**Depressed fracture** - depression usually is caused by the dislodgement of a fragment of bone into a cavity below the surface.

**REFERENCES**


DIAGNOSIS AND TREATMENT PLANNING
Diagnosis is the most important aspect of treatment of maxillo-facial fractures, as, once the exact nature of the injuries has been determined, the definitive treatment can vary with the operator's own preferences and with the equipment available to him. Incomplete or faulty diagnosis, especially in the case of condylar and middle third fractures, may lead to the necessity for delayed treatment, which is invariably more complicated and inconveniencing than the correct initial treatment.

Diagnosis should proceed along the following lines:

1. preliminary examination, followed by any emergency treatment that is necessary;
2. history of the injury;
3. general examination of the patient;
4. local examination of the injury.

PRELIMINARY EXAMINATION AND EMERGENCY TREATMENT

A preliminary examination should be made of the patient to determine whether any treatment of a life-saving nature is necessary. Complications which may need attention are: respiratory obstruction, haemorrhage, cardiac arrest, shock and pain.

It is obvious that treatment of a life-saving nature must be given priority, as stated by: Dawson (1962), Rowe (1964), Alling (1959 and 1960), Buzzard et al (1964).

According to Buzzard et al (1964), haemorrhage, thoracic, and neurological complications must take precedence over facio-maxillary problems if the former are of a critical nature. He also states that within the group of maxillo-facial injuries the
treatment of skeletal injuries always takes priority over the soft tissue; the plastic surgeon would much prefer to deal later with scars on a face of normal shape than to attempt the correction of an established dish-face deformity.

**Respiratory Obstruction**

Rowe (1964) considers that the maintenance of the airway should be the initial phase of treatment. He states that this maintenance is dependent upon:

1. the absence of any anatomic or mechanical barrier;
2. the preservation of the laryngeal reflex;
3. the existence of adequate pulmonary ventilation;
4. the integrity of the respiratory centre.

He lists the causes of respiratory obstruction as:

1. inhalation of blood clot, vomit, saliva, mucus or portions of teeth, bone and dentures;
2. inability to protrude the tongue because of posterior displacement, or comminution with collapse, of the bone at the symphysis to which the muscles are attached;
3. occlusion of the oronasopharynx by the soft palate after retroposition of the maxilla.

He then suggests that for treatment, inhalation should be prevented by:

(a) **Posture** - with the patient turned on his side and the trachea inclined slightly downward;
(b) Oropharyngeal Toilet - all clot and debris should be cleared out with swabs and forceps;

(c) Suction.

Killey (1965) states that in Le Fort type II and II fractures, and with severe injuries to the nasal complex, the nares are blocked with congealed blood, or are bleeding profusely; in either event there is occlusion of the airway. The nose should be cleared with a suction apparatus and then a McGill's no. 3 flanged nasal tube passed down each nostril. Any nasopharyngeal airway may be used, provided that a safety pin is inserted at the external end to prevent it from slipping down the throat.

Although the terms "tracheostomy" and "tracheotomy" are often used interchangeably, the true meaning of "tracheotomy" is the removal of part of the trachea. The correct term for the establishment by surgery of an artificial airway is "tracheostomy".

Tracheostomy is indicated by the following:

1. lack of tongue control;

2. gross retroversion of the middle third;

3. actual or potential oedema of tongue, pharynx, and glottis;

4. uncontrollable oronasopharyngeal haemorrhage;

5. respiratory inadequacy - pulmonary or central nervous system.

Intermediate indications for tracheostomy are:
1. essential immobilisation of jaws with inadequate nasal airway;
2. inadequate postoperative supervision.

The late indication for tracheostomy is essential immobilisation of jaws with delayed pulmonary complications.

All the foregoing indications will be accentuated in the unconscious patient.

Dingman and Natvig (1964) give a very good coverage of tracheostomy. They state that tracheostomy is necessary when there is airway obstruction in or above the larynx. This may be due to: foreign bodies, laryngospasm, oedema or tumours in the hypopharyngeal and supraglottic areas.

They then describe two types of tracheostomy: coniotomy, or superior; and inferior.

**Haemorrhage**

Haemorrhage is a reasonably rare complication of maxillo-facial injuries, although on several occasions I have had to clamp and suture intra-oral vessels after initial shock had worn off. Rowe (1964) states that, although severe and prolonged haemorrhage is unusual, there may be an occasional indication for clamping and ligation of a vessel, packing of a wound, or rarely, the control of nasal haemorrhage by the insertion of a postnasal pack, together with plugging of the nasal cavity.

Haemorrhage complications mainly occur with associated soft tissue lacerations. Archer (1966) suggests that a knowledge of the head and neck arteries and their pressure points is useful
for emergency treatment. With the use of gauze and bandages, pressure can be applied over these areas and bleeding controlled until a clamp or ligature is applied to the injured vessel.

Haemorrhage from the external carotid artery and branches may be temporarily controlled by digital pressure applied along the anterior margin of the sternocleidomastoid muscle at the hyoid bone. Haemorrhage from any branch of the external maxillary artery can be reduced by compressing the vessel where it crosses the lower border of the mandible in the facial notch just anterior to the angle. The most effective point to compress the superficial temporal artery is where it crosses the zygomatic process of the temporal bone just anterior to the ear. The lingual artery can be compressed to some extent by deep pressure under the angle of the mandible or, in severe cases, by compression of the external carotid artery. It may be necessary to pack gauze into the wounds to check inaccessible vessels, either suturing it in place or bandaging it in position under pressure. The prime object is to conserve the individual's blood supply, prevent shock, and better prepare these serious cases for transportation to the hospital, where more exacting measures can be instituted to save life.

Cardiac Arrest

According to Zaydon and Brown (1964), one of the most common causes of cardiac arrest in the injured patient is anoxia and hypoxia. Vagal reflexes come into play with an injury to the head and neck. Massive haemorrhage and shock can cause cardiac
arrest. Drug poisoning may also be a factor.

Upon heart stoppage, the patient may gasp, suddenly become cyanotic, unconscious and stop breathing. If no carotid pulse, heart sounds or blood pressure are found, cardiac arrest exists.

For treatment they state that the patient should be ventilated immediately and closed heart massage instituted. Immediate mouth to mouth breathing should be promptly carried out. Archer (1966), and Wolcott (1963) give detailed descriptions of closed heart massage and mouth to mouth resuscitation techniques.

As soon as possible, an oropharyngeal or endotracheal tube should be inserted to allow more effective oxygenation. The lungs should be inflated adequately fifteen times per minute. At times, effective lung ventilation alone may restore the patient. Without proper oxygenation, artificial establishment of the circulation is of no avail.

An intra-cardiac injection of 3 cc. of 1/10,000 epinephrine may be given through the intact chest wall. This ventricular injection may be repeated in three to five minutes if necessary.

If electrocardiograms show that fibrillation has occurred, a high voltage defibrillator should be applied.

**Shock**

Shock is a rare manifestation of maxillo-facial injuries alone. Generally, it is caused by injury to some other part of the body. Shock may be of a primary type resulting from reflex and emotional causes, and is essentially syncope. If secondary shock is present, the skin is pale, cold, and clammy from sweat;
the mucous membranes are pale; the lips, nails, tips of fingers and toes, and the lobes of the ears are grayish blue; the eyes are sunken and fixed with a purposeless stare; the pupils are dilated and react feebly; the pulse is weak, usually rapid, and there is an occasional sigh; and the temperature is below normal. All these signs are evidence of decreased circulatory volume which is becoming progressively irreversible unless aggressive measures are instituted.

The first step in the treatment of shock is to maintain body heat by keeping the normal room temperature and placing a blanket over the patient. Blood circulation should be maintained in the vital centres of the body by keeping the head lower than the feet.

If the shock is due to hypovolemic circulation, the lost body fluid should be replaced. The most satisfactory replacement is whole blood transfusion. If supplies of this are not available, human albumin is effective; or a plasma volume expander such as dextrose, 5% in saline solution may be given as an intravenous infusion drip. Adequate oxygenation of body tissues must be maintained at all times. If hypoxia is present, 100% oxygen should be administered so that even though the blood volume and cardiac output are lowered, the blood which does circulate is carrying a full capacity of oxyhaemoglobin.

**Pain**

Pain is not a common feature of maxillo-facial fractures. However, whenever pain has to be treated, certain precautions
are necessary.

Killey (1965), says that powerful analgesics and hypnotics should not be given in the early stages of treatment, as they make the assessment of the level of consciousness more difficult.

Morphine is contra-indicated as it depresses the cough reflex, and so encourages the aspiration of blood into the trachea, and it also depresses the respiratory centre. Morphine also produces a miosis and so masks any pupillary changes which may be occurring as the result of an intra-cranial haemorrhage.

It is advisable to restrict the routine use of analgesics for patients with facial fractures, as once the fracture has been reduced and adequately immobilised, there should be no pain and the onset or persistence of pain is usually an indication that something is going wrong. This valuable physical sign should not be masked with analgesics.

According to Zaydon and Brown (1964), for the relief of mild to moderate pain, one of the non-narcotic analgesics should be used. Acetylsalicylic acid in doses of 0.3 to 0.6 gm. is used most commonly. Other non-addictive analgesics such as sodium salicylate, acet-phenetidin or dextro propoxyphene hydrochloride are very helpful.

With more severe pain, a narcotic analgesic is necessary. Codeine sulphate, a non-addictive opiate, is effective in moderately severe pain. Its action is potentiated by combination with aspirin. A more effective opiate for use in severe pain is mor- phine sulphate (adult dose 8 to 16 mg.). This drug will also
induce sleep. Morphine may stimulate vomiting, with the attendant danger of aspiration. It is contraindicated in shock, in suspected intracranial injury or with any respiratory depression.

Various sedatives are available to help induce rest and sleep, as well as assist in the relief of pain. Chloral hydrate is an effective short-acting sedative. Barbituates will assist in the relief of pain, and are of special value where the psychic element is significant. Nembutal and seconal are used commonly. In children, phenobarbital is of value.
HISTORY OF THE INJURY

Rowe and Killey (1955) state that the important points of a history of the injury are:

1. the date and time of injury - will give an indication of the degree of infection which has developed in compound fractures, and the degree of bony union which has occurred;

2. loss of consciousness - the degree and duration of which is an indication of cerebral damage;

3. mode of injury - violence and direction of the force may give an indication of the nature and extent of the injury;

4. treatment prior to admission - whether there has been application of antitetanic serum, antibiotics or morphia.
GENERAL EXAMINATION

A general examination of the patient is necessary to determine whether there are injuries or conditions in other parts of the body which might complicate the treatment of maxillo-facial injuries. This should include the patient's medical history.

According to Buzzard et al (1964), three conditions sometimes complicating head injuries are:

1. **diabetes** - with emphasis on its management before and after any operation by frequent examination for sugar and frequent insulin injections as required to prevent ketosis;

2. **anticoagulants** - as a cause of occasional excessive bleeding. Urgent vitamin K injections intravenously only being necessary if excessive bleeding or particularly intra-abdominal or intra-cranial bleeding is present;

3. **adrenal corticosteroids** - sometimes present a problem in patients known or suspected to be taking them; half-hourly blood pressure readings are sometimes necessary, intravenous hydrocortisone being given for unexplained or persistent hypotension.

Complication of chest injury - Buzzard et al (1964) state that the condition of a patient with a chest injury depends on his ability to breathe and cough, and this is influenced by a number of factors. Fractured ribs are very painful, and may restrict the tidal volume and prevent clearing of the airways
and coughing.

Paradoxical respiration, which occurs when rib fractures destroy the stability of the chest wall and pneumo-thorax or haemo-thorax, impairs ventilation and coughing.

Treatment of these complications may require tracheostomy and the use of intermittent positive pressure respiration.

Neurological Complications

Buzzard et al (1964), state that in most cases of facio-maxillary injury of any severity there is usually some damage also to the brain, and this varies from mild concussion to a state which produces a more prolonged disturbance of consciousness and its attendant complications. Even where there has been little or no concussion, complications such as meningitis, intra-cranial haemorrhage and epileptic fits may rapidly threaten the patient's life, and put aside, for the time being, the cosmetic and dental considerations of the jaw injury.

Most authors agree that immediate facial treatment should be deferred for 24 to 48 hours, in the presence of cranial complications, to observe any change in the patient's condition. Treatment, such as the administration of a general anaesthetic, may mask these changes.

The types of intracranial damage which may occur are described in good detail by Archer (1966); the signs and symptoms are covered by Porritt and Hanft (1962). They found that the presence of shock, alcoholism or the clinical features of the injury itself, often confused the symptomatology of brain injury.
They list as external signs produced by the trauma:

1. **scalp injuries** - digital examination may reveal the presence of depressions, and oedema or haematoma formation;

2. **orbital and periorbital signs** - escape of cerebrospinal fluids may be so free that the tissues about the eyes become oedematous. Subconjunctival haemorrhages and periorbital oedema without a history of trauma are suggestive of a basilar fracture;

3. **escape of cerebrospinal fluid** - if this is present, then fracture of the skull must be present. Escape may be via the nose or throat, or the external auditory meatus.

They also list as symptoms produced by the injury to the brain itself:

1. **state of consciousness** - prolonged loss of consciousness usually indicates a high degree of intracranial pressure due to haemorrhage, oedema, or extensive lacerations and destruction of the brain itself;

2. **nausea and vertigo** - nausea and vomiting may be present but they cannot be considered an index of increased intracranial pressure. The presence of food in the stomach prior to the accident, shock, chronic alcoholism, and the ingestion of blood from injuries also predisposes patients to nausea;
3. shock - is present in most brain injuries of any severity;

4. pulse rate - is usually depressed by rising intracranial pressure. The onset of shock may mask this, as the pulse rate is increased by shock;

5. respiratory rate - is depressed by increased intracranial pressure, and may reach the stage where Cheyne-Stokes breathing occurs. This also may be masked by the onset of shock which increases respiration rate;

6. temperature - body temperature usually is subnormal during the initial stage of shock, and the terminal stages of acute medullary oedema approach, the temperature rises rapidly;

7. blood pressure - due to circulatory reflexes, the blood pressure is not a reliable guide to intracranial pressure;

8. impaired sensation - it is rare for an area of hyperaesthesia to be present unless there is a depressed fracture over the motor area. Involvement of cranial nerves - particularly the oculomotor, trochlear, abducens and facial - is fairly common in basal skull fractures, resulting in ptosis, strabismus, or facial paralysis;

9. pupillary changes - in shock, the pupils are dilated and the reaction to light is sluggish. Alcoholism
accentuates this. As the patient recovers, the pupils return to normal unless there is a definite increase in intracranial pressure, in which case they remain enlarged and sluggish in light reaction. A markedly constricted and pin-point pupil can result from cortical irritation due to haemorrhage or oedema.

According to Thoma (1963), failure of the pupils to react is a bad sign. He reports the mortality rate to be 95% in patients exhibiting bilateral dilated and widely fixed pupils, and 50% in unilateral cases.

Rowbotham (1964), gives a good coverage of neurological injuries. He says that on no occasion must the diagnosis of a fracture be attempted by the elicitation of crepitus, as a loose fragment of bone lying outside the dura may be driven inwards to lacerate the brain, or a haemorrhage may be started.

He says that subconjunctival haemorrhages are significant of fractures only when they cause oedema of the conjunctiva; when they are so extensive that it is impossible to see beyond their posterior limits in any position of the eye; or when they are so large that they displace the eyeball and restrict its movements.

He mentions the following signs referable to the brain:

1. confusion and unconsciousness are signs of brain damage. As long as unconsciousness exists, the patient's life is in danger. Coma is a state of complete unconsciousness in which there are no
psychologically understandable responses either to external stimuli or to inner needs. It is indicative of a very serious state within the lower centres of the brain;

2. **contracted or dilated pupils** - a fixed dilated pupil is an infallible sign of raised intracranial pressure, and means that a tentorial pressure cone has developed which is compressing the brain stem and stretching the oculo-motor nerve at the point where it is about to enter the wall of the cavernous sinus;

3. **pulse and blood pressure** - in the early stages of primary shock the pulse is rapid and thready and the blood pressure is low, but often when the patient has been put to bed and warmth applied, the circulation rapidly improves. When stasis of capillary circulation persists in spite of accepted methods of resuscitation, the prognosis is very grave, and the patient will probably succumb within twelve, or at the most, twenty-four hours.

   In states of mild confusion the pulse rate and blood pressure are usually within normal limits, and given that the mental condition is improving, they are of no particular prognostic or diagnostic value.

   A fast bounding pulse is a sign of raised intracranial pressure. It is often seen in comatose
patients with stertorous breathing and indicates embarrassment of medullary circulation;

4. **temperature** - when first seen, patients are shocked and chilled and consequently their temperatures are subnormal. In semi-coma, apart from any environmental influences, a rise of temperature of 1 or 2 degrees F is common and due to absorption of extravasated blood;

5. **papilloedema** - swelling of the optic discs, when it does occur, is an unequivocal sign of raised intracranial pressure;

6. **respiration** - normal respiration is a good prognostic sign, as it means that the brain has not received a severe intrinsic injury and is not being seriously compressed by a surface haemorrhage.

   Stertor is a sign of impending death;

7. vomiting is a common occurrence in head injuries. It has no definite neurological or pathological significance. It can be due to irritation of the gastric mucosa by swallowed blood. In the later stages of illness it is regarded as being central in origin.

**Cerebrospinal Fluid Rhinorrhea**

Severe maxillary fractures with craniofacial dislocation and cribiform plate injury may be associated with the drainage of a clear fluid from the nostrils or the pharynx. It may be
difficult to determine whether this discharge is cerebrospinal (CSF) fluid or nasal mucus. Escape of CSF is due to shattering of the cribriform plate of the ethmoid bone associated with a dural tear. Chemical analysis, the continuing appearance of the fluid at the nostrils or in the pharynx, and perhaps the patient's noticing that the fluid tastes salty should suggest that the fluid is cerebrospinal fluid.

Dingman and Natvig (1964) mention a test to differentiate between CSF and nasal mucus: nasal mucus secretion contains mucin but no sugar. Cerebrospinal fluid has sugar and no mucin — if sugar presence is demonstrated the fluid is therefore CSF. Also, the presence of blood in CSF will indicate skull fracture, intracranial haemorrhage or damage to the central nervous system.

Lewin and Cairns (1951) showed that 27.3% of all head injuries had CSF rhinorrhea. Lewin in a further series showed an incidence of 25%. Rowe and Killey (1955) in a series of 60 cases found an incidence of 23.3%.

The onset of this condition may be delayed, but it is usually present within 48 hours. Lewin reports its onset in occasional cases some months after injury. The duration varies according to these authorities; Dawson and Fordyce (1958) give an average of 9 days; Rowe and Killey, 5 to 7 days; Lewin, 7 days.

Kazanjian and Converse (1959), state that CSF rhinorrhea usually ceases spontaneously. Nevertheless, Killey (1965), states that in the absence of intracranial complications such as
intracranial haemorrhage, one of the most important factors in arresting a CSF leak is the repositioning and immobilisation of the facial fractures. Fixation is especially valuable, as it prevents the pumping action of a mobile middle fracture which, in the cribiform plate area, may pump infection up through the torn dura and produce meningitis. He also states that the question of a dural repair should be left to a neurosurgeon. Buzzard et al (1964) express doubts about the belief that reduction of maxillary fractures will effect sealing or blockage of CSF through the fractured cribiform plate.

Antibiotic therapy is necessary to prevent intracranial infection. As penicillin will not cross the blood-meningeal barrier in therapeutically effective concentration, and as a prophylactic measure, all patients suffering an injury which could produce a CSF leak should have sulphadiazine by mouth or injection. This should be continued for 48 hours after the leak has ceased, or until there is found to be no complication.
LOCAL EXAMINATION OF THE INJURY

Rowe and Killey (1955) state the classical signs and symptoms of fracture of the jaws to be:

1. a history of injury to the area;
2. pain;
3. interference with function – not so obvious with fractures of the condyle;
4. abnormal mobility;
5. malocclusion;
6. deformity;
7. swelling and ecchymosis;
8. crepitus;
9. absence of transmitted movement;
10. radiographic evidence.

Archer (1966) mentions anaesthesia or numbness of the tissues as a further symptom.

Of the above, the only absolute signs of fracture are: deformity, crepitus, abnormal mobility and the absence of transmitted movement.

Local examination of facial injuries is usually carried out in the order: extraoral examination; intraoral examination; radiographic examination.

Extraoral Examination

Rowe and Killey (1955) state that oedema, ecchymosis and deformity will be present in the fracture region. Associated
soft tissue injuries should be noted and the external auditory meatus examined for the presence of blood or CSF when a condylar fracture has been suspected to involve the middle cranial fossa.

Palpation should be carried out by commencing at the condylar region and proceeding along the length of the mandibular border, noting any tenderness or break in contour. If condylar fracture is suspected, the little fingers should be placed in the external auditory meatus to check any movement or lack of movement of the condylar head, when the mandible is moved.

Robinson (1959) has described a technique of diagnosing mandibular fractures by auscultation and percussion. This method could be used in a negative way in those cases where it is believed that radiographic examination is not necessary.

**Intraoral Examination**

According to Thoma (1960), this may be difficult because of swelling and muscular trismus.

The buccal and lingual sulci should be inspected for the presence of break in continuity of the mucosa and the existence of ecchymosis or sublingual haematoma.

The occlusion should be checked for looseness of the teeth and malalignment, which is indicative of fracture. The buccal and lingual sulci should be palpated for tenderness and alteration in contour. The suspected fracture area should be tested for abnormal mobility. Finally, the patient should be requested to put the mandible through a full range of movement and any limitation noted.
Within a few hours, the presence of bloodstained saliva and foetor oris may be noted.

**Radiographic Examination**

According to Rowe and Killey (1955), at least two radiographs at right angles to each other should be taken for a minimal survey of any part of the jaws. My technique is related to the clinical signs and symptoms; if middle third, or condylar fractures are suspected, then the appropriate radiographs are taken. Generally the minimal radiographs that I use are right and left lateral views of the mandible and one PA view. This technique is advocated by Archer (1966). He also stresses the need for dental films for a detailed examination of the tooth bearing structures. When the possibility of fracture has been determined by this preliminary survey, more specific view may be taken. These views need not be described, as they are well covered in the literature - Ennis and Berry (1959) give the most complete coverage.

The most commonly used views are:

1. right and left lateral oblique;
2. PA 0-45 degrees;
3. rotated PA;
4. Townes' projection;
5. intra-oral occlusal views of the maxilla and mandible;
6. intra-oral dental films;
7. stereoscopy.
For a further view of the condyles, a lateral TMJ view or transcranial view may be used, as described by Ennis and Berry.

Dingman and Natvig (1964) give an excellent atlas type of instruction section for many types of radiographic views. These are: lateral projections; PA of the mandible; lateral oblique of the mandible; lateral projection of the mandibular condylar processes including the zygomatic arches (modified Towne's projection); inferior-superior projection for the same; PA oblique projection of the face (Water's projection); reverse Water's projection; superior-inferior projection of the hard palate; superior-inferior oblique projection of the hard palate; sub-mental-vertical projection of the zygomatic arches; lateral projection of the nasal bones; superior-inferior projection of the nasal bones; and intraoral dental radiographs. This section consists of instructions for the taking of each type of the listed views, and specimens of each.

Caldwell and Schreiber (1964) advocate the use of the Chamberlain-Towne projection. This view is not mentioned by most texts - the patient lies supine with the chin tucked well down toward the chest so that the canthomeatal line is at right angles to the table and the film. To best demonstrate the TMJ and the condylar processes, the central ray of the x-ray beam is directed at the glabella at an angle of 30 degrees toward the feet. They claim that this view gives a clear picture of the entire mandible.
A panography technique developed by Blackman (1961) appears to have some future in facial fracture diagnosis as it provides an entire mandibular and maxillary view on the one film and can be obtained simply. Blackman states: Panoral radiography is able to produce a single-plane panoramic picture of each arch. The same film shows the supporting structures of the teeth in good detail and with fine contrast. The size of the teeth is automatically magnified to about twice the normal anatomic length. This permits complete depiction of the crown, the alveolar margin, the full length of the root, the surrounding supporting bone structures, and a more extensive amount of osseous structure beyond the tooth apex. All of this can be done without superimposed shadows. This form of x-ray examination can be standardized for reliable repetitive pictures. It is free from objectionable penumbra and has only a minimal amount of distortion.

The source of radiation is placed within the oral cavity. Radiation emanates from a target anode set at the distal end of a long projection from the main glass x-ray bulb.

**Interpretation of Radiographs**

Facility in radiograph interpretation can only be obtained by practice. Rowe and Killey (1955) discuss interpretation as follows: break in bone continuity allows x-rays to pass through the resultant gap, causing a dark line on the film; if the bone ends overlap, less x-rays will pass and the film will appear less dense in that region. Where the x-rays pass obliquely, all degrees between these results may occur.
Fig. 496. In an oblique fracture, break in outer and inner cortex may produce separate fracture line on x-ray film.
In the mandible the dense cortical layers may result in an appearance of double fracture where the x-ray of the fracture is oblique.

Fracture width can only be gauged where the x-rays pass directly through the line of fracture. Physiologic osteoporosis prior to ossification of the callus causes some apparent widening of the fracture line.

The outlines of the bone should be carefully traced for any sign of fracture.

On dental films the fracture lines are obvious. The lamina dura should be traced to establish the presence of tooth movement or fracture.

The degree and direction of fracture must be assessed using films of different projections.
TREATMENT PLANNING

Thoma (1963) suggests diagnosis and treatment planning in the following order:

1. give general treatment to the patient;
2. attend to soft tissue wounds;
3. make a careful clinical and roentgen examination;
4. determine the type and exact location of the fracture;
5. prevent or treat infection;
6. secure temporary immobilisation;
7. choose the correct type of anaesthesia;
8. give attention to proper reduction;
9. select the best method of fixation;
10. give proper attention to aftercare.

Dingman and Natvig (1964) state that when it is consistent with the patient's general condition, fractures of the facial bones should be treated as early as possible. When seen immediately after injury, fractures can be immobilised with minimal effort if the areas are not obscured by oedema or haematoma.

The possibility of infection in fractures of the facial bones increases proportionately with the time interval elapsing between the time of the occurrence of the fracture and the time of reduction and fixation. If several hours have passed since the injury and an inflammatory reaction is suspected or oedema or haematoma is severe, it may be advisable to administer anti-inflammatory drugs and wait until the oedema is reduced in order
to facilitate the surgery.

**Pre-operative Care**

General conditions should be considered before anaesthetic or treatment is attempted - such as shock, hypovolemia, dehydration, electrolyte imbalance. If there is a history of rheumatic fever or valvular heart disease, prophylactic antibiotic therapy should be carried out. Tetanus immunisation should be considered. Diabetes mellitus should be treated.

**Anaesthesia**

It is usually necessary to administer general anaesthesia for the manipulation of middle third fractures, although for fractures of the dento-alveolar component local anaesthesia may be adequate. Thoma (1963), recommends the use of intravenous anaesthesia with Pentothal sodium in order to avoid post-operative nausea and vomiting.

For many cases of mandibular fracture which I have treated, local anaesthesia or sometimes no anaesthesia at all has been adequate. Where I have used gradual elastic traction, no anaesthesia at all has been necessary. However, the trend today is towards the use of general anaesthesia for the reduction of mandibular fractures. Under general anaesthesia proper reduction can be more easily attained; otherwise a less than ideal reduction may be compromised to reduce pain. Killey (1965), states that general anaesthesia is more satisfactory for the manipulation of mandibular fractures. Thoma (1963) recommends general anaesthesia because with it muscular relaxation can be obtained.
Archer (1966) generally treats mandibular fractures with the aid of local nerve block. Rowe and Killey (1955) recommend general anaesthesia for the reduction of mandibular fractures; most often gradual elastic traction can be applied without any anaesthesia.

**Tooth in the Line of Fracture.**

Calhoun and Perkins (1958) state that with proper and adequate antibiotic therapy to control infection, teeth in or near the line of fracture may be used to secure adequate immobilisation of fractures of the mandible. I have sometimes retained teeth in the line of fracture of a simple type of fracture in order to facilitate fixation.

According to Killey (1967), if the blood supply to the pulp of a tooth is damaged as a result of a fracture of the mandible, the pulp will die. Infection from the apex of such a tooth into the fracture line will result in greatly protracted healing of the fracture, or even non-union. Therefore, if the viability of a tooth in the region of a fracture line is in doubt, it should be extracted.

**Functional Treatment**

Neuner (1959) of Austria encourages the use of the jaws after splinting to encourage healing, instead of immobilisation. He states as advantages of this functional method: since the fractured jaw alone is immobilised by intra-oral or extra-oral splints, function of the jaws is but slightly limited. The
patient can use the mandible freely and is not essentially hindered in taking nourishment during treatment. Furthermore, the functional performance of the fractured jaw effects a strong inducement to the formation of callus, which shortens the healing time. From the hygienic and biologic standpoint, the functional treatment is preferable to immobilisation, especially in cases of dislocation when it is advisable to start functional treatment as soon as possible.

Antibiotics

Antibiotic therapy is best covered in Archer (1966); Rowe and Killey (1955) and Thoma (1960) do not give any detailed description on the types or dosages of antibiotics best suited for jaw fracture treatment.

According to Archer, the choice of antibiotics should be one which will act against all pathogens, leave non-pathogens and normal cells unchanged, and be effective in minimal concentrations with no local or systemic side effects. As no such agent exists, it is necessary to observe certain therapeutic principles to achieve the best results with the antibiotics available.

As the majority of pathogens in the oral cavity are gram positive, the following range of drugs are suggested:

1. penicillin, if not contra-indicated by a history of allergy or sensitivity;
2. tetracycline;
3. erythromycin.
The duration of treatment should be continued for at least 48 hours after the clinical course seems to improve. Systemic application is generally preferable except in superficial infections which have caused no constitutional symptoms. In these cases, topical therapy may be considered, provided that the antibiotics used locally are not likely to be used systemically.

Pencillin is the most commonly used antibiotic, usually administered orally (penicillin V) in dosages of 125 to 250 mg. four times daily.

Where a broad spectrum of action is required, the tetracyclines or chloramphenicol may be administered.

Erythromycin has a similar spectrum as penicillin, and may be useful against some penicillin-resistant staphylococci.
FACIAL LACERATIONS

This section will not be treated in great detail as it is more within the field of the plastic surgeon.

Thoma (1963) classifies soft tissue wounds as:

1. contusion or bruise;
2. abrasion;
3. laceration;
4. incised and penetrating wounds.

The Committee on Trauma (1965), states these general principles of care of open wounds:

1. avoid further contamination of the wound;
2. obtain an accurate history, examine the patient and the wound and evaluate the whole situation;
3. determine the priority of care;
4. handle the patient carefully to avoid further injury;
5. treat the open wound.

In treating these wounds, observe the following order:

(a) provide suitable anaesthesia;
(b) cleanse the area surrounding the wound and cleanse the wound itself;
(c) excise destroyed tissues and remove foreign bodies;
(d) repair the deep tissues if this can be done with safety;
(e) close the wound;
(f) apply a compression dressing;
(g) put the part at rest.

Archer (1966) stresses the need for treating the patients for the possibility of tetanus — this would also apply to Australian conditions.

Rowe and Killey (1955) state that every fracture is accompanied by soft tissue injuries, and in 50% there is laceration or abrasion of the skin. The treatment for this should not be regarded as trivial, as the patient is usually more interested in the outcome of those injuries which he can see.

They state the principles of treatment to be:
1. cleansing of the affected part;
2. removal of all devitalised tissue;
3. closure.

Cleansing is carried out with soapy water, always swabbing away from the wound. All foreign matter must be removed and ingrained dirt may require prolonged scouring; a small brush is often useful and may be necessary.

During debridement, artery clips should be applied to define bleeding points and their application for a few minutes will be found to occlude all but major vessels, so that very few ligatures will be needed.

The advantages of immediate coverage are: the diminution of scarring and the control of infection. No uninfected wound of the face should ever be permitted to heal by granulation.
FIRST-AID IMMOBILISATION OF THE JAWS

The main need for the emergency immobilisation of the jaws is to provide an adequate airway. Rowe and Killey (1955) state that with mandibular fractures, in many cases no first-aid treatment is necessary; especially in the case of the edentulous mandible. The operator should consider whether any procedure intended will lead to the alleviation of pain and discomfort or is necessary for the control of respiratory embarrassment.

Where support is necessary, there are several methods available. Any method which causes backward displacement of the mandible is injurious as this tends to obstruct the respiration; for this reason, the fourtailed bandage should not be used. Simple methods are barrel type bandage; elastoplast support; elastic sling attached to webbing headcap, as described by Rowe and Killey.

Simple wiring methods should only be used to control a mobile anterior fragment.

With middle third fractures many methods of first aid treatment are of doubtful value, and may even be dangerous. As with the mandible, displaced fragments may be impinging on the airway, in which case they should be reduced.

Rowe and Killey (1955) say that if it is desired to temporarily immobilise the maxilla, an impression of the alveolar components in compound may be connected to a headcap via the impression tray. The use of mandible-maxilla fixation cannot be condemned too strongly; the pull of the mandible distracts the maxilla further from the cranial base and movements of the mand-
ible may pump infection through a fractured cribiform plate, thus encouraging meningitis. Also, when there is a nasal blockage of blood and oedema, it may be dangerous to occlude the oral airway by intermaxillary wiring.

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FRACTURES OF THE MANDIBLE
SURGICAL ANATOMY OF THE MANDIBLE

This section is covered in outline only by most of the available texts, the only detailed coverage being given by Rowe and Killey (1955). Their description also includes a classification of mandibular fracture lines in relation to the muscle attachments.

The mandible occupies a prominent and exposed position in the facial skeleton, and is therefore a common site of trauma. It articulates with the cranium via the condyles and the glenoid fossae, and a blow on the point of the chin may result in a large proportion of the force being absorbed by fracture of the condyle.

The body of the mandible is horse-shoe shaped and is composed of a compact outer and inner plate of cortical bone and a central portion of medullary bone whose trabeculae are distributed along the lines of maximum stress. The cortical layer of the body is thickest in the mental and third molar regions. The ramus consists of two thin plates of compact bone separated by a relatively narrow portion of cancellous bone. The body is considerably thicker than the ramus, and the junction of these two constitutes a line structural weakness.

Basically, the mandible is constructed of two components, the mandible proper and the alveolus. The alveolus is structurally weaker than the rest of the mandible and an alveolar fracture may occur quite independently of the main body of the bone.
In childhood the alveolus is weakened by the presence of the tooth crypts, but this is to some extent compensated by the increased elasticity of the bone.

In the edentulous mandible, the vertical depth of the bone is reduced by up to a half which accentuates the increased liability of bone to fracture with advancing age.

The slender neck of the mandibular condyle renders it liable to fracture as a result of indirect violence applied to the mental prominence. This anatomical weakness may be regarded as a safety mechanism preventing the condylar head being driven through the glenoid fossa into the middle cranial fossa.

It will be appreciated that direct violence applied to one side of the mandible is liable to produce an indirect fracture on the opposite side. For example, a blow to one side of the mental prominence in the region of the canine fossa will probably cause a direct fracture at this site, but as the body of the mandible is forced violently across towards the opposite side, a secondary line of stress is caused at the opposite angle.

Compression of the bone from side to side as the result of a crush injury will lead to a fracture in the region of the symphysis.

The Teeth

The teeth are a source of weakness, especially with reference to the long root of the canine and the unerupted thrid molar.

Normal articulation may not be present in all cases: cross-bite, mandibular protrusion, or unusual articulation of the teeth
may be normal for the particular patient. The mucoperiosteum covering the jaws is tightly bound to the underlying bone, and is continuous with the periodontal ligament; as a result, when teeth are present, fractures involving the tooth-bearing area are almost invariably compound into the mouth.

Teeth whose roots are involved in the line of fracture are liable to lose their blood supply as a result of the severing of the vessels at the apex; these teeth thus constitute a source of infection when necrotic change occurs in the pulp, and if their viability is in doubt, they may have to be removed.

The Periosteum

Gross displacement of the fragments does not occur if the periosteum remains intact; this is almost entirely confined to the edentulous mandible, the ramus, and condylar or coronoid processes of the mandible.

The Muscles

The muscles originating from the inner aspect of the mandible: the mylo-hyoid, genio-hyoid, anterior belly of the digastric and the genio-glossus exert their effect in a centripetal manner and tend to collapse the fragments posteriorly or medially. The first three muscles mentioned act as depressors of the mandible when the hyoid bone is fixed by the infra-hyoid group of muscles. The muscles inserted into the lateral and medial aspects of the ramus and the coronoid process are mainly elevators.
Factors Influencing Displacement

These factors may be classified as:

1. site of fracture;
2. direction of fracture line;
3. pull of the powerful muscles attached to the mandible;
4. direction and magnitude of the trauma.

The body of the mandible is only lightly covered by muscles which afford little protection; the ramus, however, is densely covered on both its lateral and medial aspects by the masseter and internal pterygoid muscles, which results in a splinting action, and although an extensive fracture may occur, very little displacement results in this region.

Sites and Direction of Fracture Lines

1. **condyle** - fracture may occur with little or no displacement if the periosteum is intact. Dislocation depends upon whether the capsular and temporomandibular ligaments are torn and the anterior pull of the external pterygoid muscle. Medial displacement is favoured by the weakness of the capsule in this aspect;

2. **angle** - the elevator muscles exert an upward and medial force following fracture in this region; the line of fracture modifies the degree of displacement in the following manner:
   (a) where the fracture line passes from the alveolar margin, downwards and forwards, the upward displacement of the posterior fragment is prevented by impaction
of the bone ends. Such a line of fracture is termed "horizontally favourable".\(HF\)

(b) where the line of fracture passes downwards and backwards, the upward movement of the posterior fragment is unopposed; this is termed "horizontally unfavourable".\(HU\)

(c) viewed from the occlusal surface, the fracture line which passes from the outer or buccal plate obliquely backwards and lingually, will tend to resist the medial pull of the internal pterygoid muscle; this is called "vertically favourable".\(VF\)

(d) if the fracture line passes obliquely backwards from the lingual aspect of the mandible, inward movement of the posterior fragment will take place as a result of the muscular pull of the internal pterygoid muscle; this is called "vertically unfavourable".\(VU\)

The line which the fracture follows is largely dependent upon the causative force in association with those factors previously described. When the fracture passes through the crypt of an unerupted third molar, without fracture of the teeth and without gross displacement, it is usually wise not to attempt to remove this tooth.

3. **body of the mandible** - the further forward the site of fracture occurs, the more is the upward displacement of the elevator muscles countered by the downward pull of the mylohyoid muscle. At the same time, the medial or lingual dis-
placement tends to be increased, whilst the factors previously mentioned with regard to the line of fracture remain unaltered.

(a) canine region — this is a common site of fracture, due partly to the length of the root weakening the bone structure, and partly to the fact that compression of the mandible tends to produce a fracture at the site of maximum convexity. If this fracture site is bilateral, the anterior segment may be displaced posteriorly, resulting in obstruction of the airway by the tongue. If the fracture lines pass medially from the lingual, the fracture will be HU, and displacement will occur; if the lines pass laterally, the anterior segment is impacted.

(b) symphysis — in this region the tendency towards elevation of the fragments is reduced to a minimum, and the medial displacement due to the action of the mylohyoid diaphragm is equally balanced. If the fracture line passes from the labial to the lingual surface in a straight line, the fracture is fairly stable, due to the influence of the muscles attached to the genial tubercles being equally distributed on either side of the fracture line. If there is a marked obliquity of the fracture line, then a varying degree of overlap will take place.

4. ramus — these fractures exhibit very little displacement of
fragments as a result of being to a large extent splinted by the masseter and the internal pterygoid muscles;

5. coronoid process - there is usually minimal displacement, the fragment being splinted by the tendinous insertion of the temporal muscle.

The Blood Supply

The two main sources of blood supply to the mandible are: a central supply through the inferior dental artery; and a peripheral supply through the periosteum. Although the inferior dental artery and vein are often punctured by the fracture, the bone is adequately nourished by the collateral supply from the periosteum. For this reason, osteomyelitis following fracture is rare.

The Nerve Supply

Damage to the inferior dental nerve as a result of fracture causes paraesthesia of the lower lip on the affected side over the distribution of the mental nerve. If the nerve is severed, regeneration usually takes place within six to twelve months.
Fig. 490. Fractures of ascending ramus. 1, Sub-condylar fracture. 2, Fracture of coronoid process. 3, Vertical fracture. 4, Horizontal fracture. 5, Oblique fracture of angle of jaw.
CLASSIFICATION OF MANDIBULAR FRACTURES

The classification of Rowe and Killey (1955) is the most complete and comprehensive and is as follows:

1. condylar fractures may be intracapsular; extracapsular or subcondylar. The condylar fragments in relation to the ramus may exhibit: no displacement, displacement, deviation, or dislocation;

2. coronoid process fractures usually show no displacement; any displacement is due to rupture of the temporal muscle;

3. ramus fractures may be of a linear type at a high or low level, or of a stellate radiating type;

4. angle and body fractures may be vertically or horizontally favourable or unfavourable;

5. fractures in the canine region may exhibit the posterior fragment laterally or medially displaced;

6. symphysis - a midline fracture passing between the genial tubercles usually shows little or no displacement. If the fracture line passes obliquely to one side of the genial tubercles, the balance of muscular pull is upset, resulting in overlap of the fragments. Double unilateral fractures - where only one fracture is obvious intraorally, but the degree of displacement is greater than usual, another fracture on the same side should be suspected. Fractures of the canine region and condyle, or symphysis and angle often co-exist.
Bilateral fractures may occur in combination of any of the above, but the following most often occur:

**Bilateral condylar** - resulting in anterior open bite, a variable degree of posterior displacement of the mandible and gagging of the occlusion on the last molar teeth.

**Bilateral HU fractures at the angles** - upward and medial displacement of the posterior fragment with downward angulation of the body of the mandible, resulting in a gross anterior open bite.

**Bilateral fractures in the canine region:**

1. **VF and HF** - result in no displacement;

2. **VF but HU** - there is anterior angulation of the central block which hinges upon the lower border of the mandible, under the influence of the pull exerted by the anterior bellies of the digastric muscles;

3. **VU but HF** - there is posterior angulation of the central block which hinges upon the upper border of the mandible under the influence of the genio-hyoid and genio-glossus muscles;

4. **VU and HU** - there is gross displacement of the central block both in a downward and posterior direction under the combined influence of the above muscles and the posterior fragments are medially displaced owing to the action of the mylo-hyoid diaphragm.

Multiple fractures in any combination may occur, but those more commonly observed are a fracture, usually oblique, of the
symphysis, associated with bilateral fracture or fracture dislocation of the condyles; or more rarely, bilateral fracture in the canine region, with associated fracture at the angle or condyle.

Dingman and Natvig (1964) classify mandibular fractures according to:

1. horizontally or vertically favourable or unfavourable;
2. severity – simple or compound;
3. type – greenstick, complex, comminuted, impacted, depressed;
4. presence of teeth – fully or partly edentulous;
5. site – a similar treatment as that of Rowe and Killey.

Probably the simplest classification, and the easiest to relate to diagnosis and treatment is that given by Killey (1967). He classifies mandibular fractures as: unilateral, bilateral or multiple. He further classifies according to site:

(a) dento-alveolar;
(b) condylar;
(c) coronoid;
(d) ramus;
(e) angle;
(f) body (molar and premolar area);
(g) midline;
(h) lateral to midline in the incisor region.
SIGNS AND SYMPTOMS OF MANDIBULAR FRACTURES

General diagnosis of fractures have been treated in a previous section. I will discuss the signs and symptoms relating to mandibular fractures in this section.

Rowe and Killey (1955) list the classical signs and symptoms of jaw fractures as follows:

1. history of injury to the area;
2. pain upon movement;
3. interference with function;
4. abnormal mobility;
5. malocclusion;
6. deformity;
7. swelling and ecchymosis;
8. crepitus;
9. absence of transmitted movement;
10. radiographic evidence.

The only absolute signs of fracture amongst the foregoing are: deformity; crepitus; abnormal mobility; absence of transmitted movement.

Dingman and Natvig (1964) list as common symptoms of fractures of the mandible:

1. pain;
2. tenderness - on palpation;
3. disability;
4. swelling;
5. discolouration;
6. deformity;
7. abnormal mobility;
8. crepitation;
9. salivation;
10. fetor ex ore.

They also list the following as clinical findings in fractures of the mandible:

1. malocclusion;
2. mobility at site of fracture;
3. dysfunction;
4. crepitation;
5. tumescence at the site of fracture;
6. abnormal mobility of the mandible.
TREATMENT OF FRACTURES OF THE MANDIBLE

Killey (1967) states the principles of treatment simply: the general principles of treatment of fractures of the mandible do not differ essentially from the treatment of fractures elsewhere in the body. The fragments are reduced into good position and are then immobilised until such time as bony union occurs.

Rowe and Killey (1955) list the principles of treatment as:
1. restoration of the fragments to their correct position;
2. maintenance of the fragments in their correct position until clinical union has occurred;
3. prevention of infection;
4. gradual rehabilitation of function to ensure that subsequent displacement does not occur. Muscle wasting does not take place during immobilisation, since some degree of muscular contraction results from speech and deglutition.

Rowe and Killey (1955) have classified mandibular fractures with regard to various treatments as follows:

Class I fractures - with teeth on all fragments

1. an adequate number of teeth of suitable shape and stability: wiring, either direct, continuous or multiple loop or interdental eyelet in type;
2. an inadequate number of teeth whose shape or stability is unsuitable: arch wiring where laboratory facilities are not available. Cast metal splints, preferably closed in type with locking plates and connecting bar.
Class II fractures - with teeth on one fragment only

1. short edentulous posterior fragment:
   (a) if favourable, immobilise the main fragment by interdental wiring, cap splints or arch wires as indicated under Class I (1. and 2.). Minor displacements may often be accepted.
   (b) if unfavourable, simple fractures should have the main fragment immobilised to the upper jaw by the appropriate technique, and the posterior fragment controlled by upper or lower border interosseous wires. Compound or infected fractures may have the posterior fragment controlled by pin fixation attached by an extra-oral bar to a lower cap splint.

2. long edentulous posterior fragment:
   (a) without displacement - it is usually only necessary to immobilise the main fragment to the upper jaw.
   (b) with vertical displacement - a saddle extension from a lower splint is sufficient in most instances, plus immobilisation of the mandible to the maxilla.
   (c) with medial displacement - simple fractures may be treated by interosseous wiring, but compound and infected fractures should be treated by pin fixation and connected to a lower cap splint. In both cases
immobilisation of the mandible is advisable, at least in the first instance.

Class III fractures – the edentulous mandible

1. simple or compound fractures within the denture bearing area without gross posterior or medial displacement: Gunning type splints secured by peralveolar and circumferential wires;

2. simple fractures with gross posterior or medial displacement of the fragments, or a HU and VU fracture at the angle: interosseous wiring, with preferable immobilisation to the upper jaw as in 1.

3. compound fracture with gross displacement or severe laceration of the mucosa: pin fixation, with preferably immobilisation to the upper jaw as in 1, or to a plaster-of-Paris headcap by vertical rods and connecting joints.

Fixation of Mandibular Fractures

Rowe and Killey list the various methods of fixation as follows:

1. interdental eyelet wiring;

2. arch wiring;

3. cast silver/copper alloy cap splints, locking plates and connecting bars;

4. Gunning type splints, utilising either the patients own dentures, or specially constructed acrylic splints. These are secured to the jaws by circumferential wires passing around the mandible and per-alveolar wires
passing through the alveolar bone of the maxillae;

5. interosseous wiring of the bone ends;

6. cap splints to which is attached an intra-oral bar connected to a pair of SS pins;

7. SS pins inserted into the bone, clamped together in pairs and connected by extra-skeletal bars and universal joints.

Other methods include: continuous loop wiring, direct interdental wiring, SS or vitallium plates secured to the bone ends by screws, intra-medullary pins, the Brenthurst clamp, and Kirschner wires.

Wiring is not favoured by Starr and Arnott (1944) for the following reasons:

(a) it is difficult to maintain the hygiene of the oral cavity;

(b) frequent adjustment to the wires is necessary;

(c) the jaws are fixed together and function of the mandible is not possible;

(d) where there are few teeth in the fragments, satisfactory immobilisation of the fragments is not possible;

(e) the wires may be removed or loosened by the patient;

(f) any uneven strain imposed on a tooth or teeth may result in irrevocable damage to the teeth and the supporting structures;

(g) short posterior fragments are not controlled by inter-maxillary wiring.
Also, with tightening of the intermaxillary wires, the mandibular fragments tend to be displaced outwards, at the lower border. This may lead to delay in union or even malunion, apart from the effect of imperfect reduction.

Nevertheless, many writers advocate the use of wiring as a quick and easy treatment. While wiring has many applications, the ease of the method means that many operators use it where other treatment is indicated.

Interdental Eyelet Wiring

Rowe and Killey (1955) state that the most effective use of this method is where there is an almost complete complement of sound suitable shaped teeth. The fracture should be comparatively recent and thus capable of reduction without difficulty. Teeth must be present in all fragments, except in cases of fracture of the condyle, coronoid process, and ramus. Where an edentulous posterior fragment exists, it will be frequently found that little or no displacement occurs when the body of the mandible is aligned correctly and the teeth placed in occlusion.

However, if a persistent tendency towards displacement of the posterior fragment occurs, it is a contraindication to this method as a means of definitive treatment. As has been previously mentioned, interdental eyelet wiring is of considerable value as a first-aid measure, but at all times it is of course necessary to have suitable opposing teeth in the maxillae, or an upper denture which can be secured by peralveolar wiring in
Fig. 502. Fracture in mandible immobilized by Risdon method. Jelenko splint was attached to upper jaw for internaxillary wiring.
which hooks have been embedded in the labial and buccal surfaces. The articulating surfaces of the teeth are placed in correct occlusion under direct vision, thus ensuring that the fragments are correctly aligned. Provided that the criteria mentioned are satisfied, results comparable with those attainable by any other method of treatment are achieved.

Arch Wiring

According to Rowe and Killey (1955), the main indications for arch wiring occur when the number, shape or distribution of the teeth precludes their use in the technique of eyelet wiring, and where the facilities for the construction of cast splints do not exist. The method is useful for the immobilisation of an alveolar fracture carrying, for example, several teeth when the unavoidable delay resulting from the construction of an acrylic or cast metal splint is inadvisable. They describe arch bars of the Winter's and Jelenko type which have hooks soldered to the outer aspect. The technique aims at reducing the fracture by tightening of the ligatures, thus bringing the teeth on the individual fragments into horizontal and vertical alignment with the arch bar. Elastic traction cannot be used for the gradual reduction of the fragments when they have already been united into a firm unit via the arch bar. Fractures with gagging on the molar teeth, with angulation of the body of the mandible and an anterior open bite, which occurs in unilateral or bilateral fractures occurring distal to the last molar teeth, can be reduced in this manner. In actual practice this can be effected
just as well by direct reduction with tie wires.

Berenyi (1959) describes an instrument for the freehand preparation of looped arch splints. The advantages of his method are that one instrument is sufficient to bend a splint; and in a rather short time an individual splint can be made from a simple wire bar.

**Continuous or Multiple Loop Wiring**

Rowe and Killey (1955) refer to this as Stout's method; it offers a method whereby definite blocks or sections of teeth may be wired in such a way that elastic traction can be applied in a convenient manner for the reduction of the fracture.

Thoma (1963) states that this method is applicable only if sufficient teeth are present on each side of the fracture and may be used only in cases that can be firmly impacted. The advantage of horizontal wiring is that immobilisation of the mandible can be avoided. Generally it is combined with intermaxillary fixation or transosseous wiring. The combination of horizontal and transosseous wiring prevents opening of the fracture when the mandible is used, which always occurs if the fracture is fixed at only one end. The combination is useful in simple fractures which do not tend to override. In oblique fractures intermaxillary fixation should be used.

**Direct Interdental Wiring of the Teeth**

Rowe and Killey (1955) state that this method is not as effective as the interdental eyelet wiring technique, as the
wires tend to loosen to a greater degree. Also, the breaking of one wire post-operatively necessitates the removal of all wires to enable a fresh wire to be passed.

Thoma (1963) states that this method is the simplest and the most effective. The disadvantage of the horizontal wiring techniques is that the wires are drawn down over the crowns and unless the crowns of the teeth are unusually long there is not enough space for satisfactory intermaxillary fixation. The only advantage that the horizontal techniques have is the ease with which the jaw can be opened by cutting the secondary wires, and the fact that the wires can be replaced as readily.

Killey and Kay (1966) describe a wire-twisting instrument which is an aid in the technique of interdental wiring.

Winstock (1959) advocates the use of extended eyelet tie-wires after general anaesthesia in case of vomiting or tongue swallowing. The wire ends are left extended for 3" and are covered with tape to prevent ulceration of the lips. The wire extensions can be cut back to the proper length after 24 hours.
Cast Metal Cap Splints

According to Rowe and Killey (1955), cap splinting is the method of choice when teeth are present in one or all fragments, the number, shape, and distribution of which preclude their employment in the technique of eyelet wiring. Although arch wiring is valuable under emergency conditions, cap splints afford a more satisfactory and stable means of effecting immobilisation. This is achieved by virtue of the fact that the whole crown of the tooth is enclosed within the cap splint. Bucco-lingual rotation about a vertical axis is therefore less liable to occur. This is not the case when eyelet wire or arch bars are used, and when a long term immobilisation is envisaged, the use of cap splints is essential. Also cap splints can be more easily utilised to effect a gradual reduction by employing elastic traction via hooks.

The disadvantage of cap splints is that between the articulating surfaces of the teeth are interposed two thicknesses of metal and cement. As a result there will always be a slight error of articulation on removal of the splints. This may be minimised by carefully articulating the splints before cementation and if necessary, grinding any high spots. In actual practice, this is rarely necessary, as the discrepancy usually disappears after several weeks as a result of the still plastic callus being moulded by the forces of mastication. Any error still existing can be spot ground.

To overcome this, the use of open cap splints has been
advocated. These splints do not possess any occlusal surfaces, so that the teeth can be brought into direct apposition. The labial and lingual plates of the splint are connected posteriorly and through the embrasures. Although this method would appear to be ideal, in practice it results in a weaker splint, which is more easily dislodged. This is due to the reduced surface area available for cementation, and the structural weakness resulting from the loss of the roof of the splint. However, where one or more teeth are missing, this weakness is diminished by the bar connecting the sections together, and in selected cases with edge to edge protrusive bites, the method may be of considerable assistance. One of the stated advantages of the open ferrule type of splint is that it is easy to determine if the splint is properly in position. If this is necessary for proper positioning, then one or two occlusal surfaces could be left exposed without seriously weakening the splint.

Before the present system of locking plates and connecting bars was evolved, it was customary to take a single overall impression of the mandibular teeth and to divide the model at the site of fracture. The model sections were then occluded with the model of the intact maxilla and the model articulated in this position. The splint was made from this model and after the fracture had been reduced manually the splint was forced into position and held until the cement had set. This gave rise to errors in positioning of the fragments owing to difficulty in performing this procedure; movement of the fragments during
setting of the cement; unequal thickness of the cement; and errors in laboratory technique. As a result, the method has been superseded by the individual splint technique for each fragment, the union of the sections being achieved by locking plates and connecting bars. This technique is described in good detail by Fry and Ward (1956).

Thoma (1963) tries to avoid the use of splints if the type of injury and the dental situation allows, because of the difficulty of taking impressions; the fitting of the appliance and the final attachment and adjustment are very uncomfortable under the best circumstances, and they may be extremely painful. Many splints prevent clear observation of the occlusion and therefore often give poor functional results. Rowe and Killey (1955) observe, however, that the degree of malocclusion which might occur can be corrected by occlusal grinding.

Archer (1966) agrees with Thoma in that his results using cast metal or acrylic splints were poor; he concedes, however, that in view of the excellent results obtained by the British using these methods, that his technique was inadequate.

He advocates the use of split acrylic splints as does Neuner (1959). These are constructed so that the occlusal surfaces are exposed and normal occlusion is not interfered with. This method is little mentioned in the literature, and could possibly find more application than hitherto, as an easy, efficient method of reduction and fixation.
The advantages of this method as outlined by Neuner (1959) are as follows:

1. the splint is retained without wire ligatures, screw bands or cementing;
2. the insertion and removal are very simple and require little time.
3. since the gingival edge is left free of acrylic, the patient can easily clean the teeth by means of a tooth-brush;
4. the masticating surfaces remain uncovered, so that the occlusion can be constantly checked during treatment;
5. the splint is constructed in the technical laboratory, and therefore the patient is spared time and discomfort.

This type of splint would be efficient for the treatment of dento-alveolar fractures.

Robinson et al (1966) suggest using an aluminium alloy for cast metal splints. By using aluminium alloy for this purpose, the expense and the length of time necessary for splint construction are minimised. Another advantage of aluminium splints is that they are radiolucent and therefore do not have to be removed for post-operative x-ray examination. The authors found no evidence of electrolytic lesions or galvanic pain when aluminium appliances have been used in the presence of a variety of dissimilar metals. Nevertheless, the possibility of galvanic action where dissimilar metals are used should not be ignored.
Robertson (1965) discusses the use of acrylic resin cap splints. He constructs these splints by processing clear "simplex" cold cure acrylic resin. Cementation is effected with cold cure acrylic resin resulting in very good retention. The splint can be removed with forceps after cutting with a fissure bur. Gingival irritation is minimal. This method could be of use when facilities for the construction of cast metal splints is not available.

Cementation of Splints

Bradnum (1960) listed as disadvantages of using black copper cement for cementing cap splints as follows:

1. after mixing the cement, only a very short working time is available to seat the splints accurately in position;

2. the final set of the cement is slow and no strain should be applied to the splints for at least 22 hours after cementation. This may retard the immobilisation of the fracture;

3. the cement adheres tenaciously to the teeth and much time and energy is required to remove it from them after the removal of the splint;

4. it is a dirty material and stains silicate fillings, exposed dentine, and cracks in the enamel;

5. it has an unpleasant sour taste to which patients, especially children, often object.
He then suggests the use of cold-cure acrylic resin as an alternative. I have used cold-cure acrylic resin on occasions—usually where the shape of the teeth has suggested that retention of the splint was doubtful. On all occasions it has been a satisfactory cement or filler and has presented no problems during application or removal.

Orthodontic Aids to Fracture Treatment

Perlow (1957) suggested the use of orthodontic bands as anchorage for chrome steel splints. He presents an approach which he says embodies most of the advantages of the control and stability of an orthodontic appliance but does not require painstaking efforts, and time involved in constructing the appliances is not a deterrent. While he does not present a very good case, I am sure that there is some merit in his ideas. My impression of orthodontic bands is that they are not very rigid and might not provide enough stability where strong anchorage is required. However, where the facilities are available and where speed and simplicity are the essence of treatment, an orthodontic type of soldered splint could be satisfactory.

OPEN AND EXTRA-SKELETAL METHODS OF TREATMENT

Upper Border Wiring

Upper border wiring is the placing of a stainless steel suture in the alveolus or body of the mandible to maintain reduction of a fracture. It can be used where the displacement is such that maintenance of reduction by splints is not possible.
Helsham (1961) discusses this method well. He lists as indications for this treatment:

1. fractures at the angle or molar region of the mandible with upward movement of the edentulous posterior fragment;

2. fractures of the edentulous mandible with marked displacement;

3. some shearing fractures in the canine region of the mandible, where surgical reduction is necessary. Here wiring is useful to maintain reduction while splints are constructed;

4. large alveolar fractures without supporting teeth.

This type of wiring still requires the construction and wearing of splints. It is not usually possible, especially with standing teeth to wire the alveolus at any distance from the fracture. Without the support of the splints, the wire tends to pull through the bone and displacement recurs.

The advantages of this form of treatment are many. The only possible alternative treatment is external surgery. This usually requires hospitalisation of the patient, a general anaesthetic and an external wound. While, in skilled hands, this usually gives a good result, breakdown of the external wound or some scarring is possible.

On the other hand, upper border wiring can be done under local anaesthetic, the patient is only detained for a few hours, and the wound is internal.
Fig. 540. Methods of transosseous wiring. a, Horizontal wiring indicated in fractures that can be properly impacted. If fracture is oblique so that it cannot be impacted, it is likely to become displaced when mandible is manipulated or by muscle pull when patient recovers from anesthesia. b, Showing vertical fixation which prevents displacement in these cases.
Helsham then gives the results of 30 cases of upper border wiring with successful results.

**Direct Subperiosteal Transcircumferential Wiring**

This method is described by Haines (1961) as a relatively simple way of obtaining an excellent reduction and a most rigid fixation of certain mandibular fractures.

He discusses as indications for this technique as follows: Direct subperiosteal transcircumferential wiring can be done only in cases of diagonal or oblique fractures in which a wire passing from the superior to the inferior border of the mandible will actually bind the two fractured segments together. The procedure is indicated when this type of fracture exists and there are not enough teeth for adequate fixation and immobilisation, as well as when intermaxillary traction causes an outward rotation of the inferior border of the mandible.

This technique does not involve the use of a splint, and it can be employed in either edentulous areas or areas in which teeth are present. This relatively simple method of fixation does not necessarily require hospitalisation.

This technique is presented not as a substitute for the conventional methods of treating fractures by intermaxillary wiring but as an adjunct to be used with intermaxillary wiring where extra help is needed.

If the fracture is of the oblique or diagonal type, in which a wire passing around the superior and inferior borders of the mandible can actually bind the fractured segments together, then
direct subperiosteal transcircumferential wiring can be used if indicated by the inadequacy of routine methods of intermaxillary fixation.

The technique is useful in cases in which adequate fixation and immobilisation are difficult to obtain because of mobility of teeth or an insufficient number of teeth. The stability of the reduced fracture is far greater than that obtained with inferior border transosseous wiring.

Submucoperiosteal Wire Fixation

Marlette (1963) describes intraoral open reduction and wire fixation, and states the criteria for selecting submucosal wire fixation surgery over conventional open reduction techniques as:

1. minimal comminution;
2. fracture compounded intraorally;
3. a tooth in the line of fracture is preferred but not necessary;
4. no external communication with the fracture.

He recommends the removal of a tooth in the line of fracture.

The advantages of this technique are that it offers a simple method for use in mandibular fractures that have teeth in the fracture line, and provides positive fixation with minimal post-operative complications.

Metallic Fixation by Open Reduction

The use of "L" splints for immobilisation of mandibular
Fig. 1—Schematic drawing of subcondylar and body fracture of mandible. Note grooves through cortical plate have been made across reduced fracture sites. Forceps hold "L" plate selected for immobilizing body fracture.

Fig. 2—Schematic drawing showing fractures immobilized with "L" plates. Note that distracting forces are borne by inlay portion of splint leaving screws strain free. This permits fixation with only two screws.
fractures has been reported in the literature increasingly. This technique utilises a metal plate - L shaped in cross-section - with one arm of the L inserted into a groove drilled in each fragment. This helps to prevent rotational displacement. The flat portion of the plate now resting against the bone surfaces is then screwed fast, providing a very firm fixation. Robinson and Yoon (1963) discuss this type of fixation, stating that the three dimensional action of the L plate gives it an advantage over other types of metal plates.

Robinson and Shuken (1966) also advocate this technique for immobilisation after using bone grafts.

Panuska (1967) gives a quite complete evaluation of metal implant techniques of fixation. He discusses the history of metals in tissues and metallurgical development. Stress is given to an aseptic surgical technique coupled with antibiotic coverage. He discusses the electrolytic dissolution of the metals; these may be caused by using a SS screw on a vitallium plate; metal shavings from the drill may be retained; or simply using wrong metals to secure the implants.

He lists as advantages of mandibular plating:

1. plating provides a more secure fixation than transossseous wiring;
2. it prevents distraction of bony ends;
3. it prevents overriding of fragments;
4. it permits support of extensively comminuted fractures, making possible the stabilization of fragments too
small to be wired;

5. in areas of bone loss it is a useful way to hold contour and space for future grafting;

6. it provides support for bone grafts;

7. it provides needed support in fractures of the edentulous mandible.

He then lists as disadvantages:

1. healing may be slower than that which follows wiring techniques because of lack of compression at the fracture site;

2. plating may interfere with denture construction in small, thin mandibles;

3. injury to the mandibular nerve can occur in thin, atrophic mandibles;

4. metallic alloys are not so perfect as to prevent electrolytic changes and bony resolution between the plates and screws;

5. plates of the exact types and sizes are not always available.

He reaches the following conclusions concerning metal plat- ing:

1. SS and cobalt alloys appear to be the metals of choice;

2. plating and wiring of fractures should be done under sterile technique;
3. plates can be designed to fit most situations, if basic engineering principles are kept in mind;

4. metallic alloys should not be mixed in the same patient, because of corrosion factors;

5. "metallic transfer" is an important phenomenon interfering with the success of implants. Certain precautions to prevent this are elaborated. Screw drivers of the same alloy composition as the implant should be used; contact of the implant with other metals during shipping, storage, sterilisation, and insertion should be avoided; and implants should be handled with rubber-tipped instruments;

6. all implants should be handled with care to avoid surface damage. Many metals, such as SS, depend upon the protective surface for success;

7. implants should be removed from infected areas as soon as practical;

8. body fluids are highly corrosive to metals because of their salt content and high oxygen concentration

9. metallic implants are not meant to remain in the body forever;

10. mandibular plates are excellent if used and inserted properly.

Kirschner Wiring

Killey (1967) states that fixation of fractures in the symphyseal region can be effected by reducing the fracture and then
Fig. 656. Photograph showing cranial mandibular fixation by means of Steinmann pin through anterior part of mandible and use of Frac-Sure connecting rods.
transfixing them by drilling a Steinman pin or Kirschner wire through the fragments. He says however, that this technique is most applicable and effective in cases which can be immobilised more easily by many other techniques. Dingman and Natvig (1964) describe it as the "shish kebab" method.

Scougall and Colvin (1951) describe the technique of Kirschner wiring after jaw resection. They state that the holding quality of the Kirschner wire is at a maximum in good cancellous tissue. In the small proportion of cases where the cancellous content is low, the point of the Kirschner wire may be driven through the cortex as well.

They give as special requirements of the Kirschner wire and the guide wire:

1. it must possess optimum rigidity in relation to flexibility;
2. it should be electrically equipotential with bone;
3. the perforating end should have an oblique cut at an angle of 45°.
4. the cutting point gauge should not be greater than the body gauge;
5. it should have sandblasted surfaces.

**Extra-oral Skeletal Control by SS Pins, Universal Joints, and Connecting Rods**

According to Rowe and Killey (1955), experience has shown that this method has not proved as successful as was originally anticipated. Nevertheless, in certain cases this technique is
Fig. 562. Fracture reduced by means of two pins in anterior fragment and Thoma peripheral clamp at angle of jaw.
the method of choice:

1. an edentulous posterior fragment with gross displacement, which cannot be controlled by intra-oral means;
2. fracture of the edentulous mandible with considerable displacement of the fragments which is extensively compounded into the mouth or heavily infected at the fracture site;
3. control of edentulous fragments following insertion of a bone graft.

A Gunning splint secured by wiring is precluded owing to the risk of pressure ulceration of the mucosa over the graft. There is also a risk of introducing infection via the circumferential wire.

They state the disadvantages of pin fixation to be:

1. absolute stability is difficult to achieve without additional immobilisation of the mandible as the connecting bars and universal joints tend to yield. This is partly due to the powerful leverage effect exerted by the muscles and the inherent spring in the bars;
2. loosening of the pins in the bone may occur as a result of osteoclastic resorption of the bone when any stress is exerted upon the pins;
3. infection may track along the line of insertion of the pin through the tissues and cause osteitis;
4. the appliance is awkward and unsightly during normal activities and sleep;

5. in view of these difficulties it is usually advisable to hospitalise the patient for the full period of treatment.

Killey (1967) states that there are few occasions when the fracture could not be immobilised more effectively by transosseous wiring, but if the fracture line is infected pin fixation is occasionally a helpful means of effecting immobilisation.

On the other hand, Thoma (1963) says that the advantages of this technique are numerous: it allows early and prompt reduction; moderate function is possible as the joint is free. This facilitates nutrition, oral hygiene and prevents stiffness of the joint and muscles.

The types of pin used are: Clouston-Walker; Macgregor; and the coarse threaded screw pin. The fracture is reduced manually before the joints are tightened. This is achieved by a sense of touch, although some operators expose the fracture site intra-orally in order to position the fragments under direct vision. Immobilisation should be further improved by the use of Gunning splints in the edentulous case, by coupling to a head-cap is it is considered necessary, or intermaxillary fixation.

For those fractures at the angle of the jaw, where the bone is generally too thin to hold pins that are screwed in, Thoma has designed a bone clamp, similar to the Brenthurst clamp, which is attached to the posterior fragment. This technique has the
advantage of avoiding injury to developing teeth or the mandibular nerve.

Cash (1952) reported that he did not allow patients to use their jaws for 2 weeks because the injured part requires rest during the early stages and the apparatus is mechanically unsound; movement may cause sufficient trauma to delay union.

**Tissue Reactions to Skeletal Pin Fixation**

When skeletal fixation pins are inserted, the thermal irritation to the involved bone is in direct proportion to the speeds used to insert the pins. Histological change that has been observed after insertion at high speeds is attributed to thermal insult, whereas the changes seen at low speeds can be charged to physical injury. Several studies on animals have been carried out to determine the optimum speed and best method for pin insertion.

Thompson (1958) drilled pins into the mandibles of dogs at speeds of 125, 250, 1,000 and 2,000 r.p.m., and the response to these drill speeds was studied histologically. He also studied the effect of the various speeds on the temperature of the pin immediately after drilling, and of the neighbouring bone during drilling.

He found the acute histologic reactions in bone were hyperaemia, degeneration of osteocytes, change in bone stainability, and tears and fragmentation of the bone edges around the drill holes. These reactions increased in severity with the increasing drill speed and were more pronounced 72 hours after the oper-
ation than at either 24 or 48 hours. The thermal changes in the external and internal portions of the pins were slight, but thermal changes in the bone increased with the increase in drill speeds, ranging from 38.3 to over 65.5 degrees C.

He evaluated the various drill speeds on the basis of the histologic reactions, thermal changes, mechanical effects, ease of penetration of bone and steadiness of application in order to determine a drill speed that would be desirable in clinical use, and would produce minimal histologic and thermal changes in bone. This evaluation suggested a desirable speed to be in the neighbourhood of 500 r.p.m. with the power drill. This speed produced a minimal histologic response and thermal change in bone, and yet was fast enough to prevent fragmentation and irregular pin hole margin. It also provided ease of penetration of bone and steady application of the pin.

Pallan (1960) carried out a similar study on dogs, and arrived at the same conclusion as Thompson, that the drilling speed producing the least amount of tissue destruction is 500 r.p.m. and the best method of inserting the pins is with an electric drill. He states that the duration for which the pins should remain in the bone is six weeks.

Archer (1966) recommends running the drill for 5 seconds, shutting off the power for 5 seconds, and continuing until the cortical plate is encountered.

In a follow-up of the insertion of a Kirschner wire used to unite a resected mandible after carcinoma removal, Lovett (1960)
radiographically determined the drift of the pin within the bone. In seventeen months the pin drifted anteriorly about 1 cm.
FRACTURES OF THE EDENTULOUS MANDIBLE

Rowe and Killey (1955) state that with advancing age, the increased liability to fracture which is common to all bones is particularly pronounced in the case of the mandible as a result of the resorption of the alveolar portion of the bone when the teeth are lost. The vertical depth of the bone is thereby reduced by approximately one half.

In many cases the fracture is simple and the displacement is minimal, owing to the intact periosteum and mucous membrane acting as a splint. When the fracture is compound into the mouth, especially in association with a fracture at the angle with a horizontal line of fracture, the displacement may be considerable. The upward movement of the posterior movement of the posterior fragment is increased owing to the absence of any teeth or alveolar bone which might limit this movement. Such displacement is particularly prone to occur in case of bilateral fracture.

The reduced cross-sectional area of the atrophic edentulous mandible provides a smaller area of bone to bone contact, and the diminished metabolic and cellular activity of the elderly patient necessitates a longer period of immobilisation in many cases. This is especially so when fracture occurs during removal of a misplaced or partly erupted third molar. On the other hand, the precise degree of alignment necessary when teeth are present is not essential. Minor errors of alignment can be compensated with dentures. Nevertheless, it must not be assumed that fractures occurring in the edentulous mandible are unimportant and capable
of treatment by a simple supporting bandage. Failure to follow the correct line of treatment may result in considerable deformity and impairment of masticatory efficiency.

Rowe and Killey (1955) classify the methods of fixation which should be considered as follows:

1. intra-oral control from the denture-bearing area of the mucosal surface by means of Gunning type splints. These are of very little value unless secured to the maxilla and mandible by peralveolar and circumferential wires respectively;

2. direct control of the bone fragments by open reduction with interosseous wiring between the bone ends;

3. extra-skeletal control by the insertion of SS pins into each fragment, which are then connected by means of a series of rods and universal joints.

**Gunning Type Splints with Peralveolar and Circumferential Wiring**

Rowe and Killey (1955) state that this has proved to be the most universally acceptable method for the average case of unilateral or bilateral fracture of the edentulous mandible. Optimum control of the fragments is achieved when the fracture occurs in the anterior part of the mouth since the insertion of circumferential wires in the first molar region is difficult and may sever the facial vessels. The method does not adequately control fractures occurring distal to the normal denture-bearing area of the mandible; and although the jaws are immobilised,
the stability of the posterior fragment may not be entirely satisfactory. However, the upward displacement of this fragment may be to some extent corrected by overclosure of the bite, thereby approximating the alveolar ridges of the upper and lower jaws in the incisor region, and thus restoring the alignment of the ramus and the body of the mandible. Some degree of upward displacement may be accepted, and compensated for at a later date with dentures.

Contraindications to this technique are unilateral or bilateral fractures with marked posterior displacement of the anterior fragment which remains unstable after reduction, and gross upward or medial displacement of the posterior fragment. Although it might be considered that lacerations of the tissues would prohibit the use of this method, it will be found that normal healing occurs beneath a gutta-percha lining, provided that normal apposition and suture of the wound edges is carried out. Where extreme resorption of the maxilla precludes the use of peralveolar wires, the upper splint may be secured by wiring through the margins of the pyriform fossae. Reduction is effected manually and the splint loaded with black gutta-percha, giving an impression of the reduced ridge.

Starr and Arnott suggest the use of Gunning type splints, immobilised by a barrel bandage where there is no appreciable displacement of the fragments. All cases which I have treated or seen treated in this manner have given a very satisfactory result. This indicates to me that the necessity for circumfer-
ential and peralveolar wiring is far less necessary for mandibular fractures than the literature suggests.

Degnæs et al (1965) give a detailed description of the use of existing dentures and the construction of splints (Gunning Type?, for the treatment of edentulous fractures. They advocate the use of peralveolar and circumferential ligatures to ensure rigidity of fixation. The advantages of direct bone wiring are that it eliminates concern for the usual means employed to aid denture retention (post-dam, peripheral seal, etc.); the denture periphery may be cut back and the bulk of the palatal acrylic removed from the maxillary splint. This permits some degree of oral hygiene of the buccal alveolar and vestibular mucosa.

For attachment of the maxillary splint, they use three ligatures on each side: in the incisor-cuspid, the premolar and the first molar areas. A Kirschner wire is passed through these points using local anaesthesia and the splint attached to the maxilla by steel ligatures at these points. For attachment of the mandibular splint they use five ligatures: in the cuspid, premolar and symphysis regions. These positions may be modified if there is danger of involving the fracture line or the external maxillary artery.

To avoid the possibility of laceration of the external maxillary artery and facial vein as they cross the inferior border of the mandible, the circumferential wires should be placed posterior to them if the fracture is in the molar area. The external maxillary artery is easily palpable, and there is little excuse for injuring it. Also inadvertent placing of a ligature into the
fracture site may cause distraction of the reduced fracture or possibly interfere with healing enough to result in nonunion.

Grabin and Berman (1965) describe a technique for circum-osseous wiring which obviates the necessity for making an incision to make the wire hug the bone without impinging on the soft tissue. With this technique, a needle is inserted at the inferior border of the mandible and passed through the tissues on the lingual aspect of the mandible in close apposition to the bone. The circumferential wire is then threaded into the needle and the free end grasped. The needle is withdrawn to the inferior border of the mandible and passed labially into the muco-buccal fold. The advantages of this technique are simplicity, time is saved, and there is a reduction in the armamentarium needed. Another advantage is that this procedure can be performed in the dental clinic rather than in an hospital operating theatre.

Inter-osseous (Trans-osseous) or Lower Border Wiring

Rowe and Killey (1955) state that the indications for this procedure are the presence of an edentulous mandible where a considerable alveolar resorption has occurred, which would make the insertion and retention of steel pins difficult, and also where there is considerable overlap of the bone ends which remain unstable following reduction.

Fractures of the edentulous mandible which are compound externally through a skin wound suitable for primary closure may be treated by this method since direct access to the bone is present.
**Contraindications:** fractures which are compound intra-orally should be treated with some degree of reserve, as there is a definite risk of infection from the oral cavity tracking down the fracture site, delaying union and causing sequestration and the extrusion of the wire as a foreign body. This risk may be accepted if the infection has been controlled by chemotherapy. The wound should be minimal and capable of careful closure by accurate apposition of the wound margins.

In some cases, edentulous or otherwise, an open operation will be necessary to remove muscle or debris interposed between the bone ends, which prevents reduction.

**Stability:** a unilateral fracture treated by this method is fairly stable, but where the fracture is bilateral in the molar or premolar region, the muscular pull tends to displace the anterior fragment downwards in spite of a careful wiring technique. In most cases, uni- or bi-lateral, it is advisable to immobilise the mandible to prevent this occurring. It will be found that many cases of bilateral fracture require inter-osseous wiring on one side only, the other side being controlled by intra-oral splinting. Control of an edentulous posterior fragment may be achieved by interosseous wiring provided control of infection in the fracture site is assured, and the main fragment suitably immobilised.

Irby (1958) reported on three cases of mandibular fracture treated in this way. These were for correction of malreduced fractures of the mandible at the angle. He lists as possible
causes of error with open reduction:

1. failure to occlude and fix the teeth of the two arches in their normal relationship before the edentulous posterior fragments are positioned and secured to the anterior fragments or bodies of the mandible;

2. failure to place the incision in the shadow below the angle of the mandible;

3. the use of only one transosseous wire in an attempt to immobilise a fracture.

Killey (1967) demonstrates that using lower border wiring, the anterior fragment tends to be displaced downwards. He says this tendency can be overcome to a certain extent by using a figure-of-eight type wiring at the lower border. However, the use of upper border wires through the mandible immediately below the level of the alveolar bone avoids the tendency of the upper part of the fracture to gape, for under these circumstances the pull of the muscles in the mental region only tends to impact the bone ends together. This procedure is also recommended by Helsham (1961).

Kazanjian and Converse (1959) also advocate intra-oral interosseous wiring of fractures of the edentulous mandible for the following reasons:

1. exposure of the fracture line by reflecting back the muco-periosteum is a relatively simple procedure, resulting in less operative trauma than exposure by means of the external approach;
2. reduction is accomplished under direct vision;
3. local anaesthelaial may be employed in favourable cases;
4. no additional manipulation is necessary after operation. An interdental appliance, accurately fitted to the upper and lower alveolar ridges, may provide additional support, but is not an essential requirement;
5. the technique requires only simple equipment such as wires and drills.

Barton and Chandler (1967) suggest the use of Kirschner wire or Steinmann pin in unco-operative patients. Patients who could be classed as unco-operative are those with known psychotic conditions, chronic alcoholics and epileptics. They state that the advantages of this approach are: a definite apposition of the fragments; the complete absence of visible or tactile evidence of the means of retention; minimal sign of site of skin injury. The disadvantages are: possible damage to the contents of the mandibular canal; the need for subsequent removal of the pin or wire following bony union.

Linz and Friedman (1960) suggest the use of naso-mandibular wiring for fractures of the edentulous mandible. The advantage of this method is that it eliminates the need for extra-oral appliances. They present five case reports in which this method was used successfully.
THE EDENTULOUS POSTERIOR FRAGMENT

Thoma (1963) says that open reduction is the only acceptable method for treating these fractures, and does not discuss any intra-oral methods for their treatment. He states that the defect caused by an external excision is far outweighed by the results obtained using this method. Rowe and Killey (1955), on the other hand, say that a small degree of discrepancy can be accepted, and grade their treatments of this type of fracture as follows:

1. **cases where no treatment is indicated** - in many cases, even when the fracture lines are unfavourable, the only treatment necessary will be immobilisation of the mandible to the maxilla. Under these circumstances a slight degree of upward displacement is acceptable;

2. **saddle extensions** - if the fracture has occurred far enough forward to ensure a reasonable area of mucosa upon which pressure may be brought to bear, a detachable saddle extension may be constructed distal to the cap splint. This consists of a malleable German silver plate, perforated for the retention of a gutta-percha lining. After being lined with gutta-percha, the plate is attached to the cap splint by a locking plate or a screw, after the fracture has been reduced. Unless a reasonable mucosal surface is available, ulceration and possibly necrosis of the underlying bone may occur. This method is therefore of no value in the
case of the short posterior fragment which occurs distal to the tooth bearing area;

3. **pin fixation** - which may be effected in two ways:
   (a) both fragments may be pinned as already described.
   (b) a pair of pins may be inserted into the posterior fragment and attached to the cap splint by a connecting rod; or in the edentulous case a Gunning type splint which has been wired to the mandible;

4. **interosseous lower border wiring** - this method is not advisable when the fracture is compound intra-orally, and it will be found that those fractures which are not compound in this manner do not exhibit gross displacement, and in the majority of cases the slight error in alignment may be accepted. This method gives excellent results but the occasions for its use will be limited;

5. **interalveolar or upper border wiring** - where a recent tooth socket exists, stability in the case of HU and VU fracture lines is ensured by wiring together a hole drilled in the posterior fragment through the lingual plate at a higher level than the hole in the anterior fragment which is situated in the buccal plate;

6. **Darcissac's method** - this has been discarded because of inefficiency and the risk of infection;
7. other methods - Kirschner wire; intra-medullary pinning; the Brenthurst clamp and others have been tried but for most cases more simple methods will suffice.

These techniques are discussed in detail in the previous sections.
TREATMENT OF MANDIBULAR FRACTURES WHERE TEETH ARE PRESENT IN ONE JAW ONLY

Rowe and Killey (1955) categorise these as follows:

1. edentulous maxilla with an almost full complement of mandibular teeth. If available, the patient's denture is modified by the insertion of hooks on the buccal and labial aspect.

   The mandible is immobilised to the upper denture if available or to a Gunning splint either of which must be immobilised to the maxilla by per-alveolar wiring;

2. Where severe laceration of the maxilla precludes the use of peralveolar wiring, the mandibular fragments may be controlled with capsplints alone. If there is likely to be loosening of the splint, the maxillary splint may be fixed by alveolar retention per bone screws or skeletal retention per wiring through the pyriform fossa of the nose. Another method is to wire the mandibular splint directly to the pyriform aperture.
FRACTURES OF THE MANDIBULAR CONDYLE

Classification

Rowe and Killey (1955) classify condylar fractures as follows:

1. **no displacement** - a crack fracture is present without tearing of the periosteum or ligaments and no change of relation to the fossa or ramus;

2. **deviation** - may be medial or anterior. Slight angulation exists between the condylar neck and ramus;

3. **displacement** - overlap between condylar process and ramus. Mostly the fragment lies lateral to the ramus;

4. **dislocation** - disruption between condylar head and the glenoid fossa.

Fractures of this nature are usually high level or intracapsular, the condylar fragment being pulled anteriorly and medially by the external pterygoid muscle.

Comminuted fractures of the condyle may rarely be met and are usually associated with fractures of the zygomatic arch and coronoid process.

Diagnosis of Condylar Fractures

Dingman and Natvig (1964) state that diagnosis of condylar fractures is usually made on the basis of clinical examination and confirmed by radiographs. Asymmetry of the face, caused by shifting of the mandible posteriorly and laterally, may be a feature. Premature contact of the teeth on the involved side is
caused by the upward pull of the elevator muscles of the mandible. This leaves the bite open in the front and on the opposite side. Oedema over the joint, ecchymosis and sometimes haemorrhage into the external auditory canal may occur. Tenderness on palpation over the TMJ or the external auditory canal are usual findings.

In bilateral fractures, the patient with teeth will exhibit an open deformity due to the overlapping of the fragments and premature contact of the posterior teeth.

Inability to protrude the mandible is characteristic for bilateral fractures occurring below the level of the lateral pterygoid muscular insertions.

If the operator's fingers are placed in the external auditory meatus, and the patient instructed to open and close the jaw, the intact condyle will be felt by the finger. If there is a fracture of the condyle, no movement will be felt by the finger.

Macgregor and Fordyce (1957) list the signs and symptoms of condylar fractures as follows:

1. local pain and swelling;
2. inability to open the mouth to its normal extent;
3. gagging of the bite in the molar region of the affected side;
4. deviation to the side of injury on opening;
5. rupture of the external auditory meatus causing bleeding (rare).

The difficulty in opening and deviation to the affected side would appear to be caused by spasm of the muscles of mastic-
ation related to the site of the fracture. The gagging of the molar teeth is due to this spasm and the consequent shortening of the ramus.

Discussion of Condylar Fractures

The philosophy of treatment of condylar fractures is covered in an excellent article by Macgregor and Fordyce (1957). They stress two fundamentals:

The first is that manipulative treatment to reduce the dislocation, where this is present, is almost invariably unsuccessful owing to the difficulty of maintaining the small condylar fragment in position. Local methods of fixation, e.g. plating or wiring, are not easy to apply owing to the difficulty of access and the dangers inherent in operative procedures in the vicinity.

The second important point is that, unlike the majority of fractures in long bones, the muscular force applied to the upper fragment by the lateral pterygoid muscle is not acting in a contrary direction to that of the muscles attached to the main fragment. This allows the condylar head to move with the rest of the mandible on opening, and the consequent absence of mobility of the fragments, relative to one another allows osseous union to occur.

This latter observation has also been noted in several cases at the United Dental Hospital (Sydney) (e.g. Kathy Lamb). It would appear from follow-up radiographs taken over a period of years from several patients, that the condylar fragment unites
with the ramus of the mandible in a reasonable degree of alignment, and either by a process of remodelling of the bone, or a realignment of the condylar process, it attains its former position.

Macgregor and Fordyce (1957) then list their conclusions covering over 250 cases as follows:

1. bony union occurred in all cases, whatever the degree of dislocation and even where no fixation was applied. Apart from the controlled series of patients, two mandibles, obtained post mortem from epileptics who had received no treatment at all for the fractures showed the same result;

2. no case of false joint or fibrous union was seen;

3. re-modelling of the condylar head occurs to a very considerable extent, particularly in children;

4. no patient complained of pain or any signs or symptoms attributable to their injury, save one who stated that he had slight pain on yawning;

5. no patient showed signs of limitation of opening or interference with normal function, although four patients showed very slight limitation compared to the normal on lateral excursion;

6. fracture of the neck of the mandibular condyle in children does not normally cause any interference with the growth of the mandible, and in only one child, aged 6½ at the time of injury, with a very severe compound fracture of the condyle involving
the zygoma in addition, was slight limitation of normal growth on the affected side with very slight facial asymmetry seen. This was not in fact noticed by the patient, though now a female medical student aged 19, and function is normal;

7. eleven patients in the group examined had had no fixation at all. One child had fixation, although other fractures were not present, and three adults had fixation without other fractures being present, owing to gagging of the bite. In all the other patients where fixation was applied other fractures were present necessitating this form of treatment. The results however were comparable whether fixation was applied or not;

8. no patient showed any signs or arthritic changes. This is not conclusive, since the average period of follow-up is six years and the longest thirteen years. It does, however, agree with the general experience of workers in this field, that arthritic changes in later life following fracture of the neck of the mandibular condyle are very rarely seen;

9. in view of the above facts, there would appear to be no necessity for any surgical intervention save possibly in ill-treated or neglected cases, nor any necessity for fixation for a fracture of the neck of the mandibular condyle without other mandibular
fractures provided that normal occlusion can be obtained and maintained.

Blevine and Gorey (1961) collated the results of conservative treatment of fracture of the condyloid process. The function of the jaw was good in all but two of the patients, and these two had only slightly impaired function. In several cases there was apparent re-establishment of the condylar fragment which was severely displaced at the time of injury.

Lautenbach (1965) also had good results using conservative methods of treatment. In a follow-up of his patients, he found no cases of ankylosis, and radiographic examination showed healed, well positioned fractures.

More or less in agreement, Rowe and Killey (1955) state that although fractures in other parts of the body which involve joint surfaces are frequently attended by serious complication, poor subsequent movement, and often arthritic changes in later years, these problems are seldom encountered in the case of fractures of the condyle. Experience has shown that in the very great majority of cases, these fractures, even when accompanied by gross dislocation, can be expected to heal with a good functional result in spite of poor anatomical alignment and very rarely give rise to long-term complications.

The following factors affect this result:

1. the soft nature of the present-day diet does not impose a great strain on the jaws and the force of mastication may be considerably diminished before
any appreciable impairment of function is imposed;

2. the anatomical nature of the mandible ensures that the movement of one condyle is transmitted to the condyle on the opposite side and provided that there is no interference from adventitious osseous or fibrous tissue, a good functional result may be achieved with only one intact condyle;

3. formation of a fibrous pseudarthrosis at the fracture site; between the ramus and either the displaced condyle or the glenoid fossa;

4. the pattern of muscular balance becomes re-arranged so that change in the alignment is compensated by different sections of muscle fibres developing and taking the masticatory load;

5. the non-stressbreaking character of the TMJ — although this is a controversial subject, the general opinion seems to be that little actual stress is imparted to the joint surfaces over the greater extent of the range of movement, and this no doubt plays a considerable part in elimination of post-traumatic complications.

Open reduction is favoured by Thoma (1963) because of the many detrimental sequellae which follow conservative treatment. He quotes many sources: Campbell (1932), Federspiel (1939), Risdon (1934) and others, to claim that limited movement, ankylosis, malocclusion, deviation, with a resultant loss of function,
follows treatment along conservative lines.

He lists as indications for open reduction with internal wiring fixation the following:

1. cases of fracture through condylar head with vertical overriding fragments. In unilateral fractures the shortening of the ramus may not only cause cross-bite, but may also produce derangement of the TMJ on the other side due to compensatory hyperfunction;

2. cases of low fractures with displacement, especially bilateral ones in which the condylar fragment is grossly malaligned, at an angle to the ramus and projecting over it on the inside or the outside of the jaw. The open bite is only temporarily relieved by wiring the teeth into occlusion; when the wires are removed, it often recurs;

3. cases of unilateral or bilateral fractures with loss of the posterior teeth, in either the upper jaw or both jaws. Sleeper (1952) pointed out that shortening of the ramus in such cases results in an occlusal deformity - posterior closed bite - which is difficult to correct with dentures;

4. cases in which the position of the condylar fragment interferes with normal motions of the jaw, or if impingement limits opening;

5. fracture dislocations, especially those in which the peripheral and proximal fragments are overriding,
and especially if the mandible cannot be immobilised immediately and effectively by intermaxillary ligation or otherwise;

6. in delayed treatment of fractures in which the condyle has been partly united in a completely displaced position.

The only one of these indications which I would agree with is the last — in some cases of delayed treatment of condylar fractures, open reduction is the only treatment of choice. However, Greenfield and Hirsch (1965) give two case histories of patients who received no treatment for 4 and 7 months respectively since fracture. They used intermaxillary traction to bring the jaws into correct occlusion and immobilised the mandible in an attempt to retrain the muscles to close in the desired occlusion with good function. Both of these cases resulted in good occlusion and function, which would indicate that open reduction is not mandatory with this type of case.

Thoma is not alone in his advocacy of open reduction — Stoopack (1958), Smith and Robinson (1957), Wilker (1956) and others support his approach.

The various methods of open reduction of the condylar process are well discussed by Malkin et al (1964). He mentions the three basic approaches: an incision along the lower border of the zygomatic arch; the preauricular approach; the submandibular incision used by Risdon.
The first two approaches involve greater risk of facial nerve damage than the latter. In the first method the incision is made at a 45 degree angle to many of the zygomatic branches and almost at a right angle to the temporal branches of this nerve. In the preauricular approach, the incision is posterior to the network of branches and superior to the main trunk of the nerve. The main direction of retraction during the operation, however, is inferior. Thus, it is possible for excessive pressure to be exerted against the main trunk of the nerve, or the two primary divisions, which causes temporary paralysis in some cases. In the submandibular approach, the incision is posterior and inferior to the entire nerve, except for the inconsequential cervical branch. Also, on retraction, the seventh nerve is completely within the reflected tissue, and no pressure is exerted against it. In all three approaches, there is equal possibility of injuring the vessels lying medial to the condyle and ramus.

They state that further advantages of the submandibular approach are:

1. **access** - from a strictly mechanical point of view, a horizontal incision will allow the tissues to stretch easily in a vertical direction but little in a horizontal one. The reverse is true with a vertical incision. In a condylar fracture, the vertical dimension is more important. Hence, a horizontal incision is of advantage, the access gained being in proportion to the length of the incision. A submandibular incision also gives better access to the
larger, lower fragment which is usually pulled
superiorly by the elevator muscles and which must
be retracted inferiorly for proper reduction;

2. **vital structures** - in spite of the increased access,
there is less danger to the various vital structures
in this region than with the preauricular. Specifi-
cally the facial nerve is superior to one end and
the facial vessels (external maxillary) are anterior
to the other end. Of course, the facial vessels
could be ligated and divided without much conse-
quence. The seventh nerve lies in the soft tissues
that are reflected with the masseter muscle. The
internal maxillary and external carotid arteries
and the posterior facial vein are easily protected
with a broad-bladed periosteal elevator placed medial
to the fractured segments of bone. The head of the
condyle and TMJ need not be involved in the dissec-
tion unless the head of the condyle is displaced
from the fossa or is fractured;

3. **speed of the procedure** - the tedious dissection in-
volved in the preauricular approach is necessarily
time-consuming, whereas the ease of dissection and
the good access afforded by the submandibular approach
result in a relatively short procedure.

Another approach, the retro-auricular, has been popular
with some operators; however, Rowe and Killey (1955) state that
this approach has become unpopular because there is some chance of post-operative stenosis of the external auditory meatus.

Thoma (1955) advocates condylectomy if the condylar head is comminuted, or if, in old fractures with gross displacement, it becomes fragmented when an attempt is made to detach it from the inner surface of the ramus. He presents a case report of condylectomy which was necessary because of numbness, crossbite and malfunction.

Peltier and Matthews (1965) and Doone (1963) both reported cases of the mandibular condyle dislocated into the middle cranial fossa. Diagnosis of this type of fracture is very difficult, extensive radiographic examination being necessary. Too vigorous attempts to reduction could have pushed the condyle into the middle cranial fossa with fatal results. Condylectomy was the treatment of choice in both cases.

**Treatment of Condylar Fractures**

Fractures of the condyle which are unilateral with no displacement or minimal deviation – Rowe and Killey (1955) state that if the condyle is in a position of good alignment to the ramus, the mandible should be immobilised to the maxilla for a period of four weeks. At this stage the callus is sufficiently firm to prevent further displacement, yet is sufficiently plastic to allow minor adjustments in alignment to take place under the influence of muscular forces. Likewise, Dingman and Natvig (1964) state that intermaxillary fixation for a period of 4 to 6 weeks will give a satisfactory cosmetic and functional result.
This type of condylar fracture would seem to be the one which should be immobilised without risk of ankylosis, rather than allowing functional treatment which could result in a greater displacement of the condylar fragment.

Gagging of the Bite

Where there is fracture and dislocation of the condyle the contractile spasm of the elevator muscles cause upward movement of the ramus. The last molar teeth act as a fulcrum, resulting in an open bite.

Rowe and Killey (1955) would treat this with elastic traction in the incisor region. In cases where severe displacement and dislocation of the fracture ends from the fossa exist, distraction can be effected by using gutta-percha fulcrums at the posterior end of the occlusion or splint before applying elastic traction. They would then maintain this distraction for at least four weeks to stretch the fibrous tissue and prevent relapse. After this the fulcrum attachments would be removed and the splints fixed in normal occlusion for a further four weeks.

From my experience this treatment is far too long and complicated. With the several cases of condylar fracture that I have treated, which have required a deal of distraction, I have used this method of posterior fulcrums (acrylic in my case), for no more than a fortnight followed immediately by normal function. In only one case was redistraction necessary, and in this case for less than one week.
Macgregor and Fordyce (1957) advocate still less treatment. They state: "The patient is made aware of the abnormality and is encouraged to secure normal occlusion either with or without manual assistance. The majority of patients succeeds, especially if the unpleasantness of alternative methods of treatment is forcefully pointed out. If the patient can obtain and maintain normal occlusion, even if with difficulty, no immobilisation is required. Very occasionally normal occlusion may not be secured in spite of every effort by the patient. With such patients the more standard technique of fixation of the jaws by cap splints or other methods must be applied. Treatment of marked gagging of the bite, first seen some seven days or longer after injury, frequently cannot be reduced manually, and elastic traction must be used. In such patients, over-correction of the shortening of the ramus should be employed by insertion of a two to three mm. spacer between the molar teeth prior to reduction by continuous elastic traction. Immobilisation of two to three weeks thereafter is sufficient. Long periods of immobilisation (six weeks or more) are to be deprecated as they may lead to permanent inability to open the mouth fully."

In the edentulous patient, distraction must be effected, or the maxillary tuberosities will approach the lower ridge, making denture construction difficult.

**Deviation**

Rowe and Killey (1955) state that: deviation does not usually occur but the bite should be kept under careful observation
to ensure that a "bite of convenience" does not occur. If this
does occur, a bite plane may be constructed and attached to the
lower splint to limit deviation. If the buccal sulcus is not
depth enough to limit deviation at maximum opening a second plane
may be attached to the upper splint.

I have seen some bite planes used, but I have never needed
to use them on patients of my own. Where deviation has been
present, effort on the patient's part has been the only treatment
needed.

Macgregor and Fordyce (1957) state that: deviation on open-
ing the mouth is best corrected by conscious effort on the part
of the patient. If this feature becomes more evident as the
degree of opening increases, the importance of central opening
and closing is explained to the patient and encouragement is
given in practising these movements before a mirror. Once it has
been ascertained that normal occlusion can be obtained, the pa-
tient is instructed in exercising his mandible along the lines
previously indicated, and told to eat what he likes in the
realisation that he will soon modify the diet himself according
to the amount of pain and discomfort that he experiences with
food of varying degrees of toughness.
FRACTURES OF THE CORONOID PROCESS

Dingman and Natvig (1964) state that isolated fractures of the coronoid region are rare. Single fractures in this region are sometimes seen, usually caused by a piercing or puncture type of trauma. These fractures usually show minimal displacement because they are well splinted by the dense muscle and fascia.

Fractures of the coronoid process are treated generally by intermaxillary fixation concomitantly with the management of associated fractures. In rare instances the coronoid fracture may be the only fracture of the mandible. The patient is usually more comfortable and will recover more quickly if the teeth are fixed in occlusion to provide immobilisation and rest for the injured tissues. Intermaxillary fixation prevents muscle pull which might interfere with the processes of repair.

Johnson (1958) treated one case by removal of the whole fractured fragment, because it had caused fibrous union with the malar resulting in malfunction.

Rowe and Killey (1955) state that if there is no derangement of the occlusion, no treatment is usually necessary as satisfactory function usually follows when the oedema subsides. Treatment of other fractures of the ramus which involve the coronoid process may be treated as though the coronoid process was not involved.
FRACTURES OF THE MANDIBLE IN CHILDREN

Due to the resiliency of the bone in children, fractures are rare and are usually of the greenstick type and situated in the region of the condylar base.

Dingman and Natvig (1964) state the peculiarities of fractures in children as follows:

1. the deciduous teeth may not provide good support for intermaxillary fixation;
2. healing of fractures occurs early in children, and if treatment is not carried out within 5 to 7 days, mal-union may occur;
3. general anaesthesia is indicated because fear and immature mentality result in lack of co-operation;
4. fractures of the mandible are most likely to be greenstick in variety.

While general anaesthesia is obviously indicated for open procedures or when pain is anticipated, it is hardly necessary for the simple conservative techniques usually used for these cases. The fact that deciduous teeth may not provide good support for intermaxillary fixation also applies to the use of cap splints, as the lack of undercut areas in deciduous teeth makes retention difficult.

Graham and Peltier (1960) state that the particular problems with fractures in children are: adequate immobilisation, non-interference with growth centres; rapid callus formation with resultant rapid healing; tooth buds or partially erupted teeth
in the line of fracture; and nutrition.

Rowe and Killey (1955) state that on radiological examination, diagnosis of fractures of the body of the mandible is made difficult by the presence of the crypts of the developing teeth, which may mask the fracture line. They say that injuries to the teeth and alveolus are very common, and every effort should be made to preserve permanent teeth which may have loosened. The bone surrounding these teeth has remarkable powers of recovery and many apparently hopelessly loosened teeth may be saved by splinting.

Lal et al (1959) give the disadvantages of the various methods of fixation as follows:

1. **tight bandages** - these can be used as temporary measures, but they are not good for permanent fixation;

2. **intermaxillary wiring** - is not suitable in children, for (a) wires are likely to slip because of the shape and loose contact points of the deciduous teeth, (b) because incomplete roots of permanent teeth and partially resorbed roots of the deciduous teeth are too weak and unsuitable for wiring, and (c) it is difficult and undesirable for children to keep their mouths closed for long periods;

3. **direct wiring or plating of the fractured ends** - this method is a complicated one and may be risky at times. Moreover, the permanent tooth buds may be injured;

4. **splints** - various types of splints have been designed
and recommended, but it is difficult to retain them with cement only. Children are likely to fidget with the splints and displace them;

5. **extra-oral fixation** - this is not favoured because (a) at times they are difficult to manipulate, (b) they do not give perfect immobilisation for the entire period of treatment, and (c) it is embarrassing for the patients to go about with extra-oral appliances on their faces.

They then recommend the technique of cast metal splints with circumferential wiring, and list the advantages of this technique as follows:

1. good occlusion results after this treatment;
2. it is easy to manipulate;
3. the child can open his mouth throughout the fixation period, and most of the patients can take soft food 6 or 7 days after fixation;
4. a child can be permitted to go to school one week after fixation;
5. cumbersome extra-oral fixation appliances and the operation of opening up the fragments are avoided;
6. no disfigurement is left after treatment.

They then state that this method cannot be used if there is an additional fracture in the remus, as that is likely to leave an anterior open bite. In such cases the mouth has to be kept closed in occlusion.
Although this treatment has obvious merits, to my mind it is too radical to be used for the majority of cases. I have seen cases where cap splints have been indicated, and the use of cold-cure acrylic as a cement has been adequate to ensure immobilisation, without the use of circumferential wiring.

Killey (1967) has a much more rational approach to fractures of the body of the mandible in children, varying his treatments according to the number of teeth in each fragment, and whether deciduous or permanent:

(a) if the deciduous teeth are unerupted, or an inadequate number are available, or if they have been loosened as a result of the accident and have to be extracted, an overall Gunning-type splint is very effective. Only a lower Gunning-type splint in the form of a trough is required and this is lined with black gutta-percha and retained by two circumferential wires;

(b) if a complete deciduous dentition of firm teeth is available either cap splints or interdental eyelet wiring can be used;

(c) if many deciduous teeth have been shed or are extremely mobile and the permanent teeth are not erupted an overall Gunning-type splint should be used, as in (a);

(d) if a few firm deciduous teeth and some permanent teeth are present, cap splints can be used;
(e) if all the deciduous teeth are lost and one or more permanent teeth are adequately erupted and present on each fragment, cap splints may be used;

(f) if an adequate number of fully erupted permanent teeth are present, arch bar or eyelet wiring is possible.

Poleway and Campbell (1964) described the use of an orthodontic type of splint for mandibular body fractures in children. The splint was constructed from orthodontic crowns or bands which are connected by heavy arch wire. This type of appliance has excellent retention.

Kaplan and Mark (1962) present an odd case of an 18 months old child with bilateral condylar fractures and symphysis fracture. The symphysis was immobilised by intra-osseous wiring, and the condylar fractures treated conservatively, with satisfactory results. Although several authors advocate surgical procedures for the treatment of body fractures in children — Graham and Peltier (1960), Lal et al (1959), Archer (1966), Kaplan and Mark (1962) — most of the opinions expressed in the literature were in favour of conservative procedures. The opinions regarding the treatment of condylar fractures in children were almost overwhelmingly in favour of conservative approach — Killey (1967), Dessner and Holm (1959), Rakower et al (1961), Archer (1966), Graham and Peltier (1960) and many others. The only author in favour of open reduction of the condyle in children was Wilker (1965).
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FRACTURES OF THE MIDDLE THIRD OF THE FACIAL SKELETON
SURGICAL ANATOMY

This subject was covered by most of the available texts in sufficient detail to explain their treatments. The only detailed description of all of the middle third bones was given by Rowe and Killey (1955).

The bones constituting the middle third of the facial skeleton which may be fractured following trauma to this region are:

1. the two maxillae;
2. the two zygomatic bones;
3. the two palatine bones;
4. the two zygomatic processes of the temporal bones;
5. the two nasal bones;
6. the two lachrymal bones;
7. the vomer;
8. the ethmoid bone and its attached conchae;
9. the two inferior conchae;
10. the body and lesser and greater wings of the sphenoid bone are not normally fractured, but the pterygoid processes of the sphenoid are almost invariably involved in extensive fractures of the middle third of the facial skeleton.

The Maxillae

The maxillae are designed to resist the forces of mastication, to absorb the shock of the occluding teeth, and distributing the load as evenly as possible over the cranial base. This is achieved by the arched shape of the palate, and the abutments
of the maxillae against the fronto-maxillary, zygomatico-maxillary, and maxillo-ethmoid sutures. Posteriorly a strong butress is provided by the junction of the pyramidal process of the palatine bone and the pterygoid laminae of the sphenoid bone. Some further support is provided in the nasal cavity by the vomer and vertical plate of the ethmoid bone.

The Nasal Bone and Orbits

Contained within the framework of the middle third structure are the nasal cavity and the orbits, thus diminishing the area available for basal bone structure. The surgical anatomy of the nasal region was also covered in detail by Kazanjian and Converse (1959).

The Sphenoid Bone

This bone may be regarded as the keystone of the skull, and is situated at the point where the greater part of the facial skeleton is united with the cranial base. It articulates anteriorly with the cribiform plate of the ethmoid bone, and laterally with the zygomatic and palatine bones.

The stress of mastication is transmitted by the four processes of each maxilla, via the alveolar and palatine processes to the median palatine suture of the palatal vault and thence upwards along the vomer and vertical plate of the ethmoid to the sphenoid bone; and via the frontal and zygomatic processes on the medial and lateral walls of the orbit to the frontal bone.

The lower alveolar portion of the maxilla is relatively
strong, and the lateral and posterior attachments via the
zygomato-maxillary sutures and the junction of the palatine
bones and pterygoid processes of the sphenoid, are comparatively
dense in contrast with the medial or central attachments. These
take place via the medial aspect of the orbital floor with the
delicate and thin structure of the lachrymal bone, orbital plate
of the ethmoid, and orbital process of the palatine bone. It
is apparent that the upper central section of the middle third
of the facial skeleton will crush or telescope more easily than
the lower alveolar section and that an even greater degree of
force will be required to displace the adjacent zygomatic bones
en bloc with the remainder of the facial bones.

Thus, it is apparent that although the middle third of the
facial skeleton can resist a very considerable force applied in
a vertical direction from below, force applied from anterior,
superior or lateral aspects will tend to shear off the whole
complex from the cranial base. Where force is applied in an
anterior direction, the facial bones are driven against the slop-
ing incline of the body of the sphenoid, and these bones together
with the alveolar arches and teeth are driven en bloc backwards
and downwards, producing elongation of the face, gagging of the
bite, and possibly respiratory embarrassment.

Three other factors of importance in the considerations of
these injuries are:

1. any gross disruption of the maxilla will fracture
and displace the nasal cavity and expose the paranasal
air sinuses to the possibility of infection. In addition the nasal respiration is impeded by blood clot;

2. comminution of the paper thin bone of the orbital floor and medial wall of the orbit readily occurs. This often impairs the support of the eye and diplopia occurs to a varying degree, and is most severe when there is associated rupture of the medial or lateral attachments of the suspensory ligament of the eye;

3. a shearing stress applied to the ethmoidal region results in comminution of the cribriform plate of the ethmoid, and provides direct access to the anterior fossa of the skull. Thus it is possible for bacteria from the nasal cavity to infect the CSF and enter the anterior cranial fossa.

Factors influencing the displacement of the fragments are:

1. the degree of force;

2. the direction of force;

3. the resistance offered by the facial bones;

4. the point of application of the force;

5. the cross-sectional area of the striking agent or object;

6. the attached muscles play relatively minor part in influencing the displacement of the fragments in contradistinction to the effect which they exert in
the case of mandibular fractures.

According to Dawson and Fordyce (1953) the displacement of the fragments is mainly determined by the force and direction of the blow. The maxillary block may be impacted upwards and backwards, or may be free, and therefore termed "floating". Lateral displacement is common. Gagging of the bite in the molar region is a frequent finding.

Fracture of the bony origins of the medial and lateral pterygoid muscles throws them into spasm, which results in a downward and backward pull on the separated fragment and accounts for the trismus often encountered. This displacing force is enhanced by the action of the superior constrictor of the pharynx, and by the palato-pharyngeus and palatoglossus muscles, which have origin on the fragment. In cases of "floating" maxillae, the action of these muscles may be observed when the maxillary block is seen to move during deglutition.

Dingman and Natvig (1964) state that, because of its prominent location, the zygomatic bone is subjected to injury frequently. It will absorb moderately severe blows through its buttressing attachments. But separation of the zygoma from its articulating bones may be caused by severe blows such as may be received in a fall or from a fist. With moderately severe blows, the bone may separate at the zygomatico-frontal suture and its articulation with the sphenoid bone.

Fractures in the region of the zygomatic arch usually include a portion of the zygomatic process of the temporal bone.
The zygoma is one of the principal buttresses between the maxilla and the cranium. Fractures of the zygoma combined with multiple fractures of the middle third of the face contribute to the instability of the maxilla. Fractures usually involve the infra-orbital rim, portions of the zygoma being forced into the maxillary sinus.

Damage to the infra-orbital nerve may occur with zygomatic, Le Fort II and III fractures either unilaterally or bilaterally and, depending upon whether there is neurapraxia or a neurotmesis, recovery may take eight to eighteen months. Other nerves which may be damaged are the anterior, middle, and posterior superior dental nerves. Patients seldom notice anaesthesia of the gum at the time of injury, but if the distribution of these nerves is tested at a later date areas of anaesthesia will be found.

Fractures involving the orbit may give rise to alteration in position of the globe of the eye. If the orbital floor is comminuted, there is a herniation of the periorbital fat into the maxillary sinus which may lead to an enophthalmos.

Alteration in the level of the globe of the eye will occur if the fracture passes above the origin or insertion of Lockwood's suspensory ligament. This fascial sling which cradles the globe of the eye passes from the lacrimal bone to be inserted into Whitnall's tubercle situated on the inner aspect of the zygomatic bone just below the zygomatico-frontal suture. If the fracture passes beneath Whitnall's tubercle there can be a severe drop in the zygomatic bone without any corresponding descent in the level
of the eye.

The optic foramen is a ring of compact bone and in high-level or Le Fort III injuries fractures invariably occur around it, so that it is unusual for the optic to be damaged directly as the result of a middle third fracture.

Le Fort II and III fractures and severe nasal complex injuries may involve the nasolacrimal duct, with resulting epiphora. This complication is not noticed at the time of injury, but may become apparent later.
Figs. 404 to 406. Three types of fractures of middle third of face.
Fig. 404. Horizontal fracture of maxilla.
Fig. 405. Pyramidal fracture.
Fig. 406. Transverse fracture of face combined with horizontal fracture of upper jaw.
CLASSIFICATION OF MIDDLE THIRD FRACTURES

Most of the classifications of middle third fractures are based on the findings of Rene Le Fort. His studies have been translated and abstracted by James and Fickling (1941).

Le Fort published in 1901 the results of experiments he had carried out on cadavers. In these experiments, blows were made with a blunt instrument on the heads of cadavers, some of which had been removed from the body. These blows were made on different sites, with varying direction and force in an effort to simulate the trauma of civilian injuries.

After the blow had been made, the cranium was opened, the dura mater detached, and the base of the skull examined for a possible fracture, after which the bead was boiled to permit easy removal of the soft parts. Blows directed upon skulls already macerated did not give the same results for the bones separated rather than fractured, owing to loss of resistance at the sutures.

The important features were described as follows:

The first fact was the intensity of violence needed to produce a fracture of the face. The bone structure presents special characteristics, consisting of several columns of more or less spongy tissue between which are thin compact laminae, an arrangement not found elsewhere in the body. An examination of the dry skull does not give a true idea of the resistance which exists when all the tissues are present. The prepared skull fractures readily, as is seen in students' specimens. When the bones are covered by soft tissues the fragile parts are not accessible to direct violence, while the salient points are resistant. The
thin fragile portions are supported on all sides by adherent soft
tissues, which greatly augment their strength, allowing full
elasticity, and distributing applied forces over a wide area.
The face resists injury chiefly on account of the elasticity
resulting from the arrangement of bone, periosteum and soft parts.
The extreme thinness of certain portions, far from decreasing
its resistance, adds to its elasticity. When the limit of elas-
ticity is passed, fracture occurs. These fractures differ from
those of long bones, for there are extensive fissures without
lesion of the soft parts, and displacement is exceptional. This
absence of displacement coupled with the extreme rapidity of
recovery, as shown by clinical observation, accounts for fractures
of the upper jaw being frequently undiagnosed, and thus considered
rare. Experimentally it was never possible to predict the con-
dition. Some severe and widespread lesions gave no external
sign, and skilled observers suggested that further trauma should
be applied.

The Le Fort classification as described by Dingman and Natvig
(1964) is as follows:

**Le Fort type I** - occurs transversely through the maxilla
above the level of the teeth. The fractured segment contains
the alveolar process, portions of the walls of the maxillary sin-
uses, the palate, and lower portions of the pterygoid processes
of the sphenoid bone.

**Le Fort type II** - caused by blows to the upper maxillary
region, which produce fractures of the nasal bones and of the
frontal processes of the maxilla. The fractures then pass lat-
erally through the floor of the orbit, and near or through the zygomatico-maxillary fossa. This fracture, because of its general shape, has been termed the pyramidal fracture.

Le Fort type III - craniofacial disjunction occurs when the traumatic force is sufficient to cause complete separation of the facial bones from their cranial attachments. The fractures usually occur through the zygomatico-frontal, maxillo-frontal, and naso-frontal sutures; through the floors of the orbits; and through the ethmoid and sphenoid bones with complete separation of all the structures of the middle facial skeleton from their attachments.

The classification of middle third fractures given by Rowe and Killey (1955) and subsequently by Killey (1965) is the most comprehensive of all the available texts. Based on the Le Fort system, this classification, as follows, gives the greater amount of detail necessary for adequate treatment planning:

A. Fractures not Involving the Teeth and Alveolus

1. Central region -
   (a) fractures of nasal bones or septum;
   (b) fractures of frontal process of the maxilla;
   (c) fractures of types a and b which extend into the ethmoid.

2. Lateral region - fractures of the zygomatic bone and arch -
   (a) first degree - fracture of the arch or minimal displacement of the zygomatic bone;
(b) second degree - fracture of zygomatic bone and/or arch involving the lateral wall of the antrum and interfering with mandibular movement;
(c) third degree - as above with gross comminution or orbital floor and depression of the orbital level.

B. Fractures Involving the Teeth and Alveolus

1. central region -
   (a) alveolar fractures;
   (b) low-level Le Fort I fractures;
   (c) pyramidal Le Fort II fractures.

2. Combined central and lateral fractures -
   (a) high-level supra-zygomatic fractures;
   (b) as type a with the addition of a midline split separating the maxillae into two;
   (c) as type a or b but associated with a fracture of the roof of the orbit or frontal bone.

Killey (1965) comments that this classification is comprehensive, but for ordinary practical purposes in discussing signs and symptoms and planning treatment, a simple classification dividing the fractures into the six following categories is adequate and is used in his text:

1. dento-alveolar fractures;
2. zygomatic complex fractures;
3. nasal complex fractures;
4. Le Fort I, Guerin, or low-level fractures;
5. Le Fort II, pyramidal or infra-zygomatic fractures;
6. Le Fort III, or supra-zygomatic fractures.
SIGN AND SYMPTOMS OF MIDDLE THIRD FRACTURES

This section is treated concisely by Killey (1965) in a chapter entitled: Clinical Findings in the Various Types of Fractures. He lists his findings as follows:

1. **Dento-alveolar fractures** - generally there is damage to the teeth, fracture of the crown and/or root of a tooth, or subluxation or avulsion of teeth. Fracture of the alveolus may occur.

   On clinical examination the lip is usually oedematous and there is ecchymosis. Laceration and ecchymosis of the alveolus may be present.

   Palpation of the alveolus reveals bony deformity, and crepitus is felt if the alveolus is comminuted.

2. **Le Fort I, low-level, or Guerin type fractures** - this type of fracture may occur by itself or in conjunction with Le Fort II or III types, which may mask the distinctive signs and symptoms.

   If only a Le Fort I fracture is present, the signs and symptoms are as follows: there may be slight swelling in the region of the upper lip, but there is no massive oedema of the tissues which produces the classical "ballooning" of the face in Le Fort II and III fractures. There is no circumorbital ecchymosis, no subconjunctival ecchymosis, no anaesthesia of the cheek, no flattening of the zygomatic region, and no disorganization of the naso-ethmoidal complex area.

   Intra-orally, the entire tooth-bearing portion of the upper
jaw is seen to be mobile. Usually there is marked deviation of
the upper midline and one side of the upper jaw with its attached
teeth is dropped lower than the other.

On palpation the entire dento-alveolar portion of the upper
jaw is found to be extremely mobile, and in the recent injury
it can usually be repositioned with little difficulty into its
correct anatomical situation.

Percussion of the upper teeth produces a distinctive "cracked
cup" sound.

All possible variations of open and closed type fractures
may occur and it is possible to see the condition unilaterally.

3. Le Fort II and III fractures - on superficial exam-
ination, these two types of fracture appear similar. According
to Rowe and Killey (1955), there are three characteristic features:
bilateral circumorbital ecchymosis; gross bilateral oedema of
the middle third of the face; lengthening of the face.

The circumorbital ecchymosis develops rapidly and is usually
very pronounced. The oedema also develops rapidly, resulting
in a balloon appearance. Lengthening of the face is caused by
downward and backward displacement of the middle third of the
facial skeleton, thus causing gagging of the occlusion in the
molar region, and opening of the mandible. The nares are usually
filled with blood and the patient must breathe through the mouth.
Any indication of CSF rhinorrhea must be checked. Palpation of
the cranium, orbital rims, and nasal structures must be carried
out.
When a Le Fort type I fracture only is present, no involvement of the infra-orbital nerve will occur, and there is therefore no associated circumorbital or subconjunctival ecchymosis or anaesthesia of the cheek, and oedema of the face is not so pronounced.

Intra-orally there may be absence of blood-stained saliva, and complete detachment of the maxilla may occur without the fracture compounding into the mouth. Blood from the nasopharynx often congeals in the palatal vault. There is usually some ecchymosis in the buccal sulci near the zygomatic prominences. Mandibular movement may be limited by the fracture displacement or by zygomatic arch fracture.

Palpation should commence in the upper buccal sulcus. Some alteration in contour at the junction of the maxilla and zygomatic bones may be present and the lateral wall of the antrum is frequently comminuted. Mobility of the maxilla should be tested by pushing upwards and also by trying to separate the maxillae to test for midline fracture.

Killey lists the signs and symptoms of Le Fort II and III fractures as follows:

**Le Fort Type II**

**Symptoms**

1. swelling of face;
2. swelling and bruising around both eyes;
3. blood-shot eyes;
4. pain over nose and face;
5. deformity of nose;
6. flattening of the middle of the face;
7. difficulty in opening the mouth;
8. inability to move the lower jaw;
9. gagging of the back teeth;
10. front teeth not meeting;
11. bleeding from the nose and possible salty fluid running down the nose or back of the throat;
12. upper jaw seems to move;
13. double vision.

**Signs**

1. gross oedema of the soft tissues over the middle third of the facial skeleton;
2. bilateral circumorbital ecchymosis;
3. bilateral subconjunctival ecchymosis, which may be confined to the inner half of the eye;
4. obvious deformity of the nose;
5. flattening of the middle of the face without corresponding flattening of the cheek bones;
6. lengthening of the face;
7. retroposition of the upper incisors;
8. gagging of occlusion in the molar area;
9. anterior open bite;
10. soft palate depressed on to the dorsum of the tongue;
11. no tenderness over or disorganisation and mobility of zygomatic bones and arch;
12. possible enophthalmos, diplopia and limitation of ocular movements;
13. sometimes no anaesthesia of the cheeks;
14. mobility of a pyramidal area of the middle of the face, which can be demonstrated by manual palpation between the palate and the frontonasal suture;
15. epistaxis;
16. possible CSF rhinorrhea;
17. "cracked cup" sound on tapping teeth.

**Le Fort Type III Fractures**

**Symptoms**

1. gross swelling of face;
2. two black eyes;
3. deformity of nose;
4. lengthening of face;
5. face appears flat;
6. face feels loose;
7. double vision;
8. numbness of cheeks;
9. gagging of back teeth;
10. front teeth not meeting.

**Signs**

1. gross oedema of soft tissues over middle third of facial skeleton;
2. bilateral circumorbital ecchymosis;
3. bilateral subconjunctival ecchymosis of outer and possible inner halves of the eye;
4. limitation of ocular movements;
5. diplopia;
6. possible enophthalmos;
7. anaesthesia of cheeks;
8. obvious displacement of nasal structures;
9. flattening of face;
10. displacement of zygomatic bones;
11. lengthening of face;
12. mobility of zygomatic bones;
13. mobility of facial skeleton;
14. epistaxis;
15. possible CSF rhinorrhea;
16. retroposition of upper incisors;
17. gagging of occlusion in the molar area;
18. anterior open bite;
19. occlusion of oral airway by soft palate being forced down on dorsum of tongue;
20. mandible wide open and patient incapable of separating lower and upper teeth, the upper jaw having fallen.
TREATMENT OF DENTO-ALVEOLAR FRACTURES

I will not mention the treatment of fractured or chipped teeth, as this is in the field of conservative dentistry. The only treatment to teeth that I will mention is to do with subluxated and avulsed teeth.

According to Killey (1965), slightly subluxated teeth, provided that they are in a good position, should be left alone if firm; or splinted if they are mobile. They mostly become firm and retain their vitality. If there is subsequent pulp death, root filling is necessary when the tooth has firmed.

If the tooth is avulsed or severely subluxated, it can be picked out and root filled from the root end; after which the apex is cut off and the tooth replanted and splinted. A tooth so treated usually becomes firm, but resorption of the root eventually leads to its loss – this is also the finding of Grossman (1965) and others. This type of treatment I would not attempt, as it would appear to increase the chances of introducing infection into the fracture site; also the advantages of retaining such a tooth with a poor prognosis, using a technically difficult procedure, do not seem to justify the treatment.

Fractures of the Alveolus

If a fractured tuberosity is completely detached from the periosteaum it should be carefully dissected out and the resulting soft tissue defect carefully sutured to prevent any residual opening into the sinus. If the tuberosity, with or without associated teeth appears to be attached to periosteaum, the tuber-
osity can be left alone with or without splinting.

Fractures of the alveolar floor of the maxillary sinus and elsewhere in the alveolus are treated in the same way; if the bone appears to be attached to periosteum, it may be repositioned; if it is stripped from the periosteum it should be removed.

Where a section of the alveolus with one or several teeth attached has been fractured, splinting of the fragment with the remaining uninjured teeth with any type of splint is the treatment of choice.

Rowe and Killey (1955) state that treatment without fixation is applicable in fractures with minimal displacement and mobility; and in elderly edentulous patients who are considered to be a poor operative risk and who have no gross bony displacement. Minor discrepancies in the position of the maxilla may be occasionally accepted as the masticatory force of the mandible will eventually align the upper jaw into its correct position through the medium of modelling resorption. Slight variation in the occlusion will correct itself. If the patient is edentulous, correction of the occlusion may be effected by dentures. The surgical trauma associated with the treatment may be unjustifiable in an elderly patient. The aesthetic aspect of such cases is of little importance compared to the preservation of life.
TREATMENT OF LE FORT TYPE I, II, AND III FRACTURES

Reduction

Killey (1965) treats this section most simply, without advocating open reduction or traction methods. He effects reduction manually or by the use of Walsham's or Rowe's forceps.

Reduction by Manipulation

Le Fort Type I Fractures

According to Killey (1965), reduction is carried out by grasping the tooth-bearing portion of the upper jaw and manipulating it into its correct position. If the fragment is very loose, this can be carried out with finger pressure alone; usually it is necessary to manipulate the fragment by gripping it between the blades of two pairs of Walsham's forceps or Rowe's disimpaction forceps. If the fragment is firmly impacted, it may be necessary to expose the fracture line through an incision in the buccal sulcus and mobilise it with an osteotome before applying the forceps.

Rowe and Killey (1955) state that manual reduction is indicated in recent fractures and in fractures that are fairly loose in which the deformity is due to a downward and backward displacement and where there is no telescoping of the fragments, causing impaction.

Le Fort Type II Fractures

Killey (1965) states that the tooth bearing portion of the upper jaw is grasped between two pairs of Walsham's or Rowe's forceps. If the section of bone is more or less in one main
piece, it should be gently rocked free and manipulated upward and forward up the inclined plane formed by the frontal bone and body of the sphenoid. Usually, however, there is an associated low-level fracture, and this segment moves independently of the main fragment. The tooth-bearing fragment is brought upward and forward until the occlusion is judged to be normal. At this stage, the opening between the upper and lower incisor teeth is about the width of three of the operator's fingers. When the tooth-bearing portion is adequately reduced, this fragment is immobilised and then the associated naso-ethmoidal section is reduced and fixed.

Rowe and Killey state that it is often necessary to spread the malar bones laterally to allow the central pyramidal section to come forward. Obliteration of the deformity of the infraorbital margin is important, but is often difficult to accomplish due to oedema. If correctly reduced, the fragments are fixed by impaction of the pyramidal section between the lateral segments.

**Le Fort Type III Fractures**

According to Killey (1965), these severe injuries usually comprise Le Fort I, II and III fractures associated with bilateral zygomatic complex and nasal fractures.

He states that disimpaction should be carried out in the following order:

(a) the zygomatic bones are elevated for it is impossible to disimpact the central Le Fort II portion with the zygomatic bones depressed. Sometimes this
elevation of the zygomatic bone can be effected from the buccal sulcus or it may be necessary to carry out its elevation via the Gillies approach; 

(b) next, the tooth-bearing portion of the upper jaw is reduced by grasping it between two pairs of Walsham's or Rowe's forceps, and manipulating it upwards and forwards until the normal occlusion and adequate mandibular opening is achieved. When the tooth-bearing portion is in a satisfactory position, fixation is carried out;

(c) the naso-ethmoidal section is then repositioned and finally the zygomatic complex and nasal complex sections are immobilised.

If it is necessary to pack a maxillary sinus, this is carried out after all other treatment is completed, and no further manipulation of the facial skeleton should be carried out with an antral pack in position. If the antrum is packed and then the middle third of the face is manipulated, the antral pack will be forced against the orbital floor and damage to the orbital contents may lead to loss of vision.

Rowe and Killey (1955) state that transverse fractures generally cause deformity of the orbit, often opening the sutures formed by the malar bone, especially the fronto-malar suture. The individual bones should be carefully disimpacted and moulded into place.
Reduction by Traction

Traction methods are well covered by Thoma (1963); Rowe and Killey (1955) only treat traction with regard to delayed reduction of fractures.

According to Thoma, traction may be applied between the upper and lower jaws, or externally by means of elastics attached to rods projecting from a headcap. This method is indicated in all cases where reduction has been delayed or in which muscular trismus (of the pterygoid muscles) prevents effective manipulation.

Intermaxillary traction may be used in transverse maxillary fractures with displacement to bring the teeth into occlusion. It can be accomplished in 24 to 48 hours, after which one of the various methods of fixation should be applied.

External facial traction may be used when intermaxillary traction is not sufficient; generally intermaxillary traction should be only used if the fragment is fairly mobile so that very little force is needed to accomplish reduction.

External traction is indicated in delayed reduction of maxillary fractures with displacement. It is especially useful in middle third fractures where the bony facial structures are pushed back or impacted under the projecting edge of the frontal bone. Since facial bones cannot be manipulated until the fractured cribiform plate from which the CSF leaks has been repaired, reduction by traction must be used. The direction of pull required is down and forward to disimpact the facial bones and gradually bring them into their anatomic relationship.
Thoma (1963) uses what he calls "bird cage traction", which is applied via bars connected to a headcap.

Neuner (1959) advocates the use of an intermaxillary extension to reduce horizontal fractures of the maxilla. He does this by using an anterior extension on the mandibular acrylic plate type of splint. Elastic traction is then applied from this extension to the maxillary splint to draw it into normal occlusion. He states the advantages of this method to be:

1. simplicity of construction and application of the appliance;
2. the patient can freely move his mandible, which permits unhindered mastication and oral hygiene;
3. elimination of the use of extraoral appliances. Although in some cases a chin-cap may have to be used to reposition a downwardly displaced maxilla.

This method does not appeal to me, unless the mandible is immobilised to a headcap; otherwise there will be no precise control over the direction and degree of traction applied to the maxilla from a free moving mandible.

Weight Traction

This type of traction as applied to maxillary fractures is described by Spilka (1950). It is applied by means of a Balkan frame, and the cord is attached to a splint connected to the teeth in the upper arch. Initially a half pound weight is used which is gradually increased to a total of five pounds on the
fourth day. This is generally adequate to bring the upper jaw into occlusion with the lower teeth.

External Traction in Edentulous Jaws

A method suggested by Stevenson (per Thoma - 1963) consists of passing a wire through the palate and out the nose, with protection to the tissues provided by a rubber catheter; direct traction can be applied to the wire.
OPEN REDUCTION OF MIDDLE THIRD FRACTURES

Rowe and Killey (1955) state that only as a last resort in impacted fractures should an incision be made in the buccal sulcus so that tissues may be reflected from around the zygomatic buttress and tuberosity, to expose the fracture site.

According to Thoma (1963), surgical procedures are indicated in late and old fractures in which traction is ineffective because partial or complete union has taken place. The following abnormalities may occur: malocclusion which prevents proper mastication; diplopia caused by distortion of the orbit, or impingement on nerves such as the motor nerves of the eye, or the optic nerve, causing blindness; comminution and displacement of the walls of the maxillary sinus, with or without a haematoma in the antrum; comminuted and displaced fractures in which tissue or foreign bodies have been interposed, in which a haematoma is to be evacuated, or which require internal wiring fixation.

Horizontal maxillary fractures: open reduction may be used in cases of displacement where traction is ineffective because of impaction or advanced healing. It may also be used in cases in which the walls of the antrum are comminuted and displaced and in cases where malocclusion results.

Transverse facial fractures: open reduction may be used in comminuted maxillary fractures when the malar bones are grossly displaced, when the wall of the antrum is depressed, or if the floor of the orbit, the infra-orbital margin, and the lateral
wall of the orbit are disarranged. Open reduction may be necessary on one side or both.

In most cases when the antrum is opened, a Caldwell-Luc procedure should be carried out. Where the floor of the orbit has been comminuted and the orbital contents displaced downwards, great care must be taken to replace the fragments accurately and elevate the orbit so as to correct the diplopia resulting from the herniation of the orbital contents into the antrum. Fixation may be effected by the use of an iodoform gauze pack or the antral balloon technique.

In cases where there is comminution of the margin of the orbit, the antral support alone may be inadequate, and it may be necessary to restore the orbit by means of internal wiring fixation.

Other aspects of open reduction are discussed in the section of immobilisation within the tissues.

**Immobilisation of Le Fort Type I, II and III Fractures**

Killey (1965) states that the fixation of a mobile fracture of the middle third presents a difficult problem as there is no suitable adjacent structure to which it can be immobilised. He classifies the methods of fixation into two main groups: extra-oral immobilisation; and immobilisation within the tissues.

These methods are sub-grouped as follows:

1. **extra-oral immobilisation**

   (a) suspension from a plaster-or-Paris headcap -

      i. cranio-maxillary;
ii. cranio-mandibular.

(b) indirect skeletal fixation -
   i. zygomatico-mandibular;
   ii. fronto-mandibular.

2. immobilisation within the tissues

(a) fixation by -
   i. transosseous wiring at fracture sites -
      a. zygomatico-frontal;
      b. zygomatico-maxillary;
      c. comminuted zygomatic bone;
      d. midline of palate.
   ii. transfixation with Kirschner wire -
      a. zygomatico-maxillary;
      b. zygomatico-septal.

(b) suspension by wires -
   i. circumzygomatic;
   ii. zygomatico-mandibular;
   iii. inferior orbital border-mandibular;
   iv. fronto-mandibular;
   v. pyriform fossa-mandibular;
   vi. nasal septum.

(c) support -
   i. antral packs;
   ii. antral balloons.

Rowe and Killey (1955) discuss several further techniques:
treatment with intra-oral fixation alone - this principle can only be used for alveolar fractures or fractures of one maxilla.

**External Skeletal Fixation**

This method of fixation consists of an intra-oral splint connected to a framework embedded in a plaster-of-Paris headcap by trans-buccal cheek wires attached to the premolar area; or more often by an anterior vertical rod which is fixed to a detachable projecting bar in the incisor region of the splint.

According to Rowe and Killey (1955), the general principles of reduction and fixation are:

1. immobilisation of the zygomatic bones if these are fractured and interfering with disimpaction of the dento-alveolar component to its correct position, and its fixation to a plaster-of-Paris headcap;

2. restoration of the dento-alveolar component to its correct position and its fixation to a plaster-of-Paris headcap;

3. definitive reduction of the zygomatic bones and support of the orbital floor by an antral pack if indicated;

4. reduction and localisation of any associated mandibular fractures;

5. the suture of any intra-oral or external lacerations;

6. reduction and fixation of any fractures involving the naso-ethmoidal and naso-maxillary regions;

7. removal of the pharyngeal pack;
Fig. 448. Woodard appliance with wings attached to arch wire splint.
8. application of the mandible/maxilla fixation. This may have to be deferred until the patient has recovered from the anaesthetic or if there is any obstruction to the nasal airway.

Crawford (1948) discussed several types of headcaps for use in middle third injuries. Some of these were modifications of the standard plaster-of-Paris headcap; others were various designs of preformed headcaps.

Subsequently various types of preformed headcaps were mentioned by Thoma (1963), and there are several types mentioned in the magazine literature. Charest (1962) suggests that improvement in treatment may be obtained from this type of appliance; he lists the following advantages:

1. it can be adequately installed in a matter of minutes;
2. it affords regular and considerable traction of all the facial bones in every direction;
3. it permits rigid and constant immobilisation;
4. it can be used even when there are fractures of the skull or lacerations of the scalp;
5. it does not cause pressure necrosis, as does the plaster-of-Paris headcap, when it is too tight;
6. it is easier to tolerate and lighter in weight than plaster;
7. it will not move like plaster in the case of bedfast patients;
8. it can be used for cervical traction if necessary;
9. osteomyelitis of the skull has never resulted from the use of this appliance;
10. the appliance has never become loose or been removed by the patient himself.

Panuska and Dedolph (1965) describe the use of a "halo head frame", in several cases and point out the advantages it has over plaster-of-Paris headcaps as did Charest. It would seem from the many reports of preformed headcap devices, that these could become the treatment of choice in preference to plaster-of-Paris headcaps.

Bonnette and Garcia-Oller (1957) suggest the use of skull tongs for cranio-maxillary fixation; this device is an alternative to conventional headcaps for neurological reasons: they may interfere with subsequent trephining for head injuries, or with the treatment of associated spinal injuries that require skeletal traction; extensive loss of cranial bones or severe comminution occasionally will render the use of suspension wires undesirable if not impossible; external pin fixation appliances of the Roger-Anderson type may prove unsuccessful or undesirable. The tongs are applied via holes drilled in the outer plate of compact bone of the skull. A special drill point with a collar prevents penetration of the inner table of the skull.

They state as advantages of these tongs:
1. it is easy to utilise in an emergency procedure and can be applied in a few minutes;
2. it is easily adjusted; yet it is a permanent type of fixation and will remain in place for several weeks;

3. it permits adequate access for neuro-surgical intervention as required in frontal, temporal, occipital, suboccipital and cervical regions;

4. it is suitable for use where there has been extensive loss of the frontal or temporal bones;

5. it may be used concurrently for skeletal traction in cervical vertebral injuries, with added comfort for the patient and convenience to those charged with his care. Sometimes cervical fractures are not recognised until days after injury. The use of this appliance for both the skeletal traction and maxillofacial fixation would simplify the management of both injuries.

The use of headcaps and other methods of external fixation are considered unnecessary by Zaydon and Brown (1964). Their objections to these appliances are: they are complex, and expensive and may require repeated adjustments to be effective; they are seldom well tolerated, and should not be used in children, alcoholics or the mentally deficient; any apparatus applied to the skull may be detrimental if intracranial surgery is necessary. The methods these authors use are: intermaxillary wire fixation; eyelet wiring; internal pin fixation; archbar or Risdon wiring; open surgery with direct wiring or use of a wire sling; antral and nasal packs; external nasal splints.
While their objections involve factors which should be considered and which may sometimes contraindicate the use of headcaps, this does not justify a policy of never using them. The reason for the necessity for headcaps is that many middle third fractures could not be immobilised against the movements of the mandible in any other way.

Killey (1965) states that while no plaster-of-Paris headcap is absolutely stable, in practice an efficiently applied headcap provides an adequate fixed point to which the upper jaw can be immobilised.

According to Rowe and Killey (1955), modification of external skeletal fixation is required in different cases:

**Bilateral fractures of the maxilla without midline separation**

1. with teeth sufficient to establish the occlusion present in both jaws — an intra-oral splint is attached to the maxilla and immobilised to a headcap; the jaws are brought into their correct occlusion, and when the cranio-maxillary immobilisation has been applied, the mandible is immobilised to the maxilla;

2. where the upper jaw is edentulous and there are teeth present in the mandible — some degree of latitude in the accuracy of the final position is permissible, but any degree of displacement will interfere with the correct repositioning of the associated bones and will detract from the stability and efficiency of any denture. Therefore it is necessary to prevent displace-
ment by the movements of mastication and deglutition and sleeping pressure on the face.

A Gunning splint is immobilised to a headcap and masticatory trauma prevented by immobilising the lower jaw to the maxillary splint by eyelet wires or cap splint;

3. where there are teeth present in the upper jaw and the mandible is edentulous - the maxilla is immobilised to a headcap as before. No mandibular splint is required;

4. where both the upper and lower jaws are edentulous - an acrylic splint is immobilised to the maxilla to a headcap. Wire loops are processed into the base in the premolar region for the attachment of cheek wires. No mandibular immobilisation is necessary unless there is co-existent fracture of the mandible:

Bilateral fracture of the maxilla with midline separation -

1. with teeth present in each maxilla - separate models of each segment are articulated with the model of the mandibular teeth. The maxillary splints are connected in this position for immobilisation to a headcap. Where difficulty in reduction is anticipated, localisation of the maxillary fragments is effected in the theatre;

2. with teeth present in one maxilla - the other being edentulous - immobilisation by cranio-mandibular fixation. The edentulous maxillary fragment is connected
to the maxilla by interosseous wire through the alveolus or the palatal processes;

3. with both maxillae edentulous — if displacement is minimal, the upper denture may be modified into a Gunning type splint. Otherwise, separate splints must be made. If displacement is slight, a Gunning type splint in one piece may be immobilised to a headcap. When a more severe degree of displacement is present, re-inforcement of fixation by insertion of one or more interosseous wires is advisable.

**Cheek Wires**

The use of traction wires through the cheeks from a suitable cranial base is becoming more popular. Allen (1957) advocates its use for horizontal fractures of the maxilla. Killey (1965) states that transbuccal cheek wires are most helpful for elevating the tuberosity region of the tooth bearing fragment during reduction, and, together with the anterior connecting rod, they provide a stable three-point fixation from the headcap.

According to Rowe and Killey (1955), the use of cheek wires is contraindicated in those cases where the wires tend to elevate and displace the fragments laterally. Wires may be used with a Gunning type splint; if used with a cap splint the splint should be re-inforced with a bar. The use of wires varies with the mobility and displacement of the fragments.

Associated fractures of the maxillary arch must be restored before attempting to reconstruct the mandibular arch. Modifica-
tions of technique should be in accordance with the choice of fixation in the mandible. Pin fixation of the lower jaw may be indicated, in which case the bars may be connected to the head-cap.

The upward movement of the mandible in bilateral fracture of the condyles causes gagging of the molar teeth, as does fracture of the maxilla with posterior and downward displacement of the bone. When these fractures co-exist, the result is an accentuation of the anterior open bite common to both conditions. If perfect reduction is not possible after disimpaction, the pull of the elastic traction cheek wires, plus the elastic traction in the incisor region will simultaneously distract the fractured ends of the mandible and exert upward pressure on the tuberosities of the maxilla, with almost complete restoration of occlusion which is subsequently improved by the forces of mastication following release of the fixation.

**Indirect Skeletal Fixation**

Killey (1956) describes zygomatico-mandibular fixation by the insertion of one extra-oral pin into the mandible and zygomatic bone on each side and connecting them with rods and universal joints.

The same effect can be achieved by transfixing the mandible and the zygomatic bones with Kirschner wires or Steinmann pins and connecting the upper and lower pins or wires with bars and universal joints.

Fron-to-mandibular fixation is achieved by inserting pins
into the mandible and connecting them by bars and universal joints to pins inserted in the frontal bone. In both of these methods the fractured middle third is sandwiched between the two stable parts of the facial skeleton.

Thoma (1963) describes the use of the Steinmann pin — this is used when cranio-mandibular fixation is desired. It consists of a pin passed through the symphysis of the mandible and connected to a headcap.

The Steinmann pin may also be used with cranio-maxillary fixation; the pin is passed through the face in a transverse direction in such a manner that it extends over the reflection of the mucosa and passes through the maxillary sinus. A stab incision is made in the skin, and the Steinmann pin is inserted with a hand drill. Care must be taken that the skin is not caught by the wire and lacerated. To prevent this a pin guide may be used. The ends of the pins projecting from the cheek are attached to rods extending from the headcap by means of connecting rods and universal joints. The use of this method is recommended for very complicated cases only.

**Treatment of Maxillary Fractures by Immobilisation Within the Tissues**

**Transosseous Wiring**

Transosseous wiring of the zygomatic bone will be discussed in the section on zygomatic complex fractures. This method may be used for the approximation of the palatal process of the maxillae, or the union of fragments whose line of fracture does not
conform to the orthodox pattern. It may also be of use in combination with extra-skeletal cranio-maxillary or cranio-mandibular fixation.

Transfixation with Kirschner Wires

Killey (1965) states that transfixation of a Kirschner wire through the zygomatic bones produces quite a rigid fixation. This technique can either be a single wire which transfixes the maxillae and the nasal septum; or two wires one from either zygomatic bone which pass through the nasal septum from opposite sides. At the completion of treatment the wire can be removed under local anaesthesia. These wires pass through the maxillary sinuses and the nasal passages, and as infection may occur, antibiotic cover is necessary. This technique is technically difficult, especially if one or both zygomatic bones are unstable, and great care is necessary to avoid damage to the eyes.

Cranio-maxillary or Cranio-mandibular Internal Skeletal Fixation

According to Rowe and Killey (1955), in this type of fixation, intraoral splints are attached to the tooth or alveolus and connected by the use of wires passed through the tissues to some stable point in the facial skeleton situated above the fracture line. The ends of the wires may be secured to the maxillary or mandibular splint, thus providing cranio-maxillary or cranio-mandibular fixation. Wire traction on eyelet wiring should be exerted on the mandibular teeth as traction on the upper teeth invites the risk of the wires being pulled towards the apex of the tooth.
Ricker (1962) advocates this type of immobilisation. He says that these methods offer patients comfort and reduced morbidity. The removal of any of the fixation wires does not present too much difficulty. Often the wires can be cut close to the border of the soft tissue and pulled through.

Rowe and Killey state that internal skeletal fixation is not universally applicable as the maxillae are not rigidly supported but only slung, and adequate lateral or anterior traction cannot be exerted by these means. It is of value in those cases where laboratory facilities are not available.

This principle of internal fixation as described by Adams (1942) has many advantages over external skeletal fixation, as there is no cumbersome apparatus and the technique has a special application when dealing with cases of severe scalp laceration and depressed fractures of the skull preclude the use of plaster-of-Paris headcaps. It is also useful for those patients who cannot be trusted to not interfere with external apparatus.

The suspension wires are generally connected to circumferential wires in the lower canine region, in which case the fractured middle third is sandwiched between the mandible and the base of the skull. The wires are passed through the tissues with the aid of long curved needles, awls, or cannulas. The suspension may be:

(a) circumzygomatic - the wires are passed over the zygomatic arch. Edwards (1965) describes a modified technique for the placement of circum-zygomatic wires,
which has the advantage of reducing contamination from the oral cavity;

(b) *zygomatico-mandibular* - the wire is passed through a small hole drilled in the body of the zygomatic bone;

(c) inferior orbital border-mandibular wiring;

(d) *fronto-mandibular* - by passing wires through a hole in the zygomatic process of the frontal bone;

(e) *pyriform fossa mandibular* - this is only of value in treating Le Fort I fractures;

(f) *nasal fossa-mandibular* - this is not as stable as the other forms of suspension.

Killey (1965) states that none of these suspension techniques produces an absolutely rigid fixation and some antero-posterior movements of the fragments are possible, but these are controlled by combining the suspension with mandibular-maxillary fixation by eyelet wiring or arch bars.

Sometimes it may be necessary to carry out transosseous wiring at the zygomatico-frontal and zygomatico-maxillary fracture lines before a relatively fixed portion of the facial skeleton is available for immobilisation by suspension.

The development of treatment by immobilisation within the tissues by the use of wires and pins has been made possible by the use of antibiotics without which many of these wires, passing through infected cavities such as the nose, mouth and antrums would cause complications through infection.
Treatment with Intra-oral Fixation Alone

This type of treatment can only be used for alveolar fractures or fractures of one maxilla.

In most cases it is possible to mould the alveolus and teeth into position under local or general anaesthesia. An impression is then taken and a splint constructed to immobilise the arch as a unit. Occasionally it may be necessary to construct sectional splints, connected by bars and locking plates if the treatment has been delayed and the fragments resist digital or instrumental reduction.

Methods of fixation which may be used are: interdental eyelet wiring plus the use of an arch bar in the upper jaw; cap splints with locking plates and a connecting bar; acrylic base plates secured by peralveolar wires to the upper jaw; interosseous wires either alone or in combination with splints.

According to Rowe and Killey (1955), treatment must be modified for the following circumstances:

1. **with teeth in both maxillae** - fracture of a maxilla may occur as an isolated entity at any of the levels at which bilateral fracture takes place or be associated with a fracture of the zygomatic bone on the same side. In the first case the fracture is mostly a low-level or Guerin type of injury, the displacement being mostly medial. Very often the incisors are left intact and the main block including the canine tooth is displaced inwards. In this case, the maxillary fracture is a continuation of the zygomatic frac-
ture. Clinically the upper molar teeth will be displaced downwards so that gagging of the tuberosity will be evident.

Treatment is immobilisation of the mandible and maxilla by interdental eyelet wiring or cap splints. Mandibular immobilisation is necessary as the forces of mastication would be too great for the upper splint to bear. An associated fracture of the zygomatic bone should be elevated before the maxillary fracture is treated. If packing of the antrum is necessary it must be deferred until immobilisation of the maxilla has been carried out;

2. **with teeth on the unfractured maxilla and without teeth on the displaced maxilla** - the edentulous fragments should be moulded into correct position digitally or instrumentally, any associated tears of the buccal or palatal mucosa sutured and no further treatment is necessary if the fracture does not tend to displace;

3. **without teeth on the unfractured maxilla and the displaced maxilla with teeth** - splints should be fitted to the teeth in both jaws and after the fracture has been reduced they should be immobilised by locking plates and a connecting bar. These are then immobilised to a headcap;
4. both maxillae edentulous - similar procedure as for 2. Occasionally there is a tendency for relapse of the fracture, especially when the displacement was lateral - this may be controlled by trans-osseous wiring through the alveolar or palatine bones.
FRACTURES OF THE ZYGOMATIC BONE AND ARCH

The region of the zygomatic bone and arch is referred to by most authors as the "zygomatic complex". Some authors (Knight and North - 1961) prefer to use the term "malar fractures", when referring to fractures of the zygomatic complex.

The classification of malar fractures used by Rowe and Killey (1955) agrees basically with that of Cohen (1958), and is as follows:

1. fracture of the zygomatic arch;
2. fracture of the zygomatic bone without significant displacement;
3. fracture with posterior displacement without antral involvement;
4. fracture with minimal degree of impaction into the underlying antrum;
5. severe impaction into the antrum with associated comminution of the orbital floor and/or interference with movement of the coronoid process;
6. fracture involving the outer two-thirds of the inferior orbital margin only without displacement of the main body of the bone;
7. stellate fractures with or without depression into the antrum;
8. a considerable drop associated with pronounced separation of the zygomatico-frontal suture;
9. associated fracture of the coronoid process or condyle;
10. associated unilateral fracture of the maxilla on the same side;

11. associated fracture of the maxilla on the same side;

12. associated fracture of the frontal or temporal bone.

Knight and North (1961) carried out a survey on 120 cases of fracture of the zygomatic complex, and have devised a system of classification which can be directly related to treatment, as follows:

1. no significant displacement (6% of zygomatic fractures) - no treatment required;

2. zygomatic arch fractures - this group consists of 10% of zygomatic fractures. Fracture is caused by a direct blow over the zygomatic arch; the arch is buckled inward without involving the walls of the antrum or the orbit. This buckling results in a typical angular deformity with three fracture lines and two fragments. Most patients had trismus but no diplopia;

3. unrotated body fractures (33%) - this was the largest group and the injuries were generally caused by a direct blow over the prominence of the body of the zygoma with fracture and displacement of the bone directly into the antrum. The bone is usually driven directly backward, inward, and slightly downward, resulting in flattening of the cheek with a palpable step deformity at the infra-orbital margin. On radiographic examination, the displacement appeared to be downward at the
infra-orbital margin and inward at the zygomatic prominence with slight displacement at the zygomatico-frontal suture;

4. medially rotated body fractures (11%) — the fracture and displacement appear to be caused by a blow on the prominence of the zygoma above its horizontal axis; thus the fractured bone was displaced backward, inward, and downward. The bones seemed to be rotated counterclockwise on the left when viewed from the front, and clockwise or toward the midline on the right. X-ray examination in the Water's position showed downward displacement at the infra-orbital margin and displacement either outward at the zygomatic prominence (subtype A) or inward at the zygomatico-frontal suture (subtype B). These variations provide the two subdivisions;

5. laterally rotated body fractures (22%) — fractures in this group appeared to be caused by blows below the horizontal axis of the bone, the bone being driven inward and backward. The bones seemed to be rotated clockwise on the left when viewed from the front and counterclockwise or away from the midline on the right. X-ray examination showed displacement inward at the zygomatic prominence and either upward at the infra-orbital margin (subtype A) or outward at the zygomatico-frontal suture (subtype B);
6. complex fractures (18%) - involved here are all cases in which there were additional fracture lines across the main fragment; minor degrees of comminution at the main fracture sites were disregarded.
DIAGNOSIS OF FRACTURES OF THE ZYGOMATIC COMPLEX

According to Rowe and Killey (1955), within two or three hours of injury, the underlying skeletal deformity will be masked by gross oedema. Immediately following injury or when the acute phase of oedema has subsided, there is an alteration of contour of the affected side. This is a flattening of the upper part of the cheek and an exaggeration of the fullness on the lower part due to downward displacement of bone and attached tissues and muscles. Epistaxis is usually present from the antrum. Circumorbital ecchymosis will develop after a few hours.

Clarke (1963) states that every individual who sustains a "black eye" should be suspected of having a fracture of the zygoma until proved otherwise.

According to Rowe and Killey, palpation will rarely show any mobility of the bones as they are mostly impacted. The finger should be passed around the orbital rim to find any step defects.

Intra-orally there is ecchymosis of the buccal sulcus and there is often anaesthesia due to interference with the posterior and middle superior alveolar nerves. Palpation in the sulcus will reveal a step defect in the region of the zygomatic buttress or comminution of the lateral wall of the maxilla. Limitation of the jaw opening due to impingement of the coronoid process is often present.

When fracture of the zygomatic arch occurs by itself, there will be no orbital signs, anaesthesia, epistaxis, or associated
intra-oral signs. All that may be observed is a depression or swelling over the affected region. Restriction of mandibular movement may be present, the patient being unable to open or close the mouth.

Killey (1965) lists the signs and symptoms of zygomatic fractures as follows:

**Symptoms**

1. flattening of cheek;
2. swelling and bruising around the eye;
3. blood-shot eye;
4. double vision;
5. squint;
6. one eye too far back;
7. one eye lower than the other;
8. tenderness over the cheek;
9. anaesthesia of the cheek and gums;
10. lump on the lower orbital rim;
11. difficulty in either opening or closing the mouth;
12. inability to move the jaw towards the injured side;
13. gagging of the back teeth on the injured side;

**Signs**

1. circumorbital ecchymosis;
2. subconjunctival ecchymosis;
3. oedema of cheek;
4. flattening in region of zygoma on injured side;
5. limitation of ocular movements;
6. diplopia;
7. strabismus;
8. enophthalmos;
9. limitation of lateral excursion of mandible to injured side;
10. limitation of opening or closing or mandible;
11. unilateral epistaxis on injured side.

**On Palpation**

1. tenderness over cheek bone;
2. notch in lower rim of orbit in the region of the zygomatico-maxillary suture;
3. anaesthesia of the cheek.

**On Inspection Intra-orally**

1. ecchymosis in upper buccal sulcus in region of zygomatic buttress;
2. possible gagging of occlusion in molar area on injured side.

**On Palpation**

1. tenderness in upper buccal sulcus in region of zygomatic buttress;
2. anaesthesia of upper gum.

Dingman and Natvig (1964) state that for radiographic examination, Water's position gives the best view for evaluating these fractures. These may also be used stereoscopically.
FRACTURES OF THE ORBITAL FLOOR

An increasing number of what have been termed "blow-out fractures" have been reported in the literature of recent years. According to Zaydon and Brown (1964), a sudden increase of intra-orbital pressure from blunt trauma to the orbital soft tissues may cause a "blow-out fracture" of the thin orbital floor. If this occurs, the orbital fat and fractured orbital floor are displaced inferiorly into the antrum. A blow-out fracture can either be a complication of a zygomatic fracture or it may occur independently of this fracture, with the orbital rim remaining intact. Any patient with a zygomatic fracture must be examined closely for eye injury.

Dingman and Natvig (1964) suggest a more precise classification of fractures of the orbital floor - "the term blow-out fracture, widely used today for a fracture of the orbital floor which is displaced downward into the maxillary sinus, and conversely the blow-in fracture in the orbital floor in which the orbital floor is displaced upward into the orbit, do seem equivocal; the terms "depressed" and "elevated" would be more precise terms for fractures of the orbital floor".

They state that the detection and diagnosis of depressed fractures of the orbital floor may be difficult to discover because of the presence of orbital and peri-orbital oedema, haematoma, and haemato-antrum. Radiographically they may be masked. Diagnosis may be made either by planograms, which show fragments of bone or of soft tissue herniated into the maxillary
sinus through the orbital floor, or by inspection of the orbital floor upon open exploration. The orbital floor may be inspected from the orbit, or from the maxillary sinus through an opening in the canine fossa.

Anderson (1964) stresses that early diagnosis and treatment of blow-out fractures can facilitate a favourable prognosis. He indicates diagnosis from the following points:

1. diplopia occurs on upward gaze;
2. enophthalmos caused by prolapse of the orbital contents through the defect;
3. anaesthesia or paraesthesia of the distribution of the infra-orbital nerve is usually present;
4. where injury has produced bleeding, the antrum on Water's view will be cloudy.

Killey (1965) states that x-rays will show no fracture of the orbital rim, but there may be cloudiness of the antrum and ethmoids on the affected side. Clinically there may be laceration and abrasion of the lids with ecchymosis and oedema. Subconjunctival haemorrhage occurs and diplopia. Blood in the antrum may give rise to a unilateral epistaxis. Later, orbital fat, which has herniated into the antrum, degenerates and this leads to enophthalmos. There may be limitation of ocular movements, particularly in an upward direction, brought about by incarceration of the inferior rectus and inferior oblique muscles into the fracture line where they become fibrosed.
Treatment of Depressed Fractures of the Orbital Floor

According to Bingman and Natvig (1964), the fractured segments may be replaced and supported by antral packing. If there is severe tearing of the periosteum, with displacement of the fragments and orbital contents into the maxillary sinus, packing may not give sufficient support to ensure healing of the bones in their proper relation. In such cases a thin layer of autogenous iliac bone or cartilage, preserved homologous cartilage, plastic material, or collagen may be placed on the orbital floor for reconstruction. The grafts give adequate support and provide an excellent method of reconstruction. Antral packing may be used to support the graft. Traumatic enophthalmos associated with shortening of the fascia, vessels, muscles and nerves and with atrophy of the orbital fat is impossible to correct completely.

Killey (1965) agrees with this treatment, and states that the grafts may be used as an early or late treatment.

There have been several reports of reconstruction of the orbital floor and rim with tantalum plates or mesh. Prowler (1965) describes this method and the results of nine cases: "tantalum mesh and tantalum cable may be used to reconstruct the orbit when blowout fracture of the orbital floor is combined with severe comminution of the rim. The greater the degree of comminution of rim and floor, the greater the indication for the reconstructive approach. After the tantalum has been implanted and the orbital contents repositioned, the bone seems to bury
the tantalum. Even when a large hiatus has been spanned, bone encases the prosthesis. The cable and mesh are not discernable clinically."

He states that this operation has several advantages over other approaches, including:

1. greater precision in establishing proper level of the globe;
2. obviation of secondary procedures for re-establishment of the globe;
3. simplicity.

Gerry and Giotta (1957) describe the use of tantalum plate in the reconstruction of orbitomalar and microgenic deformities. They state that "properly contoured tantalum plate implants may be inserted safely in sites which are free from infection, provided the implant fits the bony surface over its entire periphery, is properly fastened to the underlying bone, is covered by an adequate flap of healthy soft tissue, and is suitably perforated.

**Elevated Fractures of the Orbital Floor**

Dingman and Natvig (1964) report on such a case, which I failed to see mentioned elsewhere in any dental literature. Their case report stated that x-ray examination showed no fracture of the infra-orbital rim, but a clear upward bulging of the orbital floor was revealed. The authors treated this by surgically depressing the fragments. No fixation was needed and healing was uneventful.
TREATMENT OF FRACTURES OF THE ZYGOMATIC COMPLEX

Most authors classify the treatment of zygomatic fractures into that of recent or old fractures. Rowe and Killey (1955) state that treatment will depend on whether the patient is seen within ten days of injury or after three weeks when union has occurred. If union has occurred, refracture will be necessary.

Killey (1965) says that fractures of the zygomatic complex require reduction for the following reasons:

1. if the patient has diplopia;
2. when there is limitation of mandibular movement;
3. in order to restore the normal skeletal protection for the globe of the eye;
4. the last, and least important, reason for operating upon these fractures is the cosmetic result.

He states further that zygomatic fractures with minimal displacement which are not causing symptoms do not require treatment. Sometimes a more severely displaced zygomatic bone is left if the patient is elderly and a poor operative risk. Cases with diplopia always require operation, but old zygomatic bone or arch fractures which have become united and are causing limitation of mandibular movements can be treated by coronoidectomy.

REDUCTION

As with other types of fractures, there are those who strongly favour open reduction and those who favour conservative treatment of zygomatic fractures. According to Cohen (1958), each has its merits. Killey (1965), the most authoritative of all the authors,
Fig. 436. Gillies' method of reducing fracture of zygomatic arch.
only describes open techniques.

Closed Reduction

Thoma (1963) suggests reducing these fractures by gripping the zygomatic bone with the forefinger and thumb, and manipulating the bone into position. Kazanjian (1933) advised the use of double-hooked forceps to grip the fragment at the infra-orbital ridge through the skin and manipulating it into position.

In a case of recent injury, stability of the repositioned parts is assured by the interdigitation of the fragments of the fracture site, but where the refracture is carried out, this locking effect does not exist and collapse tends to occur due to the pull of the contracted fibrous tissue.

Closed reduction of fractures of the zygomatic arch may be effected similarly by the use of towel forceps inserted through the skin at the site of the depression where the fracture occurred.

Open Reduction

Fracture of the zygomatic arch may be reduced by leverage applied by an elevator which is inserted via a temporal or an intra-oral approach. Thoma (1963) says that the intra-oral approach appears simpler to most oral surgeons; however, the temporal approach, known as the Gillies approach, is recommended by most of the British authors, including Killey (1965). The temporal approach does seem to interfere with more anatomical structures without much advantage over the oral approach; probably the only advantages of the temporal approach would be less risk of infection; and better leverage.
According to Rowe and Killey (1955), where there is comminution of the orbital floor, the fracture may be treated by elevation of the zygomatic bone through a temporal approach, and packing of the antrum through an incision in the buccal sulcus. No antral pack should be used unless the maxilla is stable; is there is a maxillary fracture, the maxilla will be packed down by the gauze, resulting in too much sub-orbital pressure when the maxilla is reduced. Clark (1963) states that this approach should be reserved for fracture and comminution of the orbital floor, as the difficulties and drawbacks of the technique seldom give a good result. Cohen (1958) suggests the use of an incision around the necks of the teeth, or in the edentulous case, on the crest of the ridge, instead of in the buccal sulcus - where there is loss of bone, proper closure is otherwise difficult and permanent openings of this type are difficult to close.

Types of Antral Packs

Gauze Packs

Killey (1965) suggests the use of an incision in the buccal sulcus. There is usually a hole into the maxillary sinus due to the fracture. The zygomatic bone is repositioned from this approach and fragments of bone gently repositioned with the finger. The antrum is then packed with \( \frac{1}{2} \)" ribbon gauze soaked with acriflavine or Whitehead's varnish in order to hold the zygomatic bone in position. An acriflavine pack tends to become infected after a couple of weeks but is easy to remove when the treatment is completed. The Whitehead's varnish pack will remain
uninfected for several weeks. It is very stable, and, contrary to general belief, no difficulty should be experienced in removing it at the completion of treatment. The wound in the sulcus generally closes without the necessity for further surgery. Great care must be taken in packing the antrum not to displace any bony spicules of the orbital floor against the optic nerve and ophthalmic artery. For this reason the pack should be directed chiefly to the outer aspect of the antrum beneath the zygomatic bone.

A pack should be left in position for ten days, and although on removal it usually smells foul, infection is unlikely to supervene. The antrum may be irrigated with saline for five to seven days and then the incision left to heal by itself.

**Balloon Type Packs**

Gutman et al (1965) prefer the balloon type of pack to the gauze pack. The gauze pack is painful on removal and it has the tendency to tear whenever caught by a bony edge. The constant elastic pressure exerted by the balloon, especially in patients where treatment has been delayed, makes it an ideal appliance. It also allows for correction by removal or addition of fluid post-operatively. Gutman et al recommend the use of fluid instead of air for filling the cuff as it gives better control for correction.

According to Thoma (1963), the antral balloon inserted by the Shea–Anthony technique gives excellent results. In this technique the balloon is introduced through a nasal antrostomy.
Jaraback (1959) claims good results using the Foley catheter, inserting it so that the tube exits through the mouth, instead of through the nose as with the Shea-Anthony technique.

Gutman et al (1965) vary the technique used by Jaraback by inserting the Foley catheter via a Caldwell-Luc approach and passing the catheter stem through an opening in the medial nasal wall. This technique allows proper irrigation of the antrum, and the immediate closure of the incision prevents the formation of an oro-antral fistula.
FIXATION OF ZYGOMATIC FRACTURES

Following reduction, the fragments may be stable owing to interdigitation of the fractured bone ends, or additional fixation may be required. Instability of the fragments commonly occurs when there has been delay in treatment - the fractured ends of the bone tend to become rounded off by osteoclastic activity and after the zygomatic bone has been elevated into place it falls back into its original position.

According to Killey (1965), control of the unstable zygomatic bone may be achieved by:

1. transosseous wiring at the zygomatico-frontal fracture line;
2. transosseous wiring at the zygomatico-maxillary fracture line;
3. combination of these two methods;
4. fixation with a pack in the maxillary sinus;
5. pin fixation from the zygomatic bone to a plaster-of-Paris headcap - this technique is especially useful in the zygomatic bone which is excessively mobile following reduction;
6. direct wiring of the fragments of comminuted fracture of the zygomatic bone.

Where there is gross separation of the zygomatico-frontal suture, interposition of muscle and debris and delay in treatment may prevent direct apposition of the bone ends following simple elevation by the temporal approach. Rowe and Killey (1955) sug-
gest in this case that an incision should be made in one of the wrinkles over the fracture site adjacent to the outer canthus. To avoid damage to the facial nerve branch a careful blunt dissection is made down to the underlying bones. The two fragments are united by passing SS wire through a hole drilled in each.

Where fracture of the zygomatic bone is associated with a coronoid fracture, no treatment is necessary except to note that union may occur between this bone and the zygomatic bone. Therefore elevation should be prompt and active movement of the mandible should be encouraged.

Brown et al (1952) made a valuable contribution to the treatment of facial fractures by their introduction of the SS pin method of fixation. After reduction, SS pins are driven through the skin and the fractured zygomatic bone segments in a transverse direction and then into the solid parts of the maxilla and zygoma on the opposite side. The pins are cut off at skin level and are retained for four to six weeks. This is an expedient and effective method only in the hands of experienced surgeons. Complications such as osteomyelitis, malunion, non-union and facial deformity have been seen following attempts by inexperienced surgeons to use this method of treatment.
FRATURES OF THE NASAL REGION, FRONTAL SINUS AND PARANASAL AIR-
SINUSES

An understanding of these fractures is essential in the
treatment of maxillo-facial injuries. However, as this is in
the province of the plastic surgeon, I will not treat this sec-
ton in great detail.

Nasal fractures are discussed in detail by Zaydon and Brown
(1964), and Dingman and Natvig (1964). Both of these texts con-
tain many excellent photographs and illustrations to demonstrate
these fractures and their treatment.

Rowe and Killey (1955) classify nasal fractures as follows:

The framework of the nasal region is composed of bone and
cartilage together with a small amount of fibro-adipose tissue.
Displacement of the parts is dependent upon the degree, direction
and velocity of the impact, and the shape and mass of the agent
responsible for the injury. The great majority of nasal frac-
tures involve the frontal processes of the maxillae and may
extend to the lachrymal and ethmoid bones.

The direction of the force inflicting a fracture of the
nasal bones may be considered as lateral or anterior and the
resultant fracture is classified accordingly –

1. lateral injuries – the direction of the force detaches
   the frontal process of the maxilla and the nasal bone
to the opposite side. The septal cartilage is buckled
into an S-shaped position;

2. anterior injuries – the frontal processes of the maxilla
   are fractured and splayed outwards, whilst the nasal
bridge is flattened and the nasal bone is driven backwards, into the nasal cavity. Varying degrees of comminution occur and frequently the fracture is compounded.

Zaydon and Brown (1964) classify nasal fractures into depressed fractures - due to frontal trauma; and laterally displaced fractures - due to trauma from the side.

**Signs and Symptoms of Nasal Fractures**

Killey (1965) treats these as follows:

Skeletal displacement will be masked by the overlying oedema, in the recent injury. There will be bilateral circumorbital ecchymosis, more marked on the medial aspect. Subconjunctival ecchymosis is mainly confined to the medial half of the eyes. There is invariably epistaxis in both nostrils in the recent injury, and when the blood has clotted, there may be a discharge of serum. If the cribriform plate of the ethmoid bone has been comminuted, there may be a CSF leak.

On palpation the underlying nasal bones may be felt to be mobile and comminuted. Often sharp step-defects in the nasal skeleton are felt. The area is acutely painful on palpation.

According to Dingman and Natvig (1964), clinical evaluation is the most important factor in diagnosis of nasal fractures. Roentgenographic examination may be helpful but often shows nothing in the usual views. Fractures may be demonstrated well by using a dental x-ray film held at the side of the nose and
parallel to the sagittal plane, with exposure of the film from the side. The bony septum may be shown well by the Water's or reverse Water's projections.

**Treatment of Nasal Fractures**

Dingman and Natvig (1964) state that general anaesthesia is necessary for children; for the adult patient, the use of intranasal topical anaesthesia in conjunction with the injection of local anaesthetic solutions containing adrenalin gives an excellent result. Killey (1965) prefers general anaesthesia for all cases in order to give control over haemorrhage.

According to Killey, the fragments may be manipulated using Walsham's and Asche forceps. When the fracture is not very severe it is sometimes unnecessary to splint the nose following reduction. Usually, however, some sort of splint fixation is advisable. The most common splint is of plaster-of-Paris, consisting of eight layers of plaster-of-Paris bandage cut so as to produce a strip of plaster across the bridge and covering either side of the nose, with an extension up to and along the forehead.

If the nasal fracture is too mobile to be efficiently splinted with plaster-of-Paris, a lead plate splint either side of the nose is used. Two lead plates, each with an upper and lower hole through the centre, are fitted either side of the nose with a cotton-wool roll beneath the plates to prevent chafing the skin. They are held in position by a mattress suture of tantalum wire which is passed through the holes in the lead plates, the wires transfixing the tissues and passing beneath the nasal bones.
This splint is left in situ for about three weeks.

Kazanjian and Converse (1959) prefer to use a short general anaesthesia such as nitrous oxide-ether or Pentothal sodium. They reduce depressed fractures by means of a periosteal elevator covered with a layer of cotton to minimise trauma. Walsham's forceps are of use in straightening the lateral bony walls. One arm of the forceps is covered with rubber tubing to avoid injury to the skin. They state than an external splint is necessary to maintain the corrected position of the displaced nasal bones; the nasal arch tends to revert to the displaced position if a splint is not used because of the spring-like leverage of the septum, especially when reduction has been delayed for a few days. This splint is made from a suitably adapted soft metal tray which is used to hold a small quantity of compound against the nose. Intranasal packing may be necessary to maintain the fragments in their correct position. With comminuted fractures a combination of external compound splint and intranasal packing is necessary.

Rowe and Killey (1955) state that fixation may often be unnecessary - an important factor in stability is the accurate replacement of the septal cartilage in the vomerine and maxillary grooves.
FRACTURES OF THE FRONTAL BONE

Fractures of the frontal sinus are relatively rare; they may be classified as involving the sinus only, or involving the anterior cranial fossa. The treatment adopted by Kazanjian and Converse (1959) is to prevent infection by adequate drainage and to restore the cosmetic defect.

Dingman and Natvig (1964) treat comminuted depressed fractures of the frontal sinus by using bone hooks or elevators through the open wound to reduce the fragments. If the fragments are not in good position, direct interosseous wiring may be necessary.

Once reduced, these fractures do not tend to have recurrent displacement because there is no musculature to force the reduced fragments out of position. With extensive comminution and lack of support for the fragments, the frontal sinus may be packed with rubber drains and the ends left protruding from the wound into the nasal cavity or through an anterior ethmoid opening.

Small et al (1957) reports that repair of fracture of the external angular process of the frontal bone is essential, as it is an ideal site for suspension of a severely depressed zygomatic fracture. Such a fracture may be corrected by open reduction at the zygomatico-frontal suture line with an inconspicuous supercilial incision, coupled if necessary with elevation of the arch and infraorbital rim.
FRACTURE OF THE STYLOID Process

Armao (1960) reports a case of fracture of the styloid process following removal of a lower third molar tooth. He treated this fracture by immobilisation with interdental wiring.

The only case of styloid process fracture which I have treated was satisfactory after immobilisation for 4 weeks. This fracture was associated with extensive middle third and mandibular fractures. Immobilisation was carried out in treating these fractures and the styloid process did not complicate the picture.
PROCEDURE IN MIDDLE THIRD FRACTURES WHERE TREATMENT HAS BEEN DELAYED

According to Rowe and Killey (1955), the maximum length of time before which disimpaction and reduction can no longer be effected along orthodox lines varies widely in relation to the severity of the injury; the degree of displacement of the dento-alveolar component and other bones; and the amount of bone loss which may have occurred.

Fractures involving the nasal bones, frontal processes of the maxilla and the zygomatic bones will have consolidated at the end of three weeks; but the dento-alveolar component, unless impacted, will still exhibit some degree of mobility.

The methods of treatment used by Rowe and Killey are:

1. attempted reduction by orthodox means — this implies the application of a greater degree of controlled force than usual. It is usually successful with the frontal processes of the maxilla, nasal bones and zygomatic bones up to two weeks after injury, and may be applied to the lower tooth-bearing component for as long as three weeks after injury.

2. slow traction by a weight attached to a cord suspension from a Balkan beam — this will mainly be exerted upon the tooth-bearing component owing to the greater rapidity with which union occurs in the upper portion and the fact that the traction is directly applied to the upper splint. The position may be considerably influenced by this means up to as long as six weeks after injury.
Elastic traction cheek wires - following disimpaction and attempted reduction of a maxillary fracture, it may be found that residual gagging of the occlusion in the molar region still exists. In such cases, elastic traction cheek wires may be used to apply continuous post-operative traction.

Post-zygomatic traction cheek wires - if it is desired to apply traction in the tuberosity region, a cheek wire may be passed through the zygomatic arch to the tuberosity region.

3. elastic traction from a framework attached to a headcap - the Balkan beam method is rather cumbersome and does not permit fine adjustment.

Where firm union has occurred, any attempt at correcting the displacement by traction will be unsuccessful and resort will have to be made to the following:

i. extraction of the teeth and/or alveolecctomy - where gagging on the molar region is present, occlusal grinding may be insufficient and extraction of some or all the teeth in the molar region may be necessary in severe cases followed by alveolecctomy.

ii. surgical refracture of the maxilla -
   (a) when union is not complete;
   (b) when union is complete - maxillary osteotomy will be required.

For the forceful manipulation of old fractures, Caldwell (1961) suggests the use of a modified type of Lane bone-holding forceps. These forceps have the lower arm in the shape of a "U"
with a knob on the end. The upper arm has the serrations removed.

Burch et al (1958) recommend Balkan beam traction to reposition malunited maxillary fragments. He claims that this method of treatment has been successful in some cases up to 75 days after injury. When malposition of the maxilla has been untreated for 21 or more days, it is expedient to mobilise the maxilla partially by forceful manipulation under general anaesthesia one or two days prior to the application of elastic traction.

**Zygomatic Complex Fractures**

Killey (1965) states that some two weeks are allowed to elapse before reducing a fractured zygomatic bone, the fracture will probably be unstable because the fractured ends will no longer interdigitate efficiently. This is due to osteoclastic activity rounding off the bony spicules and transosseous wiring or pinning will therefore be required. After about a month, it will be found almost impossible to elevate a fractured zygomatic bone in the conventional manner. If the fracture is causing diplopia or limitation of mandibular movement, refracture will be necessary. If there is merely a cosmetic deformity, an onlay graft of bone or cartilage will suffice. If interference with mandibular movement is the main symptom. A coronoidectomy on the affected side may be preferable to the more extensive surgery required to refracture and reposition the zygomatic bone.
MIDDLE THIRD FRACTURES IN CHILDREN

Killey (1965) does not mention any specific treatment or differentiate for middle third fractures in children. Rowe and Killey (1955) offer the best coverage of this subject.

Injuries exhibiting the typical Le Fort lines of fracture are seldom seen in children. Such injuries are usually fractures of the nasal bones and/or frontal processes of the maxilla and occasionally in the older child the zygomatic bone may be fractured. This is for several reasons: the facial bones of the child are relatively smaller than the adult's; the presence of cartilaginous growth centres in the cranial base and the high degree of elasticity of the bone in the child allow a considerable amount of distortion of the facial framework to occur before fracture takes place.

Treatment

In every case where there is considerable displacement, the fracture must be reduced; this must be carried out as soon as possible for fractures in this region unite very rapidly at this age.

If the deciduous teeth have not yet erupted or are insufficient, the minimal fixation or no fixation at all will be required in most cases for growth and remodelling of the bone will obliterate any slight residual deformity.

In the case of the older child with permanent teeth present, immobilisation of the fractures should be effected in a similar manner to that employed in the adult. Apparatus must be kept as
simple as possible as children have a tendency to interfere with it. If a fracture is compounded externally, it is best dealt with by transosseous wiring providing the wound is not infected. Care should be taken at all stages to avoid damage to the growth centres of the jaws and to prevent injury to the developing teeth.

REFERENCES


(6) H. C. Killey - "Fractures of the Middle Third of the Facial
Skeleton". Wright, Bristol, 1965.


January 1965, page 5.


POST-OPERATIVE CARE
POST-OPERATIVE CARE

Post-operative care is divided into three sections by Rowe and Killey (1955): immediate— including post-anaesthetic procedure; intermediate— covering hospitalisation; and late— which includes treatment upon discharge from hospital, and post-immobilisation treatment. This classification of post-operative care is directly related to phases of treatment and as it allows logical discussion, I will use it here.

Immediate Postoperative Phase

After general anaesthesia the throat pack is removed in the normal way. The naso-pharyngeal tube must be left in position until the cough reflex has returned or there is a danger of breathing vomitus or blood. If there is any risk of this happening the patient should be turned into the left lateral position, with the head lowered. There is no risk that vomited material will be unable to pass freely out of the mouth as a consequence of the jaws being immobilised, as there is always adequate space in the retro-molar fossa for the passage of semi-fluid material.

According to Killey (1965), a suction apparatus, oxygen, tracheostomy set, wire cutters and screw drivers should be available at the patient's bedside in case an emergency should occur which necessitates the removal of the appliances.

No analgesics or hypnotics are given in the immediate post-operative phase, and morphine is especially contra-indicated as it depresses the cough reflex. If the patient is cerebrally irritated or restless, 3–8 ml. of paraldehyde should be given
intramuscularly.

Care must be taken with external apparatus such as pins, to avoid displacement; therefore the patient must be in a supine position.

Doneker and Hiatt (1966) describe a buccal airway device to assist in the immediate postoperative ventilation of fracture patients. A problem in patients with wire fixation of the jaws, ventilation is improved by insertion of a buccal airway device made of acrylic resin. By forming a tunnel in the cheeks, this device allows the exchange of air through the spaces between and around the teeth. They state this device is never to be used in place of an indicated tracheostomy. It is left in place until the patient has a clear nasal airway. It has been worn for as long as three days with no untoward sequelae. It is indicated in patients whose nasal air passages are compromised by mechanical, physical or disease processes.

Intermediate Postoperative Phase

Temperature rise should be checked. This may be due to respiration or oral infection.

Respiratory infection

The most common cause of respiratory infection is the plugging of a bronchus or bronchiole by inspissated mucus or blood clot, leading to absorption collapse of the lung tissue distal to the point of impaction. The inhalation of clot, tartar or other debris during the immediate post-traumatic stage of uncon-
Sciousness may result in a subsequent lung abscess.

Clinically the temperature may rise to between 100 and 105 degrees F during the first 48 hours following operation. This may be accompanied by rise in pulse and respiratory rate.

Treatment is by chemotherapy or antibiotics, which should be given in any case of fracture; the careful tracheo-bronchial toilet after removal of the throat pack; and the early institution of physiotherapy in the form of breathing exercises.

**Oral infection**

This may occur at any time, but not usually before the third or fifth day unless the treatment has been delayed, and gross infection is present prior to operative interference. Infection may be localised in the soft tissues if an open wound is present; in the fracture haematoma associated with teeth in the line of fracture; by sequestrum formation or the presence of a foreign body. Swelling persisting beyond the fourteenth post-operative day should be regarded with suspicion, and calls for investigation.

**Control of oral infection**

Prophylactic - the development of infection may be largely prevented by careful irrigation after meal, as the apparatus used for immobilisation tends to encourage stagnation of food debris.

Antibiotic therapy and chemo-therapy is covered in the section on treatment planning, page 49.
Control of Pain

This is covered in the treatment planning section, page 27.

Oral Hygiene

Killey (1965) states that in the early stages, irrigation of the mouth should be carried out after every meal, using a Higginson's syringe and warm 2% sodium bicarbonate solution. Later the patient can clean the mouth and splints with a soft toothbrush.

Diet and Methods of Feeding

According to Nizel (1961), the prime functions of adequate nutrition are to speed convalescence, to promote wound healing, and to increase the patient's resistance.

Geddes (1963) says that an initial loss of weight of as much as half a stone may be inevitable after a jaw injury until a satisfactory feeding regime is established, after which loss of weight should not occur.

As mastication is impossible, liquid and semi-liquid meals must be given. According to Rowe and Killey (1955), even in a full complement of teeth there is never any need to extract anterior teeth to allow a passage for food as there is always sufficient space behind the last molar tooth.

They mention as methods of feeding; a feeding cup with rubber tubing attached; the glass drinking straw; spoon feeding. Thoma (1963) also mentions the use of the tea-pot; catheter, Breck feeder - syringe type method, and the possible need
for rectal or intravenous feeding.

Rowe and Killey (1955) warn that due to loss of roughage in the diet, disturbances of normal bowel rhythm may occur, necessitating the use of purgatives.

The report of the Nutrition Committee of the B.M.A. (1950) (per Geddes) recommends that the convalescent male engaged in only light work, should have 2,200 calories per day for the average 70 kgm. body weight, and for females, 1,800 calories.

Rowe and Killey (1955) state that five pints of fluid are required per day for the average adult patient. As the amount of liquid capable of being ingested per meal is limited, the number of meals per day may have to be increased to five or six. A considerable variety of food is available if an electric mixer or liquidiser is used. If a variety of foods is selected, no vitamin or mineral supplement will be necessary. The main part of a fluid diet is milk, which may be combined with egg, glucose, etc. Specimen diets accompany the texts mentioned above.

Smith (1965) presents a method of feeding patients immobilised by intermaxillary fixation consisting of a liquid food diet that contained all the essential vitamins and minerals in addition to protein, carbohydrate, and fat.

The Later Post-operative Phase

Early ambulation is to be encouraged to reduce the risk of pulmonary and vascular complications. The patient should be given duties such as irrigation and feeding to give an added interest.

Discharge from the hospital depends upon the type of fixa-
tion employed, the severity of the injury and its present state, and the age and mental ability of the patient. If closed reduction has been used and the patient is apyrexial and able to feed and irrigate himself, he may be discharged after three to five days. When open reduction or osseous wiring has been performed it is advisable to wait 14 days to ensure that no sepsis develops.

Where pins have been inserted into the mandible it is desirable to retain the patient in hospital for the full period of treatment, as the risk of sepsis developing around the pins is considerable.

As a general rule, clinical union in uncomplicated cases of mandibular fracture may be expected within four weeks in the case of children, six weeks in the average adult, and eight weeks in the elderly patient.

Neuner (1959) and Lapidot (1962) both recommend the use of early mobilisation of the mandible or functional treatment. Neuner claims that the function of the fractured jaw is a strong inducement to the formation of callus, which shortens healing time. With this method hygiene and nutrition are far less complicated.

Occlusal Adjustments

Archer (1966) states that no fracture of the jaw is treated in any manner without some alteration of occlusal relationship. Therefore, the case cannot be considered completed and the patient should not be discharged until an occlusal relationship study is made and equilibration of the occlusion accomplished.
REFERENCES


(2) H. C. Killey - "Fractures of the Middle Third of the Facial Skeleton". Wright, Bristol, 1965.


COMPLICATIONS
THE PATHOLOGY OF BONE HEALING

A knowledge of the pathology of bone healing is necessary for a proper understanding of the complications which may occur during this process. This subject is well covered by Rowe and Killey (1955), Church (1963) and Muir (1960).

The following account is taken from Muir's Text-book of Pathology (1960):

When bone undergoes a simple fracture, there is tearing of the soft tissues, and a variable amount of haemorrhage occurs between the broken ends. The periosteum is usually torn through and separated from the bone to a varying extent in the neighbourhood of the breach. When the bleeding has ceased and the blood clotted, the normal inflammatory changes take place; fluid exudation into the tissues; emigration of leucocytes; which soon pass off. The process of healing begins by proliferation of cells and a new formation of blood vessels. The cells are derived from the endosteum and the deep or cambium layer of the periosteum, as well as from the bone. All of these cells are osteogenic in nature, that is osteoblasts. The new blood vessels grow out from the pre-existing blood vessels and make their way into the clot, which gradually becomes replaced by a cellular and vascular tissue. Where it is in contact with the fracture a certain amount of resorption of bone occurs, as can be seen in radiographs.

In this newly formed tissue the young bone cells have branching processes from which delicate fibrils pass in all directions.
In the process of bone formation, the fibrils are seen to become enclosed in a somewhat homogeneous matrix, in which the young cells or osteoblasts also become embedded. This osteoid tissue is ossified by deposit of lime salts in it. This bone, which is somewhat spongy in nature, comes to enclose and unite the ends of the fractured bone, and is known as the provisional callus.

In clean fractures, where there is satisfactory apposition and the parts are kept well at rest, there is a minimal amount of callus formed; if there have been movements or when there has been splintering of the bone, callus in excess is likely to be produced.

The next stage is one of strengthening the union and adapting the configuration of the bone to the functional requirements. Parts of the callus are penetrated and absorbed by new blood vessels surrounded by osteoblasts, and these cells then lay down bone in the form of Haversian systems. This goes on until a more compact type of bone is produced, which forms the permanent union - this is known as the definitive callus. At the same time the external callus is resorbed so that the proper configuration of the bone is restored.

In the case of compound fractures, repair proceeds in a similar manner but the entrance of organisms may cause suppuration in places, which interfere with the formation of callus and may lead to the resorption of callus already formed. When there is exit for the pus the healing takes place very much as in a granulating wound; there is an advancing line of ordinary granulation tissue behind which bone formation goes on, and ultimately
any spaces occupied by pus may be obliterated and the process of bone formation may be completed. When a portion of dead bone is present it becomes a nidus for organismal growth, and pus forms around it, and suppuration may, in this way, be kept up for an indefinite period of time, the pus being discharged from the sinus which leads down to the dead bone.

Richman and Laskin (1964) investigated the healing of experimentally produced fractures in the zygomatico-maxillary complex of 36 dogs. For purposes of comparison, a mobile fragment was produced in half of the animals and an immobile fragment in the other half. The animals were killed at intervals of 1 to 12 weeks, and histologic sections were prepared.

On the basis of the histologic evidence, it was shown that fractures of the zygomatico-maxillary complex in dogs heal by a combination of mature fibrous tissue and bone. Although isolated islands of cartilage were seen occasionally, this tissue did not play an active part in the healing process. Mobility of the parts retarded the rate and altered the type of healing which occurred and was considered an unfavourable condition.
FACTORs THAT AFFECT THE RATE OF REPAIR OF FRACTURES

McKelvey (1962) divides these factors into those of a local nature, and those that affect the general body physiology.

Local Factors

He states that long oblique or diagonal fractures where the medullary area is widely opened have a better potential for healing because of the large vascular area exposed and the greater medullary surface available for callus formation. Where broad fracture surfaces can be properly re-approximated and fixed, healing is likely to be expedited. On the other hand, if the bony plates are thin and difficult or impossible to re-approximate properly, then bony healing may never take place and the fracture site may heal by fibrous bridging. This type of healing takes place many times in the fractured thin plates of the facial bones such as the fractured walls of the maxillary antrum or nasal walls. In such instances where function is restored and deformity minimal, with a firm fibrous union, the result is usually satisfactory from a practical standpoint. Where there is a gap between fragments because of muscle pull, incomplete reduction, or loss of bone substance, then a delay in repair may be expected or true bony union may never take place.

Infection is one of the most important factors in the delay of healing which may lead to malunion or a nonunion. The infectious process produces a hyperaemia and consequently decalcification. This decalcification process continues as long as the hyperaemia is present. The hyperaemia may be expected to continue
for an indefinite period, even after the infection is controlled.

Sequestrums of devitalized bone must be removed when separation is evident. Delay in active treatment at this point will prolong the period of hyperaemia with continued bone reduction.

Teeth in the line of fracture are potential sources of infection. They should be retained initially only if they are essential in the reduction and fixation of the attached fragments. At any time during the healing process when evidence of devitalisation is present, these teeth should be removed. Today, with the better methods of fixation and the wider satisfactory usage of interosseous wiring, it has become increasingly less desirable to retain teeth in the line of fracture that may become devitalized before the time that bone healing is anticipated. Not infrequently clinical and roentgenographic evidence of healing is delayed for a considerable period in instances in which teeth closely approximate the line of fracture but have not given definite signs of devitalisation. On careful re-examination the tooth or teeth are found to be untenable. Then on extraction of the tooth, the fracture rapidly progresses to sound clinical healing. By such examples, it is evident that all teeth approximating fracture sites must be kept under constant surveillance during the course of fracture healing. Delay in expected healing, widening of the periodontal membrane about these teeth, excessive mobility, tenderness on percussion, gingival inflammation, or similar signs or symptoms may indicate the need for immediate extraction.
Adequate immobilisation ranks next in importance as a prominent factor in the healing of fractures. Failure in immobilisation permits shearing, crushing and tearing forces that injure the young granulation tissue and prevent its normal proliferation in the early stages of repair. This trauma increases, prolongs or re-establishes a period of hyperaemia, which in turn results in further decalcification of the injured bone ends. If this sort of traumatism continues indefinitely, fibrous tissue is laid down parallel to the fractured surfaces and the continuity between the fractured fragments is lost. Eventually a stage of ischemic fibrosis occurs which leads to recalcification. However, this recalcification is not in the bridging callus mass but occurs on the fractured surfaces of these parts. When such sclerosis has become established, nonunion has occurred. This is not a reversible process; consequently, surgical intervention must be resorted to in order to remove these sclerotic plaques and again open the way to proper bone healing.

**General Physiological Factors**

According to McKelvey (1962), age is an influential factor in the healing of fractures. It is well known that bone healing progresses at a more active rate in the child than in the teen-age youth and faster in the youth than in the older adult. Factors which cause this are the higher metabolic activity of the younger person as a whole, more rapid cellular proliferation, better assimilation and better vascular supply.
Generalised disease or debility certainly affects the progress of healing. Examples of such conditions are malnutrition, senile osteoporosis, anemias, and diabetes. Active therapy, wherever possible, must be instituted immediately for treatment of the systemic diseases that may be present in order to improve the physiological function required for proper bone healing. Debilitating diseases or concurrent injuries increase the possibilities for a prolonged healing period or possibly even failure.
DIFFERENTIATION OF DELAYED UNION AND NONUNION

According to McKelvey (1962), some fractures heal more slowly than others simply due to individual variation in healing time. As an example an uncomplicated fracture of the mandible may be expected to show clinical union within a five week period of immobilisation. When the traction is removed and the site is checked clinically, movement may still be elicited by manipulation. An x-ray of the area may show no undue separation of the fragments, no cavitation of the fractured surfaces, no decalcification or sclerosis of the parts. This fracture should be considered a slowly uniting one, and the surgeon should immediately return it to a status of immobilisation.

If a fracture has the same clinical mobility as just mentioned in the preceding paragraph, but the roentgenographic examination shows cavitation and increased decalcification of the bone ends, the surgeon should consider this a delayed union and not one that is merely slowed because of individual variation. Infection or inadequate mobilisation, both of which cause a persistent hyperaemia, are the conditions that usually predispose to delayed union or nonunion. Consequently, the mode of treatment is to combat actively any infectious process, remove any bony sequestration, and provide absolute immobilisation. If these recommendations are carried out, the progress of healing, though delayed, should continue to the point of complete and satisfactory healing.

Nonunion is established when the gap between the bony frag-
ments becomes filled with dense fibrous tissue. This dense fibrous tissue is relatively avascular, and so rounding off the bone ends occurs with the formation of a false joint characterised by sclerotic bone plaques forming over the former fracture surfaces. Suitable roentgenograms will illustrate this point. Clinically there is limited movement of the parts, or more springiness, on manipulation. No amount of continued immobilisation will allow this condition of nonunion to go on to a satisfactory calcified union. The site must be entered surgically, the fibrous tissue and sclerotic bone plates removed as far as bleeding bone, and the ends accurately re-approximated to themselves or to an intervening bone graft to supply continuity.

The term malunion merely signifies that bony continuity has been restored and the healing is complete, but that this union has taken place with a resulting deformity. This deformity may be sufficiently significant functionally as to modify such functions seriously or there may be minimal clinical evidence of a loss of normal contour and aesthetics. The x-rays of the site reveal the severity of the defect. A certain amount of correction may occur naturally because of the long-term process of reconformation of bone. This reconformation may occur if normal function can be restored and the musculature and ligamentous anchorages have been re-attached properly.
COMPLICATIONS ARISING IN THE TREATMENT OF MANDIBULAR FRACTURES

According to Rowe and Killey (1955), no loosening of the teeth occurs, nor is there any subsequent gingivitis when interdental wiring, arch wiring or splints have been correctly applied. For this reason it is necessary to examine all teeth for caries and periodontal disease, before treatment. Excessive strain on a tooth during reduction of a fracture by elastic traction may have to be reduced or its direction altered. Care must be exercised in the removal of splints from bulbous teeth as the danger of displacement of the teeth is great.

Provided that the bone ends are accurately apposed, the fragments adequately immobilised and infection prevented, the fracture will readily unite. When some deviation from the normal course of healing occurs, this may be considered in relation to delayed union, malunion or nonunion.

Rowe and Killey (1955) state that fractures in the region of the ascending ramus and the TMJ may also be complicated by: pseudarthrosis; ankylosis of either a fibrous or bony nature.

They state that the aetiology of these complications may be due to local or general conditions as follows:

Local Conditions

a. infection - this is inevitable to some extent in fractures compound into the mouth. Liability to infection is increased by the stagnation of debris in the mouth. For this reason, 500,000 units of penicillin should be given twice daily for five days.
The continued retention of a tooth involved in the fracture line may cause infection of pulp death and subsequent gangrene. Also the presence of foreign bodies in the fracture line such as a displaced tooth root; a fragment of cortical bone deprived of periosteum; a fragment of copper cement; etc.

If antibiotic therapy does not abort the condition, extra-oral drainage must be instituted as soon as fluctuation has become established. If a sequestrum or foreign body is judged to be the causative agent it must be removed.

b. inadequate immobilisation - this results in a disturbance of the normal process of osteogenesis at the fracture site. The shearing effect of the osteogenic tissue which may lead to fibrous or non-union. Another disadvantage of this movement is the pumping action at the fracture site which tends to conduct infective debris into the bone.

c. imperfect reduction - leads to disturbance of the occlusion. Some degree of discrepancy may be accepted in the edentulous patient, and minor discrepancies in the occlusion may be compensated by occlusal grinding.

d. excessive separation of the bone ends - as a general rule a gap of more than $\frac{1}{2}$" will not unite readily without the introduction of a bone graft. Radiological confirmation is provided by the appearance of sclerosed margins at the bone ends.

3. interposition of tissue or foreign substance - this will inhibit the normal course of callus formation, either by mechanical obstruction or ionic disintegration upsetting the
requisite pH of the fracture haematoma. In most cases, the foreign body is a tooth root which shows up on the radiograph, and can be removed during primary treatment of the fracture.

f. pathologic conditions of the bone – invasion of bone by neoplasms may delay or prevent healing.

Extensive infection with prolonged suppuration, such as occurs in osteomyelitis, leads to a suppression of osteogenic activity, but periosteal new-bone formation eventually takes place.

If the fracture occurs in an area of osteoradionecrosis, the vitality of the bone is so depressed that healing cannot take place; resection and replacement by a bone graft will probably have to be carried out.

Pseudarthrosis is deliberately encouraged in the case of fracture dislocations of the condylar region by the early institution of movement.

The development of fibrous or bony ankylosis, is not usually a complication of simple fractures of the condylar or coronoid process of the mandible. However, when associated with fracture of the zygomatic arch, the possibility must be envisaged.
MIDDLE THIRD COMPLICATIONS

These may be treated under the headings of cranial, orbital, nasal, antral and general complications.

Cranial Complications

According to Rowe and Killey (1955), these are met as a result of direct trauma to the cranium. Headaches and cerebral irritation of varying degrees occur but are usually of a transitory nature. In more severe cases post-traumatic headaches may persist for many months, and in some instances structural damage to the frontal lobes may result in personality changes of a permanent nature.

The dural tear commonly associated with fracture of the cribiform plate mostly heals spontaneously when proper reduction and immobilisation of the middle third of the facial skeleton has been carried out. Occasionally a CSF leak may persist, necessitating a repair of the dura mater by fascia lata, or in the untreated case, meningitis is liable to occur. CSF is treated in detail under diagnosis.

Rupture of the olfactory nerve may result in some permanent impairment of the sense of smell. Stretching of the third and sixth cranial nerves may give rise to ocular palsy which is usually temporary but on occasions may be permanent.

Other cranial complications are treated under the section of general examination of the patient, page 32.
Orbital Complications

Permanent displacement of the medial or lateral walls of the orbit will interfere with the attachment of the suspensory ligament of the eye with resultant diplopia; this may be caused by inadequate reduction and alignment of the orbital floor with prolapse of the peri-orbital fat. Involvement of the inferior oblique muscle in the fracture line may lead to scarring and adhesions with consequent interference in action. Minor degrees of diplopia may be compensated for by the patient, but a gross displacement of the orbital level will necessitate operative repositioning of the orbital floor by the subperiosteal insertion of a bone graft or some inert substance.

The third, fourth and sixth cranial nerves are often involved either in their intracranial or extra-cranial course but usually recover during the first few weeks following injury. The optic nerve is protected at its point of entrance into the orbit by a dense bony ring, and damage to the nerve is rare; the danger of forcing sharp fragments of bone against the optic nerve during insertion of an antral pack must be avoided.

Kazanjian and Converse (1959) discuss traumatic enophthalmos as a complication. This usually appears after the subsidence of oedema, haematoma and inflammation. This is difficult to correct because of atrophy and shortening of the intra-orbital structures.

Damage to the lachrimal duct may cause epiphora.
Nasal Complications

Adequate treatment should prevent nasal complications from arising, otherwise refracture may have to be carried out. The possibility of an infected septal haematoma must be borne in mind, during the immediate post-traumatic phase or this will lead to serious destruction of tissue and the production of a saddle-nosed deformity.

Antral Complications

Rupture of the mucosal lining of the antrum leads to the formation of a haematoma which may become infected subsequently but the administration of antibiotics renders this unlikely. Complications from the paranasal sinuses are rare.

General Middle Third Complications

Untreated cases of middle third fractures show a flattening of the features associated with an apparent increase in the interorbital width which is called "dish-face deformity". The vertical height of the middle third of the face is often increased with lengthening of the features, associated with limitation of the vertical excursion of the mandible as a result of the lowered position of the maxilla.

Van Sile and Samuels (1961) reported a case of postoperative parotitis, after maxillary fracture, which involved the facial nerve. They claim that this complication has increased in incidence over the last few years, primarily since the advent of antibiotics.
OTHER COMPLICATIONS

Beke et al (1965) describe a case of post-traumatic cervico-facial neuritis in a 32 year old patient who had suffered fracture of the mandible three years previously. He presented symptoms of pain on the left side of the face, deafness, and neck and oral pain over the previous six months. Surgical intervention removed what was found to be a fibrous union and bone impingement on the inferior alveolar nerve in the body of the mandible and re-immobilisation was carried out. This treatment completely cured the symptoms.

Thoma (1955) reports a case where condylectomy was necessary after malunion of the fragment had caused symptoms - numbness, crossbite, malfunction. Condylotomy completely cured the symptoms.

Morgan (1960) reports a similar case, where abnormal union of the condylar fragment caused deviation, loss of function, and gagged bite. The condyle was surgically cut away from the ramus and normal occlusion was attained within a month.

Tongue Grafted to Dental Pulp as a Complication

Roberts (1957) reported on a case where a lacerated tongue grafted itself to an exposed pulp. This occurred as a result of the splint wiring catching the tongue, and holding it in apposition to the exposed pulp.

Broken Circumosseous Wires

Occasionally, when removal of circumosseous wires is performed
incorrectly by the surgeon or ineptly by the patient, breakage is encountered. The result may be a wire knot, buried in the deep tissues, that is difficult to remove without extensive dissection.

Selman et al (1966) have devised a technique in which the free, unknotted portion of the wire is drawn through the reopened stab incision and threaded into the pointed end of a large-gauge, hubless spinal needle until it exits from the blunt end. Guided by the wire it contains, the needle is then rotated and pushed toward the knot. If the needle's lumen accommodates the entire knot, the wire and its attached knot may be drawn freely out of the blunt end. If the knot obstructs the lumen, it will be necessary to pass the needle further to the submucosa of the oral fornix and then make a simple incision to expose the needle and wire knot, both of which then may be passed through the incision and drawn out of the mouth.

**Soft Tissue Complications**

According to Rowe and Killey (1955), soft tissue complications may be due to trauma or infection. Occasionally pieces of foreign body may become embedded in the tissues, but careful exploration of the wound with a probe will usually reveal the presence of such fragments.

The late complications in connection with the soft tissues are primarily due to the formation of cicatricial tissue, or the development of chronic infection from a low-grade bacterial source which is frequently of a penicillin-resistant anaerobic strain
or in rarer cases, actinomycosis.

The scar tissue may be removed after six months. The infection may be treated by administration of terramycin or aureomycin but it may be necessary to institute external drainage.

Dental Complications

Interference with normal nervous sensation of the teeth varies with the severity of the injury, but vascularisation of the pulp is rarely impaired, and unless a severe degree of damage has been sustained by the periodontal ligament or gross suppuration supervened the useful life of the teeth does not appear to be affected.

Inadequate reduction will lead to malocclusion which is usually an anterior open bite, which may be difficult to treat other than by exodontia or maxillary osteotomy. Some improvement in position from modelling resorption of bone under the stress of mastication may be expected during the first three months after release of the fixation.

Persistent Anaesthesia

According to Dingman and Natvig (1964), persistent anaesthesia of the lower lip, the infraorbital or nasal areas, or areas of the forehead usually is transient, and complete recovery of sensation can be expected in a matter of 12 to 18 months. Such recovery depends upon the extent of damage to the nerve. The crushed nerve usually regenerates faster than the nerve that has been severed. If large sections of the maxilla or the mandible
have been avulsed completely together with parts of nerves, regeneration does occur from anastomosis with other nerve systems or fibres in the area.

If nerve regeneration fails, and is considered to be due to obstruction in the nerve pathway, exploration may discover the cause of the obstruction, and elimination of it may permit nerve regeneration.

**Interference with the Function of the Lacrimal Apparatus**

Kazanjian and Converse (1959) state that this may be due to fractures at the level of the lacrimal sac, due to backward displacement of the frontal process of the maxilla in fractures associated with comminuted fractures of the nasal bones. Treatment consists of establishing a new channel into the nose.

**Osteomyelitis**

Bosco (1960) describes a case of bone grafting from the iliac crest in a 46 year old woman to reconstruct bone loss due to osteomyelitis. Since the advent of antibiotics, osteomyelitis has become a rare complication of facial fracture treatment.

**Traumatic Bone Cyst**

Traumatic bone cysts or haemorrhagic cysts are usually cavities of doubtful origin. This case was discovered by Baird and Askew (1958) because of its involvement in a fracture site.

The cavity was exposed, the contents enucleated and healing occurred in six months.
Salivary Gland Infection

Traiger (1963) reports a case of infection of a minor salivary gland, following laceration. The swelling of the infection resulted in respiratory embarrassment. This was treated successfully by antibiotic therapy. It is possible for salivary gland infection to progress to such an extent that respiratory embarrassment may occur.

REFERENCES


(13) H. Bosco - "Reconstruction of Mandible Following Bone Loss Due to Osteomyelitis in the Line of Fracture". Oral Surgery, Oral Medicine, and Oral Pathology, Vol. 13, No. 6, June 1960, page 663.
