INFECTIVE COMPLICATIONS OF MANDIBLE FRACTURES

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OBSERVATIONS ON THE TREATMENT OF ACUTE INFECTIVE
COMPLICATIONS OF FRACTURES OF THE MANDIBLE.

PREFACE.

The importance of the fracture surgeon is now realised in medical surgery. Advances in this specialty have been as great as those in other branches of surgery - indeed in some aspects much greater.

A great variety of fractures can occur in the numerous bones which make up the skeleton of the body. A multiplicity of complications to soft parts, organs, etc., can occur. These facts emphasise the profound knowledge of their subject which is required by fracture surgeons and justifies their inability always to obtain results which leave nothing to be desired.

Since the War there has been a growing tendency amongst general surgeons to acknowledge that the oral surgeon has special qualifications and ability for treating fractures of the mandible and the maxilla. Many and varied methods of reduction and fixation have been devised, each with its special objectives and adherents. My observation of fractures of the mandible however, suggests a lack of literature dealing with the treatment of infective complications and their sequelae.

The complications and after treatment are so dependent upon, and influenced to such an extent by, the methods of reduction and fixation, that they cannot be discussed separately.
The object of my thesis is to deal with the complications of fractures of the mandible, more especially the acute infective complications, their recognition, treatment, and methods adopted in avoidance of them. In consequence it is intended only to discuss the other aspects of treatment with reference to their influence on complications, omitting considerations which are of a purely prosthetic nature.

I welcome this opportunity to express my profound gratitude to my friend and teacher Dr. A. J. Arnott, whose encouragement and guidance have influenced the pursuance of my studies in this and other directions, and to whom I am deeply indebted for affording me the opportunities for observance and treatment of cases.

The observations contained in this thesis are based on cases treated at the Dental Hospital of Sydney. The records are compiled from those of the Hospital, which were also kindly made available by the Superintendent, Dr. A. J. Arnott.
DESCRIPTION OF FRACTURES.

DEFINITION: A fracture may be defined as a sudden solution of continuity in a bone.

VARIETIES OF FRACTURE: Practically all varieties of fracture are met with in the mandible:—

- Compound fracture.
- Simple fracture.
- Comminuted fracture.
- Greenstick fracture.
- Impacted fracture.
- Transverse fracture.
- Oblique fracture.

Most fractures of the body of the mandible are compound, with the exception, perhaps, of edentulous cases with no displacement. Simple fractures usually occur in the ascending ramus and its processes.

Fractures may be single or multiple, unilateral or bilateral.

SITES OF FRACTURE:

(a) Body.
(b) Ascending ramus.
(c) Condyle (intra and extra - articular).
(d) Coronoid process.

In accordance with the architectural weaknesses of the mandible, fractures of the body of the mandible occur in four principal situations:—

1. Symphysis.
2. Mental foramin.
3. Between the mental foramin and the angle.
4. Angle of the mandible.
Fig. 2.

Radiogram - Lateral plate - showing Fracture of the Neck of the Condyle - N.B. Direction downward and backward.
CAUSES OF FRACTURE.

The causes of fractures of the mandible in keeping with those of other bones may be divided into (a) exciting (b) predisposing.

(a) Exciting causes may be:

1. Direct violence.
2. Indirect violence.

1. In this type of fracture the solution of continuity of bone occurs at the site of contact with the traumatizing agent, and is best seen in a gunshot wound, the force being great and concentrated results in a local shattering at the site; such cases are usually also associated with extensive soft tissue destruction.

2. In this type the fracture occurs at some point or points remote from the site of the original or causative trauma. This is the usual variety met with in civil practice, and it is with this type mainly that I propose to deal.

3. This type is associated with old age and general or local bone disease, the sudden muscular action resulting in fracture of the brittle or weakened bone.

(b) Predisposing causes: These are local conditions such as impacted teeth, unerupted teeth, cyst, osteomyelitis, sarcoma, and general bone conditions such as rickets and osteomalacia, in addition to architectural weaknesses of the bone.
Fig. 3.

Radiogram showing impacted third molar in site of fracture - such a tooth acts as a predisposing cause.
BASIC PRINCIPLES OF THE UNION OF BONE.

Before considering the general principles of treatment I shall outline the principles governing repair of bone.

Opinion seems to be divided into two opposing schools of thought. On the one hand we have those who advocate the principle of immobilization, and on the other those who suggest treatment based on slight mobility or mobilization and massage. In consequence the treatments show fundamental variation in principle. The slight mobility is considered to stimulate the repair and organization of the callus, prevent muscular atrophy and ankylosis of the joints, while the massage is intended to increase the blood supply to the part. The increased blood supply is undoubtedly beneficial since adequate blood circulation is one of the chief factors predisposing to repair of any tissue.

I am convinced, however, that immobilization is the ideal in treatment of fractures of the mandible, whatever be the concensus of opinion as to the efficacy of the method of treatment advocated by Lucas Champoniere¹, viz., massage and passive movements, in treatment of other bones.

It is contended that slight movement will stimulate repair of bone in the initial stages. This is purely empirical and there are many instances where it is indicated, although not conclusively proved, that the effect is disadvantageous.

I have known cases where the method of slight mobility, purposely or inadvertently instituted in the treatment, has

¹ Treatment of Fractures by Mobilization and Massage. - Mannell.
resulted in delayed union, necrosis, osteomyelitis and even non-union. Undoubtedly many fractures will unite when treated in this way, but in such cases there is good blood supply, and union occurs in spite of, rather than by virtue of the movement.

Bone repair is governed by much the same fundamental rules as soft tissue repair; the factors predisposing to repair being physiological rest, good blood supply, warmth, air and absence of infection.

That physiological rest is an important factor in the repair of soft tissues is usually admitted. We have every day examples of movement retarding healing in soft tissues, e.g., a crack on the lip, or an incised wound coinciding with a wrinkle of the palm of the hand. Indeed nature's guide in the form of pain on movement indicates a demand for rest on the part of the tissues. As collateral evidence of the effect of that extra degree of rest, I should like to cite the instance of the healing of an ordinary tooth socket as especially shown in the incisor region.

When a denture is placed over sockets immediately after extraction of the teeth, provided the sockets have been allowed to fill with a blood clot before contact with the saliva, sockets which would normally be expected to be troublesome, will frequently heal without breaking down of the blood clot, i.e., by primary intention. Such sockets would heal in any case with more or less trouble, but that extra degree of physiological rest prevents the continual breaking down of the forming granulation tissue. It is not unusual for this to occur even in previously chronically infected cases.
There is little evidence to suggest that this principle is not also applicable to bone conditions, while on the contrary it is my experience that there is much evidence that it does have beneficial effect, and I would like to emphasize that the means of fixation is only the best for a given case which will produce the maximum degree of immobilization obtainable in the circumstances prevailing in that case.

In support of this I recall cases where methods inadvertently allowing slight movement have resulted unsuccessfully, and that the same cases have proceeded satisfactorily when a method has been instituted to give the maximum immobilization. Again a case which proceeded to the stage of partial union only, remaining thus for an extended period, became firmly united in a short period, when a new splint was made to overcome the slight mobility resulting from alveolar absorption beneath an important part of the old splint.

The following case history and radiographic records (Figs. 4, 5 and 6) will serve to illustrate many of these contentions.

Brief account of the History and Treatment of case of Miss. E. aged 18 years.

History: This patient sustained a fracture of the body of the mandible in the second molar region. The second molar was removed and fixation, by a method allowing for slight mobility, was employed. Following three months of this treatment acute cellulitis developed necessitating removal to a general hospital. The patient was referred to Dr. Arnot, Superintendent of the Dental Hospital for treatment. Radiographic and clinical examination revealed extensive osteomyelitis and the presence of a large sequestrum. Extension of the necrosis had included the first molar in the seat of the fracture.

Treatment: Under general anaesthesia the first molar and sequestrum were removed; intra-oral drainage was incidentally established. Regular irrigation with warm normal saline solution was commenced. An inter-maxillary splint, designed to permit access to the intra-
oral communication, was applied on the following day. The after-treatment was religiously performed until the acute condition had subsided. Fixation was maintained and small sequestra removed from time to time. Fibrous union was found to have occurred at the end of three months. (Fig. 4 is a Radiogram of the condition taken at this stage and showing marked loss of bone between the fragments—unfortunately in printing the Radiograph was reversed)

The splint was worn for another six months and at the end of this period, the union was found to be still only fibrous.
A new interdental splint was fitted in order to overcome the slight mobility resulting from alveolar absorption in the region of the fracture, and to allow the adjacent structures to function. Five weeks later I could feel a definite improvement in the firmness of the union, and observed a marked reduction in the chronic inflammatory swelling of cheek muscles. With improvement of the latter condition the deformity was much less pronounced. (Fig. 5 is a Radiogram taken at this stage of the treatment)

The immobilization was maintained and at the end of a further period of six weeks, definite bony union was felt. (Fig. 6 is a Radiogram taken at this stage)

A short time later the splint loosened and came off, and at the patient's request splinting was discontinued. The final result was entirely satisfactory under the circumstances.

Repair of bone is brought about by organization and calcification of the callus formed at the site of fracture. The callus is derived from the bone marrow, from the broken off splinters, from the periosteum, from the muscles attached to the bone, and also from the haematoma. The better the blood supply the more rapid the bone formation.

This callus can be likened to the granulation tissue in the repair of soft parts. In consequence it is not surprising to see rapid union taking place in comminuted fractures, as there is an abundance of callus forming material. In fact, inflammatory conditions being equal, it is seen that a comminuted fracture can be expected to unite at least equally as well and as rapidly as a transverse fracture. The slightest movement will cause a breaking down of the granulation, and in consequence a resorption of the ends of the fragments resulting in a failure of bony union, and establishment of a locus minoris resistentia, predisposing to complications such as osteitis, osteomyelitis and necrosis.

Logically the only stage at which benefit from the advocated method of slight mobility to stimulate bone union
could be expected, would therefore be during the first
day (to promote the formation of a haematoma). Henceforth
it would tend to retard the union.

In a displaced fracture this stimulation will be
unavoidably brought about during reduction, and in a
fracture without displacement it will have occurred at the
time of injury, and will not have been disturbed.

Briefly, since union is brought about by organization
and calcification of the callus formed at the site of
fracture, it is only logical to expect that the optimum
conditions for bone regeneration in an infected fracture
would be :-

1. Immobilization of the fragments.
2. Unrestricted blood circulation.
3. Adequate drainage of inflammatory products.
4. Removal of causes contributing to infection.

In the absence of sepsis, union may be expected to take
place in from five to six weeks, if the patient is normally
healthy.
GENERAL PRINCIPLES OF TREATMENT.

Treatment may be described under the following general headings:

1. Diagnosis.
2. General treatment of the patient.
3. Treatment of extra-oral wounds, mouth conditions and site of fracture.
4. Reduction and fixation.
5. After treatment and treatment of acute infective complications.

DIAGNOSIS.

There are various conditions with which fracture may easily be confused when the patient is first examined, but it is well to keep in mind the possibility of a fracture when the patient presents an acute inflammatory condition of the mandible. The history of the case as elicited from the patient is often of paramount importance in leading us to a tentative diagnosis of fracture. On the other hand it must be borne in mind that very slight trauma has at times resulted in fracture.

The next important guide is examination of the symptoms. The usual symptoms of inflammation are mostly present, also trismus and in the case of displaced fractures disturbance of the occlusion. Crepitus is less frequently a diagnostic feature, but pain on movement of one part against another, should lead to a tentative diagnosis of fracture. The cardinal symptoms of crepitus, mobility, loss of function, and deformity are frequently absent.

X-ray examination is the final and most satisfactory diagnostic procedure. Having made a tentative diagnosis
of fracture of the mandible it is essential, owing to the frequency with which fractures, in addition to the one complained of, occur - a fracture of the body being complicated by a fracture of the ascending ramus or the condyle in a very high percentage of cases - to obtain sufficient exposures to show all parts of the mandible.

Should X-ray examination not reveal a fracture where one is suspected from clinical observations, X-rays from other angles should be taken before a negative diagnosis is made. (see Fig. 7)

Fig. 7.
Radiogram taken in antero-posterior position showing a fracture of the condyle which, although suspected from local signs and symptoms, could not be detected in plates taken at other angles.

One should not make a diagnosis of fracture from an X-ray only; the history and clinical findings must support the diagnosis of fracture.
GENERAL TREATMENT OF PATIENT.

In cases of recent fracture the patient may be suffering from shock, and attention must be directed towards overcoming this condition. Again, the patient may be suffering from systemic conditions such as syphilis, or from new growths such as sarcoma, carcinoma, cyst, etc..

The symptoms of shock are:

1. Pale and clammy appearance of the skin.
2. Persistent fall in blood pressure as indicated by weak and rapid pulse.
3. Shallow respiration.
4. Subnormal temperature frequently exists.
5. Muscular relaxation.
6. Mental torpor.

Treatment:

(a) Administration of cardiac stimulants.
(Aromatic stimulants usually suffice; but camphor plus oil, or camphor plus ether, injected subcutaneously may be necessary).

(b) Patient must be put to bed, kept warm, and given hot fluids to drink.

(c) Avoid causing mental anxiety - careful handling of the patient is an important factor in overcoming the condition, and a quietly confident and reassuring manner is of primary importance.

(d) Temporary measures to relieve pain are effective, e.g., temporarily stabilizing the fracture and administration of a general sedative.
TREATMENT OF EXTRA-ORAL WOUNDS, MOUTH CONDITIONS AND SITE OF FRACTURE.

Frequently a fracture of the mandible is complicated by more or less serious external wounds.

An incised wound may safely be cleansed and sutured if the case is seen within five to six hours after the occurrence; but if, as is usually the case, the wound is twenty four hours or more old, drainage must be maintained, and the wound dressed to prevent further infection.

External wounds showing extensive laceration should be cleansed, and any damaged tissue likely to slough should be removed. The wound should then be dusted with boracic acid powder and a dressing of sterile vaseline applied on aseptic gauze. If infection does not supervene the wound may later be sutured. Ordinarily, dressings should be continued and the wound allowed to heal by granulation.

When wounds have been contaminated by road dust or the like, injections of anti-tetanic serum should be given as a precautionary measure. Usually such cases will have had this attention before they are encountered by the oral surgeon.

General oral prophylactic treatment should be instituted at the earliest opportunity, and includes:

1. Removal of infected teeth.
2. General scaling of the teeth and cleansing of the mouth.
3. Removal of foreign bodies - or teeth, roots etc. acting as such - in the site of fracture.

These procedures will be discussed in greater detail later (vide page 60).

While it is unnecessary to give details of the
surgical technique involved in the removal of teeth, a few remarks, as to the choice of the method of anaesthesia - owing to the important bearing on the incidence and treatment of acute infective complications - are in place.

Frequently in unilateral multiple fractures with much displacement, a tooth in the site of the anterior fracture may be removed without resorting to anaesthesia, as the anterior segment may be anaesthetic from injury to the nerve at the proximal site.

Mandibular block anaesthesia with noxocain is of undoubted value in many cases. The advantages of this method in dealing with fractures of the mandible are twofold:

1. The necessary surgical intervention can be carried out with a minimum of trauma. Trauma during general anaesthesia is frequently unavoidable.

2. Following anaesthesia, and consequent cessation of pain, muscle spasm is found to be greatly decreased. Reduction and fixation of the fragments are thereby facilitated.

Unfortunately the degree of trismus existing occasionally precludes the method of mandibular nerve blocking, and as danger may attend injecting into acutely inflamed tissues, a general anaesthetic must be administered.
REDUCTION AND FIXATION.

Despite the diversity of opinion as to the correct method of reduction and fixation, the various methods have been successfully used. Therefore I conclude that none of the methods should be absolutely discarded.

Though good results can be obtained with most methods, provided they are properly carried out and used on suitable cases, they cannot be expected if one method is used to the exclusion of all others. Certain methods, however, are applicable in a greater percentage of cases than others. The methods and modifications to which reference will be made, will be those which the writer has found most useful. The salient features of such methods are capacity for:

1. Immobilization.
2. Cleanliness.
3. Permitting treatment (preventive or operative) of acute infective complications.

The object of all methods is the replacement and maintenance of fragments in correct functional position without deformity, but the degree of success in attaining these objectives in any given case varies with the method adopted.

By reduction and fixation is meant the replacement and maintenance of the fragments in normal functional position, and the procedures may be conveniently divided into two groups:

1. Surgical.
2. Non-surgical.
I. SURGICAL procedure includes:

Plating of the fragments to one another.
Wiring of the fragments.
Circumferential wiring.

With the exception of circumferential wiring, these methods are only used in closed fractures and are contra-indicated in recent fractures of the body, and in compound fractures of the ascending ramus and its processes. In general these should be reserved for use only when the non-surgical methods have not produced the desired results.

2. The NON-SURGICAL methods include:

(A) Wiring
   (a) inter-dental.
   (b) inter-maxillary.

(B) Splinting
   (a) inter-dental.
   (b) inter-maxillary.

A non-surgical procedure should ensure:

1. Maximum uninterrupted immobilization possible in the given case.
2. Reduction of the fracture with a minimum of trauma.
3. Hygienic mouth conditions.
5. Unrestricted blood supply.

Frequently one requirement can only be complied with at the expense of another, for instance, a fracture of the body complicated by a fracture of the ascending ramus is treated by indirect fixation of the mandible to maxilla with the bite closed. This precludes good access to the
intra-oral wounds and prevents free movement of the tongue as a means of keeping the mouth clean and also complicates the difficulty of administration of food. While it may be so arranged in this type of fixation that the mouth can be opened, this produces interrupted fixation of the fracture in the ascending ramus which is undesirable. When this provision is made, access to the mouth wound is gained at the expense of the fracture in the ascending part.

RESUMÉ OF NON-SURGICAL METHODS COMMONLY USED AND THEIR INADEQUACIES.

(A) WIRING.—Two main principles have been utilised in this form of fixation.

(a) INTER-DENTAL WIRING.—By this method adjacent fragments are wired to one another, either directly, or indirectly through the medium of arches or wires. The method of wiring directly to one another has by most surgeons been discarded because loosening of the anchorage teeth almost invariably results, reduction is difficult and fixation is usually inadequate. The method of indirect fixation to arches is only applicable where sufficient serviceable teeth are present in each segment, but where pronounced displacement exists reduction to the correct occlusion is difficult. Better fixation can be obtained by single cast or swaged splints in such cases. The Angle method of fixation by means of bracket bands and arch does not greatly differ from the single
splint method, with occlusal surfaces of teeth exposed. (Fig. 8)

Fig. 8.

Photograph of Inter-dental Cast Splint - occlusal surfaces of teeth exposed.

(b) INTER-MAXILLARY WIRING:— This consists in wiring the lower fragments to their corresponding places, in occlusion, with the intact maxilla and presupposes a sufficient number of teeth both in each segment and in the opposing maxilla. This in my experience is becoming less frequent, and is rather the exception than the rule, e.g., more frequently it is found that in a fracture in
the molar region the proximal segment is edentulous, or probably the molar region in the opposing maxilla, on the side of the fracture, is edentulous. In each case wiring is impossible without the introduction of some support such as a block of composition. Obviously because of the inability to keep such an addition clean and also because of the tendency of the proximal fragment in such cases to displacement and tilting towards the medium line, this method leaves much to be desired. This method also precludes access to the mouth even in the simple cases of fracture of the body, uncomplicated by fracture of the ascending ramus or its processes. Moreover it is incapable of completely overcoming the inward tilting of segments, as the wires pull only on the buccal and labial aspects of the teeth, and owing to the constant necessity of tightening the inter-maxillary wires, the result is an interrupted immobilization in many cases.

The advantages of wiring are:

1. The armamentarium necessary is limited.
2. Application is easy and expeditious.
3. The fracture may be reduced and fixed immediately the patient is seen.
4. Should remaining teeth or site of fracture give trouble, measures of correction are easily instituted.

The limited armamentarium necessary, the facility and expeditiousness of application of these and like methods should not influence one to adopt them in preference to any other method, the application and
constructional technique of which is much more involved, should the latter be capable of producing even slightly better results.

It has been contended that some weeks usually elapse between the time of admittance of the patient and the construction of a swaged or cast metal splint. It is my experience that the average time required in difficult cases is about eight hours and the results more than justify the time expended. While it is obvious that the sooner reduction and fixation in correct functional position without deformity can be accomplished the better, it will be seen that since the splint can be made and fitted in the same day as the impressions are taken, there is no considerable loss of time. Attention to the mouth conditions, such as removal of teeth or roots in the site of fracture, or teeth over which it is deemed unwise to cement a splint, usually more or less occupies the interval.

Summarizing, I consider that inter-maxillary wiring should only be practiced in selected cases, and that its chief value is as a temporary expedient, pending the construction of some form of splinting.

(B) SPLINTING.

Classification of Fractures for the Purpose of Splinting.—

Considerations of displacements, reduction and fixation, movements of the mandible and treatment of complications suggest the following classification:

Class I.

(a) Fractures of the body not presenting difficulties in reduction, and in which a sufficient number of serviceable teeth remain in each fragment.

(b) Unilateral fractures of the body in which a sufficient number of serviceable teeth remain anterior to the molar region.
Class II.

(a) Fractures of the body difficult of reduction.
(b) Bilateral fractures of the body in each fragment of which insufficient serviceable teeth remain.
(c) Fractures of the condyloid and coronoid processes.

Class III.
Fractures of the ascending ramus, unilateral or bilateral.

Class IV.
Fractures of edentulous mandible.

A Class I fracture, which is also Class II, is for purposes of treatment considered as a Class II.

A Class II fracture in which complications exist or are expected to ensue, and which is also Class III, is treated by the method of successional splinting, firstly in accordance with the methods adopted for Class II fractures, and finally (when acute conditions in body-site have subsided) by methods adopted for Class III fractures.

The displacements occurring, as a result of fracture of the body of the mandible, have been excellently illustrated and described in "Essentials of Oral Surgery" by Blair and Ivy.

(see Figs. 9 and 10)
Fig. 9.
Radiogram showing displacement following Fracture at Angle.
Fig. 10.

Radiogram illustrating direction of displacement of the anterior fragment following a Double Fracture of the Body of the Mandible.

In splinting two main principles are used:

(a) Inter-dental splinting.
(b) Inter-maxillary splinting.

(a) Methods of INTER-DENTAL SPLINTING are only applicable to fractures of the body of the mandible. The various methods used include such splints as the Kingsley,
Hammond, and Tomes splint, and their modifications. They have the advantage of allowing use of the jaws during treatment.

The bandaging associated with a Kingsley splint is not conducive to a good blood supply and lymph drainage, and does not sufficiently immobilize the parts. Its use is almost entirely restricted to edentulous cases.

The Hammond splint, in my estimation, is very limited in its field of usefulness.

It is my experience that the swaged or cast metal splints and their modifications (figs. 8 and 11) are pre-eminently the most satisfactory methods for treatment of Class I fractures.

Fig. 11.

Photograph showing a modification of the single or interdental swaged metal splint. In the molar region a biting surface has been reproduced in vulcanite.
Such splints have the following advantages:

1. They can be cemented in position, thus obviating the accumulation of putrefactive debris under them.
2. Movement of adjacent tissues is not restricted.
3. Access to intra-oral wounds and proper mouth cleansing is possible.
4. Little discomfort or inconvenience to the patient is caused.
5. Difficulties in feeding are eliminated.
6. Interference with the blood and lymph circulation is avoided.

Unfortunately their use is restricted to Class I fractures.

(b) INTER-MAXILLARY SPLINTING is the method of choice for Classes II, III and IV. In this method a combination of direct and indirect fixation is employed. Of this type we have the various modifications of the double or compound Tomes splint and the Gunning splint.

Cast or swaged double metal splints or the compound double metal splints, having vulcanite attachments over edentulous regions, are an unqualified success in treatment of Class II and Class III fractures.

Two fundamental variations are used:

I. Those intended for fixation of Class II fractures are designed with the bite slightly open. (Fig. 12)
Fig. 12.
Photograph of Inter-maxillary splint with bite slightly open.

Advantages from point of view of avoidance and treatment of infective complications:

(a) Intra-oral access makes possible intra-oral drainage in all its forms.

(b) The mouth can be cleansed of putrefactive debris.

(c) Difficulty in administration of food is minimised.

(d) The use of bandages (as fragments are held in position by cement or by muscle action) is obviated.

(e) Some action of the tongue and muscles of mastication - which is conducive to good blood circulation and lymph drainage - is allowed.
2. In Class III fractures the closed bite method gives the best results. The advantages of the open bite method in fractures involving the ascending ramus only, are minimised, while the disadvantage of impaired function is quite appreciable. When fixation in the open-bite position is used in the case of a fracture of the ascending ramus, the proximal fragment may rotate around a centre corresponding to the glenoid fossa, whereas the anterior fragment, governed partly by the intact side, will rotate around a centre approximately 1" - 1½" below and behind the position of the glenoid fossa. Hence, should union take place in this position, the fragments cannot be in good apposition, and on removal of the splint considerable impairment of function is frequently found, both in the condylar and masticatory regions.

Intermaxillary fixation in closed bite position (Fig. 13) avoids these distressing results. I consider that it is the best method in unilateral or bilateral fractures of the ascending ramus, but as previously mentioned, should such fractures be associated with serious fractures of the body of the mandible, successional splints are preferable.

Fig. 13.

Photograph of Closed-bite. Inter-maxillary Splint.
Reduction and fixation in Class IV fractures is unsatisfactory. The most uniformly applicable method is that of the Gunning splint and bandages. This method leaves much to be desired, as do the alternative methods so far made use of.

This class of fracture is frequently very stubborn, principally as a result of our inability to obtain a high degree of immobilization, and also as a result of the restricted blood circulation occasioned by bandaging. Fortunately, as a general rule, infection does not play such a prominent part in defeating our efforts. Muscle atrophy is more prone to occur in these cases.

Edentulous cases frequently have dentures which can be joined together forming an accurate Gunning Splint, or can have arms attached after the principle of the Kingsley splint.

Summarizing, I consider that methods of splinting should be used as follows:

Class I fractures - Inter-dental splint.
Class II fractures - Open-bite, Inter-maxillary splint.
Class III fractures - (a) Closed-bite Inter-maxillary splint.
               or (b) Successional Inter-maxillary splints.
Class IV fractures - Gunning or Kingsley splints.
PRACTICABILITY OF CONSTRUCTING A SPLINT IN CORRECT OPEN-BITE POSITION.

Modern writers are unanimous in their condemnation of the open-bite splint. It is claimed that faulty occlusion, poor approximation of the fragments - with the formation of V shaped spaces at the sites of fracture - result. Further, it is maintained that permanent stretching of the muscles is likely to occur.

In regard to the latter contention, I am of the opinion that for permanent stretching to take place, muscle atrophy and adhesions must supervene. Muscle atrophy is due to restricted blood circulation, and adhesions are the sequelae of inflammatory conditions in connection with muscles which cannot be exercised. A cemented splint allows for muscle exercise because a muscle can work and contract without the points of origin and insertion approaching each other. It also permits treatment in minimising the extent of the inflammatory conditions.

Respecting the former statement, I feel that in the past there was some justification for it, but I consider that the view is no longer tenable. Formerly I have experienced similar unsatisfactory results, and arrived at the conclusion that they were due to the following causes:

1. Lack of appreciation of the movements of the mandible in opening.
2. Failure to apply the knowledge of muscle action in its relation to displacements.
3. Application of the open-bite method in cases where it is contra-indicated, due to a lack of classification of fractures.
I. As a result of investigation of the path travelled by the mandible in opening, conducted by Tomes & Dolomore, Tomes\textsuperscript{2} states: "that no simple circular motion round any fixed centre can truly represent the path of the mandible; nevertheless the actual path does not greatly diverge from the arc of a circle described round a point generally an inch to an inch and a half below the condyle, and somewhat behind it. Thus the old statement that the axis of rotation lay upon the plane of the masticating surfaces of the teeth prolonged backwards is not accurate, but is not very far from the truth."

Professor Burkitt\textsuperscript{3} came to the conclusion that the mandible rotates about a transverse axis drawn through the insertion of the sphenomandibular ligaments (i.e. at a point a little below and behind the mandibular foramin).

Gysi places the rotation point somewhat higher and further back.

Investigating this geometrically, I have found that, while these various points are widely separated, circles, described with these points as centres, to represent the path travelled by the teeth, will for all practical purposes coincide.

\textsuperscript{2} Tomes' Dental Anatomy. Eighth Edition.
\textsuperscript{3} Notes on Dental Anatomy by Professor A.N. Burkitt.
Fig. 14. - Diagram to illustrate the approximate coincidence of the rotation circles.

- Tomes rotation centre: TRC
- Burkitt rotation centre: BRC
- Gysi rotation centre: GRC
- Gysi articulator rotation centre: GARC

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Fig. 14.

- Tomes rotation circle: TRC
- Burkitt rotation circle: BRC
- Gysi rotation circle: GRC
- Gysi articulator rotation circle: GARC
Fig. 15.- Geometrical representation of the error of opening a bite around a centre of rotation corresponding to the temporo-mandibular articulation, or any such incorrect centre.

Fig. 15.

R. represents a rotation centre corresponding to the temporo-mandibular articulation.
r represents the approximate natural rotation centre.
A B represents the plane of occlusion of the maxillary and mandibular teeth.
The relationship of the biting surfaces of an open-bite splint constructed to a rotation centre R will be A B to $R^1 R^1$. This relationship obviously results in faulty apposition of the fragments.

When union has taken place and the splint removed the mandible in closing will move around its natural rotation centre r; so that the oclusal surface will tend to take up the position $A^1 B^1$.

An open bite splint constructed to a rotation centre corresponding with r. will have its oclusal surfaces in the relationship A B to $r^1 r^1$.

On removal of the splint when union has occurred, rotation in closing the mandible will again take place around the natural centre r, so that the oclusal surfaces will return to the original position A B.

Should the hinge of the articulator in its relation to the oclusal plane, correspond to a point X (Fig. 8) - as is frequently the case - the inaccuracy will be still more pronounced.

Fig. 16 is a reproduction of a typical illustration" emphasising the danger of dressing the mouth open". It will be seen from the foregoing that models mounted in such a manner and on an articulator of this type should always produce the results complained of, when the splint is constructed to the open-bite position.

2 and 3. In fractures of the ascending ramus the open-bite position is contra-indicated, because, when the bite is opened the proximal fragment will not open simultaneously. In fact it may be thus allowed to displace still further forward under the action of the temporal muscle. In either case after union has occurred in open position, the ramus by colliding with the tuberosity of the maxilla may result in a permanent opening of the bite.

Another danger is that, should one ascending ramus be intact and union take place in the open-bite position; the condyle of the intact side will have moved forward, while that of the injured side will not, consequently on closing the bite the occlusion will be found to be displaced laterally towards the intact side.

When displacement occurs following a fracture of the neck of the condyle the head of the condyle is drawn forward by the external pterygoid muscle. The fractured end is prevented from doing so by the ascending ramus. Should union take place in the closed bite position, limitation of movement is likely to occur; because the preternatural forward movement of the head of the condyle is restricted by the anterior ligament of the joint capsule.

Believing that the condition is due to empyrosis Zemske\textsuperscript{7} and others advise treatment by mobilization rather than immobilization. I consider that this treatment could only result in fibrous union. A false joint thus obtained is quite unnecessary, and if the fracture is treated by immobilization in the open-bite position, no appreciable impairment of function will result. It is
also worthy of mention that, the treatment by mobilization in the case of an intra-articular fracture of the condyle, may result in ankylosis, which might have been avoided by the employment of any method of fixation.

So far as my observations extend no great displacement occurs in fractures of the coronoid process. This is due probably to the extensive attachment of the tendinous insertion of the temporal muscle. Reduction of the displacement is both impossible and unnecessary. Fixation for from five to eight weeks will restore the function.

METHODS OF OBTAINING SATISFACTORY CORRELATION OF THE MANDIBULAR FRAGMENTS TO THE MAXILLA IN OPEN-BITE POSITION.

I. By means of a face bow the relation of the patient's maxilla to the glenoid fossae is obtained. (This is quite practicable in a case of fracture, and does not require more than a few moments to carry out).

The plaster model of the maxilla is next mounted on a Gysi Articulator; a reasonably correct relationship of the glenoid fossae and centre of rotation, to the model being established by means of the face bow measurement. The model of the mandible is articulated to the upper or maxillary model.

(The underlying theory and details of procedure have been exhaustively dealt with by Professor Gysi5).

2. By mounting on a straight line articulator with due consideration to the natural axis of rotation of the mandible of the particular patient, reasonably good results may be obtained. In this case the models are mounted well

5. Correct Mounting of Artificial Teeth by Professor A. Gysi.
forward on the articulator, and much higher than is usually the case. The objective is to mount the models so that the plane of occlusion will be approximately in correct relationship to the axis of rotation, (i.e. the hinge of the articulator).

This method is not so accurate as the former one.

Fig. 17.

Shows relationship of plane of occlusion and condyles to a plane line articulator.
Fig. 16.
Radiogram showing open-bite splint used in Class II fracture.
- Note good apposition of the fragments.
AFTER-TREATMENT AND TREATMENT OF ACUTE INFECTIVE COMPLICATIONS OF FRACTURES OF THE MANDIBLE.

Infection provides one of the most serious problems in the treatment of fractures. Danger to life, prolonged illness, and extensive loss of tissue with resultant deformity are all possible.

The treatment of infective complications calls for discriminating judgment and depends to such an extent on the circumstances of each individual case, that it is difficult to lay down definite rules. A sound understanding and interpretation of the phenomenon of inflammation, and of the importance of physical and physiological rest, in their relation to repair of tissue, are prerequisites to treatment.

Inflammation is the reaction of the body tissues to irritants. In the case of infection, the irritant substances will be the bacteria and their derivatives. (We are dealing with irritants, the concentration of which fluctuates, and the chemical composition of which is insufficiently known). The inflammatory process is the means at the disposal of the body for protecting itself against invasion by infective microorganisms.

In acute inflammation it frequently happens that the reaction, or some phase of it, is overdone and defeats its object. Often quoted, but too often not acted upon, is the dictum handed down to us from Hypocrates; "Diseases are cured by Nature".

The word "Nature" is not merely a "façon de parler"; it is the only word which can adequately express the vital powers. The surgeon or the physician is only the servant
of nature, and when he is called upon to interfere, it is to guide the tissue reaction - to assist nature in the natural healing process when its powers are failing. Accordingly when suppuration, which results from interaction between infection on the one hand and lymph and blood on the other, occurs at a greater rate than it can be drained away by the lymphatics - thus setting up a vicious cycle by interfering with the lymph and blood supply - we should assist and support nature's healing process by instituting additional drainage.

Again, should nature's protective inflammatory reaction not be sufficiently pronounced to arrest the advance or spread of the infection, we should stimulate an inflammatory process, e.g., by heat. This will usually result in the formation of free pus, which must be drained artificially, because, in our righteous zeal to arrest quickly the spread, we incite an inflammatory reaction, which produces the essentials of pus formation, more rapidly than they can be removed naturally. Or should some phase of the natural healing inflammatory reaction be overdone, for instance by excessive exudation, we should guide and regulate the reaction.

In general the symptoms of a disease are indications of nature's methods of treating that disease. The symptoms of infective complications of fracture are mainly those of acute inflammation, and the treatment is based on an understanding of this process. Inflammation in this case indicates that nature's method of treatment is to increase the blood and lymph circulation, just as pain indicates nature's demand for rest to diseased or injured tissues.
PROCESSES PRESENTING IN TREATMENT OF AN ACUTE INFECTION.

1. The elimination of the infection by removal of the site and in addition much of the unaffected tissue, e.g., amputation.

Here again we depend on nature to heal our wounds. This method is obviously impracticable in the case of infection associated with fractures of the mandible. We should, however, remove a contributing cause such as a tooth, foreign body or sequestrum.

2. Chemical sterilization as by Carrel-Dakin method; this is also not suitable for oral conditions.

3. Assisting and regulating nature's inflammatory process in attaining its objective.


It is my intention to deal with the surgical bacteriology of fracture of the mandible, only insofar as it supplies a sound working basis for the treatment of infective complications. Therefore, while recognising that many organisms can be concerned in such processes, I consider that it will suffice to confine discussion to the two most important pathogenic organisms concerned, (the pyogenic cocci - the staphylococcus pyogenes aureus and albus, and the streptococcus pyogenes).

In compound fractures as exemplified in the body of the mandible, infection occurs as a result of one or both of these groups of bacteria gaining entrance to the site of fracture. In the course of their growth and multiplication toxins are produced, which give rise to the local and general symptoms of the disease.

10 - Chemical Sterilization of Wounds by Carrel & Dakin.
Opposing this invasion is the defensive mechanism of the body in the form of lymph and blood. The result of the encounter will be either death of the invading bacteria with resolution and repair, or death of the protective tissues and some of the bacteria, with spread of the infection with or without the formation of free pus.

SUPPURATION.

Suppuration is the term used to describe an inflammation which results in the formation of pus. Pus is composed of inflammatory exudate in which are an enormous number of dead and degenerating leucocytes and tissue cells, together with living or dead bacteria, toxins and certain ferments.

It is proposed to distinguish between the formation of pus, or its essential constituents, in quantities so small that the natural drainage, i.e., the lymph drainage, is sufficient to render recovery possible under favourable circumstances, and the formation of free pus or suppuration. From the latter condition resolution must usually be preceded by the establishment of collateral drainage, spontaneous or therapeutic.

DEFENSIVE MECHANISM OF THE BODY.

Broadly speaking there are two methods of offensive and defensive action of the tissues:

1. By elaboration on the part of the tissue cells of soluble substances capable of neutralizing or destroying injurious agents.

2. By the phagocytic and lytic activity of certain of the body cells.
(Indirectly the fibroblasts are also to some extent concerned in that they take part in the formation of the leuocytic barrier in the later stages).

The reactive processes as manifested by visible changes at the site of introduction of, or invasion by, irritating substances, are termed inflammation. Inflammation usually refers to the focal reaction of the tissues against irritants. But the general reaction must be borne in mind. The larger portion of the cells which take part in local inflammatory reaction are derived from the blood stream into which they are discharged from the myelogenous and lymphogenous tissues in increasing numbers during the course of the reactive phenomena.

FACTORS INFLUENCING RESULT OF INTERACTION BETWEEN INVADING BACTERIA AND BODY DEFENSE.

1. Virulence of the infection.
2. Resisting power of the patient to the invading bacteria.

1. The virulence of a bacterium in common with macroscopic organisms depends on the suitability or otherwise of the environment in which it has grown.
2. The resisting power of the patient depends on (a) general health (b) degree of immunity to the invading bacteria and (c) access of fresh blood and lymph circulation to the bacteria.

SIGNS AND SYMPTOMS OF AN ACUTE INFLAMMATORY REACTION RESULTING FROM INFECTION.

These are:— (A) Local. (B) General.
(A) LOCAL SIGNS.

Varying manifestations of the five cardinal signs, viz., heat, redness, swelling, pain, and loss of function.

Heat and Redness - resulting from vascular dilatation and cell metabolism.

Swelling - due to effusion of lymph, termed edema (and characterised by pitting on pressure) and also to vascular engorgement.

Pain - resulting from the swelling and consequent involvement of sensory nerve terminals, and also to some extent from the action of the toxin on the nerve terminals.

Loss of function - resulting from (a) natural inclination of the patient to follow the dictates of nature, i.e. to give rest to the part; (b) interference with muscular action by the presence of inflammatory exudate in interstitial tissues, fascial planes or muscle insertions; (c) injury to motor nerves from toxic action.

(B) GENERAL SYMPTOMS.

(a) These are usually those of sphenic fever in which case they are in direct proportion to the severity of the inflammatory reaction, so that varying degrees of the following result:

1. Raised temperature.
2. Increased pulse rate (full and bounding).
3. Increased respiration.
4. Reduction in natural secretions resulting in dryness of the skin, furred tongue, constipation.
5. Toxaemia manifested by malaise, headache, and even prostration in severe cases.
(b) On the other hand in cases where the resisting power of the patient is low, or the virulence of the infection great, a slight and inadequate local inflammatory reaction may be associated with marked general signs of toxaemia, or even septicaemia or pyaemia with

1. Subnormal temperature.
2. Pulse rapid but weak in volume.
3. Leucopenia.

GENERAL CONDITIONS ARISING FROM INFECTION.

I. Toxaemia. 2. Septicaemia. 3. Pyaemia.

I. TOXAEMIA is the presence of toxins in the blood.

The effects are:

(a) Loss of normal functioning power on the part of the parenchymatous tissues. The resulting symptoms usually are:

1. Rise in temperature to 103°-104° F.
2. Rapid pulse.
3. Increased respiration.
4. Malaise.
5. Headache.
7. Constipation.
8. Skin hot and dry.

These symptoms are manifested in the early stages following infection.

(b) Direct toxic action upon susceptible cells.

2. SEPTICAEMIA is the more serious condition in which the bacteria themselves, having gained entrance to the blood stream, are undergoing growth and multiplication.
There is grave danger of secondary infection occurring in areas of reduced resistance, and of secondary infection of organs essential to life.

Reaction symptoms are those of Toxaemia but more pronounced. Temperature may rise to $104^\circ - 105^\circ F$. In severe cases respiratory embarrassment may occur with evidence of cyanosis. This latter condition may exist entirely apart from any respiratory obstruction. The exaggerated headache condition may manifest itself as delirium, or the patient may be mentally apathetic or in a state of lethargy. Examination of the blood shows marked leucocytosis.

3. PYAEMIA is a general septic condition resulting from the presence in the blood stream of septic emboli. These may give rise to secondary foci of infection in other parts of the body, in the event of their becoming blocked in a small capillary vessel.

The symptoms are those of severe septicaemia. The acute stage of the disease is characterised by rapid rising and falling in temperature, and alternating rigors, sweats and fevers. The onset of symptoms is usually late, but not always.

SEQUENCE OF EVENTS FOLLOWING INFECTION.

When infection takes place any one of several phenomena may be exhibited:

1. The protective powers of the body may be sufficient to at once overcome or control the invader and neutralise its poison, so that no appreciable manifestations of local or constitutional reaction are provoked.

2. Should the infection be very virulent, or the resisting power of the host low, there may occur no reaction
on the part of the tissues of the host. In this event the latter is more or less rapidly overwhelmed as a result of the rapid and extensive dissemination of the microorganisms and their toxic products throughout the body. Death, in such cases, soon supervenes, preceded by a gradual collapse characterised by mental lethargy, lowering of the blood pressure, increase in pulse rate, drop in temperature and leucopenia. This type of reaction is termed asthenic fever. When no body reaction follows infection, the time intervening between infection and death depends upon (a) the importance of the tissue attacked, (b) the rate of growth of the infecting microorganism. In such cases death is due to the intense toxæmia i.e. the poisoning of the various tissue cells by the toxin in the blood.

3. Following infection there usually occurs a period of incubation during which the invaders continue to multiply and during which there is at best an inadequate reaction on the part of the tissues of the host. This may last only twenty four to forty eight hours, or may continue for one or two weeks. The incubation period terminates with either the onset of symptoms described in (2) or the commencement of reaction of the body manifested by inflammation, rise in temperature, rapid pulse rate, increased respiration and increase in the white blood cells - indicating increased metabolism. These symptoms are characteristic of sthenic fever, which is the usual reaction.

Should a demand for leucocytes arising from local accumulation, or their destruction, be increased beyond the capacity of the myelogenous tissues to supply such
cells, leucopenia ensues and onset of symptoms of asthenic fever is manifested. Hence in an acute infection such as cellulitis, diminution in the number of leucocytes indicates one of two things - (a) that the demand has lessened and resolution may be expected early, or (b) that the leucocyte producing functions have become exhausted, so that there is grave danger of a fatal termination.

ACUTE INFLAMMATORY REACTION.

The important phenomena associated with acute inflammation are:

1. Dilatation of blood vessels.

2. Exudation of lymph into the interstitial tissues.

3. Accumulation of cells.

It is chiefly through an exaggeration of the second stage, viz., exudation of lymph, that harm may result. Because of too great an amount of exudate in the interstitial tissues, the tension in such tissues may be so raised as to interfere with the efferent blood and lymph vessels. Drainage is thereby reduced or even arrested. Under certain circumstances even the arterial circulation is inhibited, or blood supply so slowed and reduced that, although there is an increased amount of blood present, the circulation is inadequate. The result is either relative or absolute ischemia. Absolute ischemia results in necrosis or gangrene, and is likely to occur during acute inflammation of bone; the pressure of the exudate compresses the arteries in the Haversian canals owing to the limited space, thus cutting off the blood supply to the part of the bone. This is more likely to occur when from arterial disease, general debility, or pedunculation - traumatic or natural - the blood supply to the part was previously poor.
THERAPEUTIC GUIDANCE OF AN ACUTE INFLAMMATORY REACTION RESULTING FROM INFECTION ASSOCIATED WITH FRACTURE OF THE MANDIBLE.

The treatment is (A) Local and (B) General.

(A) LOCAL TREATMENT, in addition to reduction and fixation consists in:

1. Removal of contributing causes.
2. Relief of pain.
3. Ensuring adequate blood circulation and lymph drainage in the part - mostly by correcting or preventing increased extra vascular or interstitial pressure.

I. CONTRIBUTING CAUSES are.- (a) foreign bodies in the site of fracture, and (b) septic teeth, roots, calculus and other factors tending to general oral sepsis.

(a) Foreign bodies in the site of fracture or teeth, roots, and - if the case is seen late - small loose sequestra, acting as such, should invariably be removed at the earliest possible moment irrespective of the degree of inflammatory reaction. Removal of the cause is acknowledged as the first principle of surgery. In this case the cause is bacterial and so cannot be removed surgically. A contributing cause, however, can, and should be removed.

Fig. 13:

Intra-oral radiograph showing a tooth in the site of fracture. Had the case been seen earlier immediate removal of the tooth would probably have avoided sequestration of the comminution.
Intra-oral radiogram showing a fractured tooth in the site of fracture. The apex as well as the tooth should be removed immediately.

Admittedly observance of this rule involves the sacrifice of a few teeth which might have been saved, but in the aggregate this will be more than compensated for by the reduced incidence of sepsis and delayed union. Exceptions to this rule are less frequent than is usually assumed, and comprise - (1) an unfractured vital tooth, the apical third of which does not lie in the line of fracture, and which would prove of decided advantage for fixational purposes. (Fig. 21) Such a tooth, at least in the early stages of treatment, may be allowed to remain. (2) Large sequestra - which must be distinguished from (1) undetached comminutions and (ii) dead bone which has not become separated off - should be retained until the formation of the involucrum unless the condition of patient precludes this procedure. Much deformity will thereby be avoided, and the danger of pseudarthrosis is reduced.
Fig. 21.

Radiogram showing oblique fracture. In this type of fracture the teeth have not acted as a predisposing cause. Radiographic evidence is sometimes misleading, for instance, the distal root of the first molar appears, at a cursory glance, to be fractured. Closer observation and clinical examination did not support that conclusion. The first molar is typically one which may safely be retained, and in this case the progress and union were uneventful.
This radiogram reveals a fracture through the apical half of the mesial root of the third molar. This apex, which is in the anterior fragment, must be removed in addition to the remainder of the tooth situated in the posterior or proximal fragment.
This radiogram reveals a tooth which must be immediately removed, even though, if retained, it would be of decided advantage for fixational purposes. When the patient was admitted for treatment the clinical examination supported the radiographic evidence that the tooth had already become a source of sepsis.
Fig. 24.

Radiogram showing a Double Fracture with a bicuspid in one of the sites of fracture. The removal of such a tooth is imperative. (It is an almost invariable rule that, when a tooth has acted as a predisposing cause, the fracture will involve the apex, and the removal of the tooth is essential, whether the tooth is vital or non-vital.—compare with Fig. 21).
Fig. 25.

Radiogram of a Fracture in which necrosis has occurred as a result of the retention of a tooth in the site of fracture. This case was seen late because the patient at first suffered little discomfort, loss of function or deformity. Had it not been for the tooth in the site of the fracture, the patient's method of "home-treatment" might have been successful.
Fig. 26.

Radiogram of a case of Non-union as a result of the presence of a second molar in the site of fracture.
(b) Preliminary prophylaxis is essential in this regard as in any major surgical procedure in the mouth. Irrigation, mouthwashing and swabbing of the teeth with peroxide of hydrogen, to cleanse the mouth from the foetid accumulation of blood-stained saliva, and debris, are important preliminary measures.

Acutely infected teeth should either be removed immediately or - should too many such exist - should be gradually eliminated. In the case of useful quiescent infected or carious teeth, provision must be made for a continuance of the prevailing conditions. Marginal infection associated with calculus is in many cases a contributing cause, and scaling of the teeth is necessary to improve the conditions. Precautions must be taken to prevent lodgement of the debris in the site of fracture.

Splints designed to be cemented in position, and to allow some cleansing movement of the tongue and saliva, together with regular mouth washing and irrigation, will do much to maintain the mouth in a hygienic condition; this minimises factors contributing to oral sepsis. The influence, of the method of anaesthesia adopted, has been previously dealt with (vide page 18).

2. PAIN IS RELIEVED BY.- (a) obtaining rest to the inflamed part and (b) counter-irritation.

(a) Rest is mainly obtained by splinting. Movement of the fractured surfaces tends to spread the microorganisms and their toxins over the body. The rapid drop in temperature and relief of pain on splinting, when nothing else is done, is a most striking feature of the treatment of fracture of the mandible. The contradiction to the point mentioned in (3a) is only apparent.
(b) Application of a mixture of equal parts of chloroform, chloral hydrate, camphor and menthol, along the course of the nerve externally, or on the mucoïd membrane covering the alveolus in the region of the fracture.

3. Measures adopted to ensure ADEQUATE BLOOD CIRCULATION AND LYMPH DRAINAGE are:

(a) Provision for quiet physiological action of adjacent structures. Movement of muscles maintains blood circulation; for as has been shown by Bier, muscle action propels venous blood when it contracts. Inactivity would tend to venous stasis in an undesirable degree. It must be pointed out that a muscle can work and contract without the points of origin and insertion approaching each other. Tight bandaging restricts blood and lymph circulation. Restricted movements of the tongue will interfere with lymph drainage. Quiet physiological action is to be distinguished from active movement, which, as previously mentioned, is detrimental. The danger of squeezing an abscess to increase drainage, emphasizes the fact that the action must be kept within definite limits.

(b) APPLICATION OF COLD in the form of an ice bag is advocated by Blair & Ivy, Berger, and Zemsky as the method of choice in regulating an inflammatory reaction. This procedure undoubtedly relieves pain and, as maintained, tends to prevent suppuration. The question, however, arises as to whether in a dangerous infection, suppuration with drainage is to be looked upon as an unfortunate occurrence. In my opinion, should the condition be that

of a firm exudation and symptoms of stasis exist, continued application of cold is detrimental and even dangerous. The action of cold is to reduce hyperaemia, and as a rule this is undesirable in inflammation associated with infection. Should for some special reason, cold be resorted to, it must be used intermittently and requires much care and constant attention in its use. The latter applies equally to use of passive hyperaemia. The intermittent application of cold causes a temporary reduction in blood supply, and the interval sometimes affords the opportunity for the efferent vessels to reduce congestion.

(c) Heat increases hyperaemia by dilatation of the deep as well as the superficial blood vessels and lymphatics. Increased blood circulation means increased resistance. An increased amount of blood in the part does not increase resistance unless the blood is circulating.

Extravascular pressure, due to excessive exudation, causes stasis. In this condition there is an increased amount of blood in the part, but the resistance is not increased as the blood is not circulating. When such a condition exists application of heat principally brings about a dilatation of the venules and lymphatics; its action on the already dilated arterioles is not so marked. That application of heat is capable of overcoming stasis can be demonstrated clinically. A hard brawny swelling showing signs of stasis - i.e., circulation does not return soon after pressure and pulsation is not felt in the part - is found to have its circulation restored, at least to a degree, on application of heat, as indicated by (1) the rapid return of circulation when skin is blanched by pressure; (2) the detection of pulsation in inflamed part.
Provided this condition is maintained, localization and fluctuation or resolution will occur in a variable period of time, if the general resistance of the patient is, or can be rendered, capable of overcoming the infection.

Heat tends to bring about suppuration and pointing, and when applied externally, drainage should be obtained surgically after fluctuation occurs - or the presence of pus is determined - and before spontaneous discharge takes place. This procedure is of prime importance in avoiding unsightly scars. On the other hand, in less dangerous cases, heat can be so regulated that, if biologically possible in the particular case, resolution will occur without suppuration and the necessity for external drainage.

Should the inflammatory reaction be inadequate, as is frequently the case in a streptococcal infection, the continued application of heat will arrest the spread and localise the infection, provided, of course, that the general resistance of the patient is sufficient.

PRECAUTIONS TO BE OBSERVED IN APPLICATION OF HEAT.

1. Heat must be restricted to the area of infection.

2. For some unknown reason heat tends to cause pointing at a position opposite to the centre of the area of applied heat. Since it is advisable to drain at the most dependent point, the centre of the area of applied heat should correspond with such point.

METHODS ADOPTED IN APPLYING HEAT.

The two most satisfactory methods are (1) Poulticing and (2) Fomentation.

(1) The linseed poultice still performs an important office in this regard, although other poultices such as
Antiphlogistine etc. (containing counter-irritants) are often preferable.

(2) Aseptic gauze or flannel soaked in hot water and wrung dry will, when frequently changed, maintain a continued moderate degree of heat which is very beneficial. This method is particularly indicated after drainage has been obtained, as the moist packs do not interfere with drainage, and prevent coagulation of the draining inflammatory exudate.

(d) COUNTER-IRRITANTS.- In spreading inflammation such as cellulitis or erysipelas, counter-irritants, e.g., ichthyol, iodine and aconite, are of undoubted value. The painting of the affected area and about an inch beyond it with ichthyol ointment, iodine or aconite and iodine, greatly assists in arresting the spread of the infection.

(e) DIATHERMY.- In this method use is made of the heating effect of a high frequency current passing through the body from a localised area. I have found this method more useful in relieving pain than in localising infection. The soothing effect is greatly appreciated by the patient. In applying this method of radiant heat the following precautions should be observed.—(1) The area should be powdered or chalked, to avoid pulling of the fine hair of the skin. (2) The oscillations should be increased gradually. (3) The rapidity of the oscillations should be reduced, or the current switched off, before the terminal is applied or removed.
Fig. 27.
Photograph of Portable Diathermy. The terminals are of varying sizes so that it is possible to localise the effects.

(f) DRAINAGE.—Natural drainage is maintained by lymphatic vessels, and the methods of its therapeutic guidance have been mentioned. Natural drainage is frequently inadequate and intra-oral or extra-oral drainage, or both, become necessary.

Intra-oral drainage in the case of a fracture of the mandible is seldom obtained by incision. Occasionally, however, it is expedient to incise slight inducations in the mouth resulting from a localised osteoperiostitis. I wish to emphasise that in my experience thorough and regular irrigation of the wound with warm normal saline
solution is a valuable form of drainage. The use of solutions which coagulate the discharged secretions render the method almost useless as a means of drainage.

Extra-oral drainage is the key to successful treatment of acute infective complications associated with fracture of the mandible; but its injudicious application is fraught with grave danger. The time to institute such drainage is of paramount importance. The methods adopted will be discussed in detail later. (see pages 84 and 106).

The unfortunate results reported to have ensued after attempted drainage in acute cases and which have been the cause of the great diversity of opinion entertained in this regard, have convinced many that it is better practice to wait until the acute inflammatory process subsides or the abscess points and evacuates spontaneously. These failures are attributable to one of two main causes:

(a) The attempted drainage was instituted before pus formation or in the early stages of pus formation, before the body reaction characterised by inflammation had resulted in the formation of a localising zone or barrier of resistance. Frequently it was established at the stage of purely edematous inflammation. At this stage the trauma, due to the surgical interference, would appreciably aid the spread of infection, and unless of a very extreme nature could not materially benefit the lymph and blood circulation, by a liberation of the excess inflammatory exudate.
(b) When timely the technique adopted:
1. Resulted in failure to obtain drainage.
2. Resulted in inadequate drainage.
3. Although adequate, caused sufficient detrimental trauma to counteract any benefit, e.g., injured blood vessels.
This acts deleteriously in several ways.
(i) The immediate haemorrhage reduces the resistance of the part, although undoubtedly a slight degree of haemorrhage of a temporary nature is of benefit when stasis has occurred in the inflamed part.
(ii) Secondary haemorrhage may result from infection, and the danger of metastatic infection in other organs due to septic emboli resulting from thrombosis in veins is greatly increased.

An intelligent understanding of the importance of (1) the leucocytic barrier and (2) the mode of spread of infection, is essential in the treatment of acute infective complications associated with fracture of the mandible.

(1) LEUCOCYTIC BARRIER. - This consists of a wall of living leucocytes surrounded by a zone of cells - derived from the fixed connective tissue of the part, i.e. fibroblastic cells - also containing leucocytes. This connective tissue cell proliferation is the first stage of attempted repair. As pointed out by Mills & Humphreys⁸, this connective tissue proliferation does not mechanically prevent spread of an abscess. It is only, when the tissues

⁸. Surgery for Dental Students - Mills & Humphreys.
have at least temporarily overcome the infection by the means described under Defensive Mechanism, that spread is arrested. Numbers of bacteria are found in advance of the circumvallating zone; should the tissue reaction hold in check or overcome the focus of infection, these advance bacteria being cut off from the main focus are usually easily dealt with by the blood and lymph. They may, however, form secondary foci of infection in adjacent situations, for example, a focus in the lower molar region may be overcome, but a secondary focus probably originating from these advance bacteria may occur in adjacent tissue such as the cheek in the facial planes between the buccinator and masseter muscles. This is especially likely to occur should a locus minoris resistentia exist in such situation. Should the effective body reaction be sufficient only to check temporarily the advance of the invading bacteria, the wall breaks down and is reformed in a retreated position if the defensive mechanism is not exhausted. The result is a spread of infection with an enlargement of the pus cavity. It is contended that this so-called pyogenic membrane or pus sac, seen to best advantage in an apical abscess, but occurring also in vascular soft tissue, while it does not mechanically prevent the spread of infection is capable of assisting to prevent the spread of the pus cavity especially when drainage is instituted. From observation, the formation of this circumvallating zone is coincident with the formation of free pus, or at least, clinically, that is the only stage at which we may be sure of its existence. Recognition of this fact is of paramount importance in
obtaining artificial or collateral drainage. It indicates the time to institute drainage. The time is the all important factor in obtaining results. Spread should, at least temporarily, be localised before surgical interference is undertaken.

DETERMINATION OF THE PRESENCE OF FREE PUS.

The Signs and Symptoms are (a) Local (b) General.

(a) LOCAL SIGNS.— With the formation of free pus the local signs and symptoms are those of acute inflammation, and in addition especially in cases easy of diagnosis:

1. Circumscribed swelling.
2. Fluctuation and, in later stages, pointing. Fluctuation is the sense of the presence of fluid such as is experienced when two fingers are pressed alternately on either side of a swelling when free pus is present. An excellent example of fluctuation is the peculiar sensation observed when a loose bag of fluid, for example a water bag, is pressed alternately with a finger of each hand.

A swelling with suppuration must be distinguished from a swelling which is purely edematous, i.e., pits on pressure. This distinction is complicated by the fact that edema is also present. The sign of surgical importance is the fluctuation.

The diagnosis of the presence of free pus may be further complicated by (i) extreme tension of the fluid making fluctuation hard or impossible of detection, (ii) location of pus under muscle layers or in dense fascia.
Important information, in cases difficult of diagnosis, can frequently be obtained from subjective signs, for instance the patient often describes the pain as "throbbing". Increasing edema associated with throbbing pain usually indicates pus formation.

Where the presence of pus is reasonably suspected, but fluctuation cannot be detected, the general signs of pus formation must be depended upon in arriving at a diagnosis. The general signs should also support the diagnosis when the local sign of fluctuation is present. An element of risk attends diagnosis of presence of pus in the "difficult cases" from general signs and symptoms without fluctuation, but circumstances frequently indicate this procedure. With discriminating judgment and careful attention to such diagnostic points as the history, general health and habits of the patient, together with the local and general signs and symptoms, a wrong diagnosis will seldom be made. Should, after such due consideration, a diagnosis prove to be illfounded the surgeon will have acted in the best interests of the patient.

(b) GENERAL SIGNS AND SYMPTOMS.— With the formation of pus the signs and symptoms of sphenic fever plus leucocytosis are usually present.

1. Rise in temperature.
2. Increased respiration.
3. Increased pulse rate.
4. Hot dry skin.
5. Furred tongue.
6. Constipation.
7. Leucocytosis.
(2) SPREAD OF INFECTION.- In the early stages of infective complications, infection is seldom entirely of one type, but one or other predominates. They are consequently named according to the infection which predominates, e.g., staphylococcal infection is usually also partly streptococcal and vice versa. The tendency in a purely staphylococcal infection is for the bacteria to be rapidly overcome or controlled, and localised by the body defenses - owing to the great positive chemiotaxis of this organism - unless the patient be debilitated. In cases of debilitation a gangrenous condition may result. After localisation the resultant pus formation, if small in quantity, will be removed by the lymphatics and blood, and repair will commence. Should on the other hand a relatively large quantity of pus be formed it will tend to make its way to the surface, and after evacuation, the process of repair will commence, if, or when, the contributing cause has been removed by the surgeon or by the body reaction. Should, however, as is frequently the case, the infection become mixed with streptococcus, at the stage of drainage, the course of the disease may become that of a more or less spreading infection, e.g., erysipelas.

A purely streptococcal infection tends to spread rapidly, via the tissue planes, lymphatics or blood stream. Owing to its lesser chemiotaxis, the local inflammatory reaction is not incited to the same degree. Hence the defensive localising barrier is not formed, and unless therapeutic measures are taken to promote and guide an inflammatory reaction, with the object of localising the infection and obtaining drainage, and unless attention.
is directed towards improving or sustaining the general health, death is likely to occur from the intense toxaemia, septicaemia or pyaemia.

SUGGESTED HYPOTHESIS TO ACCOUNT FOR ECCENTRICITIES OF SPREAD.

Mills and Humphreys\(^8\) have called attention to the interesting fact that, while the staphyloccoccus usually causes a localised abscess at the primary site of infection or in the lymph glands, the streptococcus usually gives rise to the diffuse spreading forms of the infection. No explanation of this seems available.

The following hypothesis is based entirely on clinical observation of the progress of spread of infection, and to the best of my knowledge is neither supported nor contradicted by bacteriological investigation; hence its only value is to provide a workable theory from a clinical viewpoint on which treatment may be based. It is assumed that, as has been previously mentioned, most cases of infective complications associated with oral wounds are mixed infection and frequently mutually antagonistic. The experiments of Marmorek, Mechnikoff and others\(^9\), have shown that the standard of virulence of streptococci may be raised by their introduction into favourable surroundings. It seems reasonable, therefore, to presume that the streptococcus pyogenes may be raised in standard of virulence on gaining the cellular tissues as in cellulitis, or the fine reticulum of lymphatics in the skin as in erysipelas. It seems possible that infection from a primary focus, such as osteoperiostitis or osteomyelitis, or from the secondary focus such as a suppurative lymphadenitis, which are predominantly staphyloccocal, but which are also mixed with

streptococcal infection, may, on spreading into the cellular tissues - either directly from the primary focus or as a result of rupture of a lymph gland - provide the streptococcal element with suitable environment permitting the potential predominance of the streptococcal infection with its characteristic spread, and serious prognosis.

Clinically, treatment based on this assumption has proved sound practice. It may, however, be proved bacteriologically to be another of those instances where the practice was right but the theory wrong. The value lies in the fact that it emphasises the necessity of viewing all suppurative involvements of the cellular tissue planes as serious, and indicating that drainage should be established as soon as possible if resolution does not immediately commence, because a more virulent streptococcal infection may be incubating.

(B) GENERAL TREATMENT in therapeutic guidance of an acute inflammation reaction resulting from infection consists in:

2. Counteraction of the effects of toxaemia.
3. Regulation of the body temperature and control of pain by internal medication.

1. The resisting power depends to a great extent on the state of general health of the patient, and treatment must be directed towards improving or maintaining the general health.
To compensate for the increased drain on the myelogenous and lymphogenous tissues, physical rest and nourishing food are essential, more so in severe cases. Because of the impaired functioning of the digestive organs, resulting from toxaemia, food must be of an easily digestible nature. Fresh air, sunlight, and freedom from worry are also important in general supporting treatment. When the period of convalescence is prolonged, or patient is debilitated, administration of tonics is indicated.

2. The presence of toxins in the blood results in derangement of function of various organs. Those of primary importance are :

(a) Organs of elimination and secretion - bowels, kidneys, liver, skin.

(b) Digestive organs.

(c) Heart.

Methods of counteraction:

(a) The proper functioning of the bowels is imperative, and in accordance with the degree of functional derangement, it will be found necessary to administer:

(1) Laxative - Magnesium Sulphate; Castor Oil.

(2) Purgative - Calomel, enema.

The importance of maintaining the skin in correct functional order cannot be over emphasised, as it acts beneficially in two ways:

(1) Regulating body temperature.

(2) Reflex stimulation of the bowels when skin is bathed.
Encouraging the patient to drink plenty of water favours elimination of toxic products via the kidneys, and also supplies the necessary moisture for evaporation from the skin.

(b) As has been mentioned previously, the diet in severe cases must be easily digestible, e.g., milk, egg flip, or proprietary preparations such as Ovaltine, etc.

(c) Should symptoms of exhaustion ensue with reduction in the blood pressure, cardiac stimulants such as brandy or hypodermic administration of strychnine, camphor plus ether, or camphor plus oil, may become necessary.

3. The regulation of body temperature by means of antipyretics, and the control of pain by internal medication, are also frequently indicated; e.g., A.P.C. and Dovers Powders, which act both as antipyretics and sedatives.

The use of powerful sedatives such as bromides and opiates, to which we resort in cases of delirium or extreme pain, must be tempered with judgment. Frequently the continued administration of such drugs, by producing a state of lethargy, "prevents the patient from helping himself". The contra-indications for administration of these will be dealt with later (vide Edema of the Glottis).
IMPORTANT HISTOLOGICAL CONSIDERATIONS.

Before dealing with the infection of the constituents of bone a review of the important histological features of normal bone is appended.

Bone is a form of connective tissue impregnated with lime salts. There are two varieties of bone, spongy or cancellated, and compact. The spongy bone is the fundamental form, yet only in the compact form are all the structural peculiarities of bone present. A cross section of compact bone shows a number of round openings — the Haversian canals. The central opening of a Haversian canal is surrounded by layers of bone concentrically arranged — the concentrically disposed lamellae —, this canal and the surrounding lamellae forming a Haversian system. In the longitudinal section the course of these canals seems to correspond to the long axis of the bone, although some run obliquely and establish communication between adjacent canals. All the Haversian canals communicate with the central marrow cavity and may be viewed in the light of continuations from it. Each Haversian canal contains bone marrow — myelitic substance — a tissue richly supplied with blood vessels, lymphatics and nerves. The spaces between the Haversian systems are filled by short lamellae, which are not arranged in any definite way. These are called the interstitial or ground lamellae. The circumferential lamellae are those which surround the bone on its outer and inner circumference; i.e. they are located immediately under the periosteum and around the central marrow cavity. In the ground matrix are located the lacunae, from which minute channels radiate —
the canaliculi. Each lacuna contains connective tissue elements - the bone corpuscles. These bone cells exhibit processes which extend into the canaliculi. The lacunae of a Haversian system communicate with one another by means of their canaliculi, but not with the canaliculi of adjoining systems. The channels through the circumferential lamellae, which carry blood vessels, lymphatic vessels, and nerves from the periosteum to the Haversian canals, and those which run across the inner circumferential lamellae to the central marrow cavity, are known as Volkmann's canals.

Bone is surrounded by a fibrous membrane, the periosteum. It consists of two layers: the outer fibrous, dense protective layer; and an inner, less dense layer very rich in blood vessels and composed of delicate white and elastic fibres. The inner layer is concerned with the formation of bone and is known as the osteogenetic layer. The outer layer contains the larger blood vessels, the inner layer the smaller though more numerous blood vessels. The osteoblasts are located in the osteogenetic layer. The fibres of Sharpey are fibres from the periosteum which have remained in the lamellae without undergoing calcification. The central cavity and all cancellated spaces are filled with marrow of which two varieties are recognised, the red and the yellow, the red being the younger variety and the yellow the older. Bone marrow is a blood-forming organ and consequently contains all varieties of blood cells as well as myelocytes, nucleated red blood cells, giant cells, fat cells, mast cells etc.. Bone marrow consists of a delicate connective-tissue framework supporting a rich supply of capillaries. The connective-tissue cells in marrow are the marrow cells which are concerned in bone
formation. In yellow marrow, the marrow cells have been replaced by fat cells. In addition there are to be found in marrow some large connective-tissue cells - the giant cells - which are concerned in the absorption of calcified tissue and which are known as osteoclasts.

If a section of the mandible be examined it will be found that it is composed of thick layers of compact bone externally and internally and that within the layers of compact bone the cancellated or spongy bone is found. The latter is made up of the thin bony walls of the cells which contain the medullary or myelitic substance. In life these cells - the so-called cancellated spaces - are not exactly spaces, being almost entirely filled up by the myelitic substances. The character of the bone in the walls is identical with that of the compact layer which surrounds the mandible in all of its aspects except at the upper aspect through which retention is afforded to the teeth. The walls of the alveoli, internally, appear more or less smooth and are made up of a layer of compact bone, although everywhere, as is seen in ground sections examined microscopically, cancellated spaces open through it.

(This histological description of bone is compiled from the article by G.A. Piersol - Textbook of Normal Histology -).
MODE OF SPREAD OF INFECTION.

When infection occurs at the site of a fracture it will either be immediately overcome by the body defenses or spread will take place. The mode of spread may be conveniently differentiated into:

I. Primary spread.
2. Secondary spread.
3. Tertiary spread.

1. Primary spread results in the inflammatory condition of.
   (a) Osteoperiostitis
   (b) Osteomyelitis.

Either of these conditions may give rise to general symptoms of toxaemia.

2. From the primary focus infection may travel.
   (a) via the lymphatics draining the area,
   (b) by extension along the cellular tissue planes,
   (c) via fine reticulum of lymphatics in the skin, the condition being termed erysipelas.

   As is pointed out by Blair & Ivy 4 (and as is only to be expected) in most instances the infection travels by a combined route, but usually either the lymph nodes or the tissue planes show the greater involvement, and the resulting inflammation is designated accordingly a lymphadenitis or a cellulitis. The general symptoms will again be those of toxaemia.

3. From the primary or secondary foci the infection may spread via the blood stream, either directly or as infected emboli, and may give rise to general conditions of.
   (a) Septicaemia
   (b) Pyaemia.

In general it must be pointed out that the resistance of the patient may overcome the infection at any stage with or without treatment, but on the other hand death may occur from the intense toxaemia or from the secondary infection of organs essential to life following tertiary spread.

I. PRIMARY SPREAD.

(a) Osteoperiostitis.— The term Osteoperiostitis is used in preference to periostitis as some degree of osteitis always accompanies an acute infection of the periosteum. This condition almost invariably follows a compound fracture of the mandible, and — depending on the type of organism and resistance of the tissues of the patient — will either remain localised to the alveolar periosteum, or become progressive. In the former case it is known as a localised osteoperiostitis, in the latter as a diffused osteoperiostitis.

In the early stages the periosteum becomes inflamed and the bacteria penetrate to the deeper layers. This periostitis is always associated with some degree of osteitis due to infection of the Haversian canals of the subjacent compact bone, from the periosteum. The resultant inflammatory exudate cuts off the blood supply and causes superficial necrosis or caries. Should, by proper treatment, infection be overcome at this stage, the osteoclasts and leucocytes remove the dead bone and the osteoblasts lay down new bone; it is to be remembered, however, that these will not function in the presence of active bacterial infection.
Diffused osteoperiostitis produces a deeper infection of the bone with a greater depth of superficial necrosis, and is usually complicated by an infection of the cancellous bone and the marrow, constituting osteomyelitis.

TREATMENT OF LOCALISED OSTEOPERIOSTITIS.

The considerations of first importance in treatment of this condition are:—(1) removal of contributing causes, (2) fixation of the fragments. The promptness of response to this treatment is usually very marked—the acute exacerbations frequently disappear in twenty four hours. Intra-oral access is desirable as regular irrigation of the intra-oral wounds, and the use of hot antiseptic mouth washes are important factors in the treatment. Obviously, with the formation of pus, or the presence of bacteria, under the periosteum, movement of the fragments predisposes to the more serious condition of diffused osteoperiostitis.

Localised periostitis may, however, be quite severe with marked pus accumulation and edematous involvement of the tonsils and epiglottis, similar to that associated with diffused osteoperiostitis and submaxillary cellulitis. When pus accumulations are present with induration in the mouth, liberation of the pus by incision is advisable either before or after fixation of the fragments. In such cases varying degrees of toxaemia are manifested, necessitating treatment to secure free action of the bowels, and in addition, general supporting treatment.
This inflammation is usually accompanied by a molecular superficial destruction of the compact bone, that is to say, the individual cells die. The bone in this event is removed by the osteoclasts and leucocytes or comes away in the pus. On the other hand relatively large scales of necrotic bone may result, which should at the opportune time be removed intra-orally by surgical intervention.

TREATMENT OF DIFFUSED OSTEOPERIOSTITIS.

In this condition the infection spreads diffusely, and when suppuration occurs the pus strips up the periosteum from the bone around the body as well as the alveolus, so that there is grave danger of spread into the fascial planes of the floor of the mouth and neck, or those of the cheek muscles, i.e., cellulitis.

Local treatment consists in:

1. Removal of any contributing cause such as a foreign body or tooth in the site of fracture.

2. Early fixation.

3. Irrigation of the intra-oral communications.

4. Localisation and drainage.

When fluctuation occurs the pus, which is located under the periosteum, must be drained extra-orally from the most dependent point. Intra-oral drainage should be maintained by regular irrigation of the wounds with hot normal saline solution.
Fig. 28.
Radiogram of Class II fracture disclosing a second molar in the site of fracture. Diffused osteoperiostitis was present at this stage. The radiograph also reveals myelitic involvement.
Fig. 29.

Radiogram showing previous case (Fig. 28) after removal of the tooth and fixation of the fragments. The open-bite inter-maxillary splint employed allows access for the purpose of intra-oral irrigation. Drainage brought about resolution, and repair followed in due course.

N.B. A splint extended to include the retro-molar triangle in this way does not cause pressure necrosis unless movement of the splint is permitted.

PROCEDURE IN ESTABLISHING DRAINAGE.

The patient may be given a general anaesthetic, e.g., Nitrous Oxide plus Oxygen, or Ethyl Chloride, or the region may be locally anaesthetised with Ethyl Chloride Spray. The latter method is usually to be preferred, and the pain incident to establishment of drainage with this method of anaesthesia is surprisingly well within the bounds of human endurance. The region to be incised is sterilised with
iodine, alcohol or ether, and a small incision running in the line of the lower border of the mandible is made. This incision is only through the skin. A pair of sinus forceps, closed, is entered and pushed through the muscles, fascia and distended periosteum. The forceps are then opened and the pus is allowed to run down between the blades of the forceps. The sinus forceps are withdrawn open, establishing an exit for the pus. In the majority of cases it is found advisable to insert a drainage tube to maintain free drainage. Strict aseptic precautions must be observed, and for personal safety the operator should wear surgeons gloves.

Fig. 30.
Photograph of a case of acute diffused osteoperiostitis with drainage tube (T) in position.
Acute diffused osteoperiostitis being associated with varying degrees of osteomyelitis, early treatment is necessary to minimise the extent and danger of the myelitic involvement. The supervision of marked myelitis results inter alia in the formation of areas of necrosis, the removal of which involves more radical treatment (to be described under osteomyelitis). Early drainage of pus accumulating under the periosteum will avoid formation of definite sequestra and subsequent prolonged treatment.

Fig. 31.
Radiogram of a fracture with a bicuspîd in the site. (Another fracture which is not evident in this radiogram was present on the right side).

History.—The case did not present for treatment until three weeks after the accident. The patient was
undernourished and extremely debilitated.

Treatment.—(1) The tooth in the site of fracture was removed under general anaesthesia. (2) the fracture was reduced and immobilized by means of an inter-maxillary splint as shown in the radiogram Fig.32. Drainage was also established.

Progress.—The local and general symptoms were alleviated but the condition proceeded to necrosis, because (i) the resisting power of the patient was low. (ii) the osteomyelitis was more extensive than the radiographic evidence indicated.

Fig. 32.

Radiogram shows previous case one month later. Necrosis has developed in the site of fracture. Drainage was maintained until the sequestre were discharged. Union did not take place until four months later.
GENERAL TREATMENT IN ACUTE DIFFUSED OSTEOPERIOSTITIS.

The marked toxæmia usually existing calls for careful attention to the general condition of the patient, with the object of ameliorating the symptoms, and maintaining or improving the resisting powers of the patient.

The general symptoms are usually those of asthenic fever, but the fever, however, may be of the asthenic type, either initially or following a prolonged condition of asthenic fever.

CONTROL OF PAIN.—Locally applied heat, timely drainage to liberate pus, and physiological rest frequently require to be supplemented by the administration of general sedatives.

REGULATION OF BODY TEMPERATURE.—Body temperature is reduced by means of anti-pyretics, but these should not be immediately employed. Such drugs should be resorted to principally in cases of abnormally high or prolonged high temperature. High body temperature is a symptom and not a disease; therapeutic measures are only adopted when the exaggeration of a symptom is causing harm. Abnormally high temperature or prolonged high temperature are detrimental, as they are dangerous to the heart and also sap the general strength of the patient.

In fevers of long duration repeated administration of antipyretics becomes dangerous, and tepid sponging must be resorted to as a means of controlling the body temperature.

A.P.C. Powders, which act both as a sedative and
antipyretic, usually suffice. In very severe cases Dovers Powders are indicated. Constipation resulting from toxaemia is combated by the administration of a purge. Free action of the bowels is essential in excretion of the toxic products.

Copious draughts of water are exigent to quench thirst, favour elimination via the kidneys, and supply moisture for evaporation from the skin. The skin is the chief factor in regulation of the body temperature.

Supporting treatment comprises:

1. Nourishing and easily digestible food.
2. Rest – in severe cases confinement to bed.
3. Fresh air and tonics.

In convalescence sunlight is a very beneficial curative measure.

(b) OSTEOMYELITIS.

In compound fractures of the mandible, more especially those of the body, opportunity is afforded the infection for entrance to the more open and more easily affected cancellous bone. This is a common complication of untreated, or improperly treated cases.

The predisposing causes are:

1. Lack of immobilization of fragments.
2. Inadequate blood circulation in the region.
3. Inadequate drainage of the region.
4. Highly virulent invading microorganisms, or reduced resistance of the tissues of the patient, to the particular organism.
5. Foreign bodies, teeth, roots etc. in the site of fracture.
The products of bacterial decomposition or their toxins spread in the cancellous bone with considerable rapidity, and influence the structure far in advance of the actual bacterial infection, causing progressive destruction of the bony trabeculae, and finally giving rise to the characteristic diminution of opacity to X-rays.

The exudate derived from the inflammatory reaction incited, compresses the blood vessels in the Haversian canals, cutting off the blood circulation to areas of bone. This leads to the formation of small or large areas of necrosis.

Acute septic process taking place in the vicinity of bone leads to increased radio-translucency, implying the loss of inorganic and organic structure of the bone. The exact cause of this radio translucency has not been satisfactorily settled. It is probably due to a loss of lime content in the bone.

The diminution of opacity does not imply complete loss of structure, and if the trabeculae are still to be seen (on careful examination of the X-ray) running through such a radio-translucent area, it is probable that there is only a potential cavity.

It follows that loss of radio-opacity does not necessarily mean the entire loss of the bone structure, but rather implies a diminution of the calcium content. Apparently it is mainly by virtue of this salt that radio-opacity exists, and the degree of resistance to the penetration of X-rays depends on the concentration of calcium present in the bone.

Thus, if the trabeculae still remain with some amount of lime salts in them, the condition has not progressed
beyond repair, provided correct treatment is instituted.

It does not follow that, before regeneration will commence, all the radio-translucent bone will have to be sequestrated. Some of it undoubtedly will sequestrate, for instance, those areas referred to as areas of necrosis, the blood supply of which has been completely cut off. Judicious removal of these as they loosen, or when the line of demarcation is formed, will greatly improve the local and general condition and predispose to repair, since they act as pabulum for the infecting bacteria.

Fig. 33.

This radiogram shows osteomyelitis with the formation of a large sequestrum at the lower border of the mandible.
Radiogram of case shown in Fig. 33 revealing bony union following immobilization - by means of an inter-dental splint -, establishment of drainage and removal of the sequestrum.
It should be emphasised at this stage that premature removal of dead bone will tend to result in deformity, fibrous union or non-union.

If the general condition of the patient will permit the retention of large sequestra until the formation of the involucrum, or the method of fixation allow the surgeon access to permit the removal of small sequestra from time to time, these distressing sequelae will be avoided.

LOCAL TREATMENT OF ACUTE OSTEOMYELITIS.

Consequently (if possible in the particular case) in designing the method of fixation, provision should be made for such treatment to be instituted when local and general conditions indicate that it is timely. In providing for this exigency access for the purpose of intra-oral irrigation, which is an important factor, will be simultaneously obtained.
This radiogram shows a case of osteomyelitis associated with a fracture in the molar region. (The condition was much more evident on the negative).

History.—Patient sustained fracture six weeks previously. Mobility was permitted in treatment employed during that period. When seen the local condition was alarming.
Fig. 36.

Radiogram of case shown in Fig. 35 four weeks later. The opening (0) through the saddle portion of the cast silver inter-dental splint employed, allowed for irrigation, stimulation with aromatic sulphuric acid, and removal of small sequestra as they loosened.
Fig. 37.

Photograph of patient at the stage of treatment shown in Fig. 36. No deformity is noticeable. The patient was discharged one week later.

Occasionally it happens that the general condition of the patient precludes the conservative procedure of "masterful inactivity", and indicates that the best line of treatment is operative removal of the dead bone. This treatment will seldom fail to improve the general condition of the patient, and - provided the line of demarcation has been formed between the living and dead bone - skilful eradication will not expose the patient to great danger of spread of the infection. This procedure is, however, contra-indicated in the early stages of acute osteomyelitis - for example before radiographic evidence of bone destruction can be observed.
or the line of demarcation formed—because of the risk of general or tertiary spread.

Large areas of necrotic bone can, however, be temporarily retained without causing serious general disturbance. If good drainage is established and maintained the discharge will soon become merely serous. Under these circumstances the chief effect of retaining necrotic bone is to delay complete union. Normal body reaction is capable of bringing about sequestration simultaneously with reparative changes. Should separation not occur in a reasonable time, operative procedure for their removal is indicated.

Fig. 38.
Radiogram revealing necrosis of the lower border of the mandible following osteomyelitis in the site of a fracture in the bicuspid region.
In long standing cases stimulation with aromatic sulphuric acid will do much to avoid such intervention. Careful daily movement of a large sequestrum facilitates its final removal. Small sequestra can be removed without anaesthesia, but when the time is opportune for removal of large sequestra or dead bone which has not become separated off, a general anaesthetic should be given. Frequently nitrous oxide plus oxygen analgesia is sufficient, which greatly reduces the risk of septic pneumonia resulting from inspiration of septic matter from the focus. Nitrous oxide plus oxygen anaesthesia is also to be preferred when extensive removal is undertaken to improve the general condition of the patient. It is the ideal anaesthetic when the patient is suffering from toxaemia.

The following precautions should be taken in surgical intervention for removal of sequestra or dead bone:

1. Asepsis - as in all surgical intervention.
2. Careful resection to avoid injury to the reparative tissues. It is sometimes found advisable to divide the sequestrum by means of Rongeur forceps in order to facilitate its removal.
3. After-treatment of the cavity. On removal of the sequestrum the cavity should be well irrigated with warm saline solution and then lightly packed with plain gauze soaked in Dakarin. (Should haemorrhage be excessive the cavity should be packed tightly).

When large sequestra have been removed suturing may be necessary.
The wound should be regularly redressed and irrigated for two or three days after which the irrigation only should be continued, and the cavity allowed to heal by granulation.

It is frequently necessary to modify the method of fixation in order to permit treatment and to protect the granulating cavity.

Fig. 39.

Photograph of sequestra removed from a case of necrosis of the mandible following osteomyelitis. (see Fig. 40 and history of the case)

Acute osteomyelitis is accompanied by diffused periostitis; consequently the local treatment will include that indicated for diffused osteoperiostitis. It is obvious from the discussion concerning the latter that an osteomyelitis may be secondary to an acute
osteoperiostitis.

In addition to the beforementioned local treatment it may be found necessary to drain the medulla of the bone; but usually the fracture and tooth socket provide the exit. When suppuration occurs under the periosteum, adequate drainage must be established and maintained.

Fig. 40.
Radiogram of necrosis following osteomyelitis associated with a fracture of the mandible. This X-ray was taken
after removal of sequestra (seen in Fig. 39) and establishment of tube drainage. The tube is seen in position.

History of case.- Patient sustained a fracture and was admitted to the Dental Hospital for treatment. The pref ixational surgical measures were performed and impressions taken for construction of the splint. Following relief from pain the patient, to use his own words; "decided to treat himself", and did not report until six weeks later. The case then presented an acute submaxillary cellulitis and radiographic examination revealed extensive necrosis of the mandible, with the formation of large and small sequestra.

Treatment.- Under general anaesthesia the sequestra were removed and intra-oral drainage provided. Extra- oral drainage was established and maintained by a tube as shown in radiogram. An inter-maxillary splint - providing good access to permit maintenance of the intra-oral drainage by irrigation with normal saline - was applied. The splint was retained for twelve months, and at the end of this period bone regeneration was found to have occurred.

In acute osteomyelitis there is a double indication for immobilization and establishment of free drainage because of the danger of septicaemia, pyaemia, and the formation of metastatic foci of infection in other parts of the body. Progress reports of these cases must be very carefully observed.

GENERAL TREATMENT OF ACUTE OSTEOMYELITIS.

General treatment is also along the lines suggested for treatment of diffused osteoperiostitis. Pain in the early stages is frequently extremely severe, necessitating the administration of the more powerful sedatives. Stimulants are more frequently needed to counteract the effects of toxaemia. The course of the disease is protracted and tonics are essential - especially when the patient is debilitated.
Radiograms showing the three important stages of an acute osteomyelitis which resulted in necrosis. The exciting cause was slight trauma, but because of the extremely debilitated condition of the patient, the bone involvement was extensive and the course of the disease extended over a period of two months.

Fig. 41.

Fig. 41 - At this stage diminution of opacity is seen far in advance of the focus; but the trabeculae are still visible running through the radio-translucent area. The sequestrum has not as yet formed. (unfortunately the radiograph was reversed in printing)
Fig. 42.

Radiogram showing condition when sequestrum had formed. The radio-translucency is more marked.
Fig. 45.

Radiogram showing condition after operative removal of the sequestrum. Drainage was, of course, maintained throughout the treatment. The general supporting treatment included administration of tonics.
2. SECONDARY SPREAD.

(a) LYMPHADENITIS.— When infection spreads from the primary focus via the lymphatics, resulting in enlargement of the lymph nodes and suppuration within the glands, treatment should be confined to (1) the primary focus and (2) general condition of the patient. No good purpose can be served by instituting therapeutic measures to the glands themselves so long as the capsules remain intact. It is rather the rule than the exception to find a marked lymphadenitis associated with a fracture of the mandible subsiding in forty eight hours after fixation is obtained and proper treatment of the primary focus instituted. The condition may, however, persist to a mild degree for a considerable period before returning to normal.

In the event of rupture of the gland capsule the infection travels into the cellular planes, resulting in cellulitis. A localised cellulitis referred to as periadenitis is treated after the manner adopted in cellulitis. The general treatment is that prescribed for the primary infection.

(b) CELLULITIS.— Spread of infection via the cellular tissue planes following rupture of a suppurating lymph gland, or direct spread from a primary focus, is pregnant of grave possibilities.

While submaxillary cellulitis is the more common form of spread from a primary focus in the mandible, cellulitis in the cheek also occurs. The acute conditions are frequently manifested following a comparatively long incubation period.

Marked acute submaxillary cellulitis can produce not
only grave sepsis, but also serious respiratory obstruction, and result in septic pneumonia. The resultant inflammation and suppuration in fascial planes of the floor of the mouth and neck, force the tongue upward and backward into the pharynx causing difficulty in breathing. Marked cyanosis may occur, which may be reduced by placing the patient in an upright position, or by holding the tongue forward. Obviously cyanosis per se would adversely affect the resisting powers of the patient. Respiratory embarrassment from this cause is much more prone to occur following the administration of powerful sedatives. It is my opinion that in this condition such drugs are contra-indicated. I have observed marked improvement when powerful drugs have been discontinued, pending improvement in the local condition following appropriate treatment. The improvement I think results from "allowing the patient to help himself". Should the patient become semi-comatose from exhaustion, the tongue forceps are the only means at our disposal.

The edema of the mucous membrane of the mouth may extend to the tonsils and glottis. Edema of the glottis is a grave sign, and should marked respiratory impediment ensue, a tracheotomy will have to be performed. Edematous inflammation of the glottis may be relieved by intra-oral incision of the mucous membrane of the body of the mandible. Such incisions will not materially influence the submaxillary cellulitis, and are not to be depended upon as a treatment of the chief condition.

Unless the condition of the patient precludes the procedure, the treatment must be supplemented by thorough
and regular irrigation of the primary focus with hot normal saline solution. Poulticing within the mouth is an unsatisfactory procedure.

TREATMENT OF ACUTE CELLULITIS.

The cardinal rules in local treatment of this condition are:

(I) Removal of contributing causes.
(2) Localisation of the infection.
(3) Obtaining and maintaining adequate drainage of the fascial tissue planes.

(1) Wherever possible, contributing causes such as infected teeth, foreign bodies, sequestra etc., should be removed irrespective of the severity of the inflammation.

(2) Localisation in this serious condition is best obtained by the application of heat in the form of linseed poultices. Painting around the region with ichthyol ointment is an important adjunct to the treatment.

(3) Immediately the presence of free pus is determined from local and general conditions, tube drainage should be established. Definite fluctuation may not be perceptible. It is inadvisable, even when the general condition of the patient is not alarming, to continue poulticing until pointing and spontaneous discharge take place. This modus operandi leads to unsightly scars.

PROCEDURE IN ESTABLISHING DRAINAGE IN A CASE OF ACUTE CELLULITIS.

In this condition the pus is located in the fascial planes, whether the cellulitis is in submaxillary, cheek or cervical regions. The objective is to pass a tube
of adequate size into the fascial plane, at the most
dependent part of the pus accumulation, in order to
drain the area, and to accomplish this with the minimum
of disturbance to the inflamed area. One tube is not
always sufficient.

In such acute conditions anatomical relationships
are frequently disturbed, so that in direct incision to
liberate the pus there is unusual danger of cutting
important blood vessels and nerves.

The method adopted is similar to that employed in
treatment of diffused osteoperiostitis.

Steps in procedure:

(a) Anaesthetization of the region by means of
locally applied ethyl chloride. Local anaesthesia
involves an unnecessary risk, and general anaesthesia is
frequently contra-indicated.

(b) A small skin-deep incision is made, preferably
in a natural fold of the skin, or at a point which on
subsidence of the inflammation will lie under the shadow
of the lower border of the mandible. The skin over the
region to be incised must be previously sterilized by
means of iodine or ether.

(c) A pair of sinus forceps (Fig. 44) with the beaks
closed is now placed in the opening and pushed through
the intervening tissues until, on slightly opening them,
pus runs down between the blades. The beaks are now
opened and the bulk of the pus drained. When the forceps
are withdrawn the blades are kept sufficiently open to
ensure a passage large enough to admit a rubber tube, in
order to maintain drainage. Various gauges and lengths of rubber tubing are used for this purpose; the portion which is to lie in the infected region should have nicks cut in the sides. (Fig. 44) The tube being in situ a safety pin may be passed through it at the skin level, so that with the aid of two strips of zinc oxide plaster it can be retained in position.

Hot moist fomentations are now applied to the immediate region to promote the reaction. This process must be maintained until the condition shows evidence of subsidence. During periods when fomentations are not being applied the discharging wound must be dressed with aseptic or antiseptic gauze dressing to avoid risk of
mixed infection. The region around the discharging wound must be regularly cleansed to minimise the irritation from the toxins of the discharge. When the condition has subsided it is expedient to discontinue the intubation. Tubes are foreign bodies.

It is, of course, essential to observe the strictest aseptic precautions throughout the entire procedure.

When the patient is debilitated it may be necessary to maintain free drainage for as long as three to five weeks, pending improvement in the general resistance of the patient, until such time as his tissues are capable of a reparative reaction. Indeed during this period it is not unusual to find it necessary to drain other foci of infection which may become acute.

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Fig. 45.

Photograph of a debilitated patient presenting an acute cervical cellulitis. The primary focus is an acute osteomyelitis of the mandible in the second molar region.
The photograph was taken immediately before drainage was established in the manner previously described. The marks showing on the left side of the face - in the temporal, infra-orbital and submaxillary regions - are the result of recent openings to drain acute foul occurring in these regions at various times during the course of the disease. Because of the poor general resistance of the patient the course of the disease was extended over a period of eight weeks.

Following appropriate measures to improve the general resistance of the patient in order to make possible an effective reparative reaction - in addition to the local treatment previously described - resolution occurred. The condition shown was the last to require surgical interference.

Fig. 46.

This photograph shows the same patient (Fig. 45) one week later. It will be seen that the face incisions are no longer noticeable, and that the cervical cellulitis has almost completely subsided.

The reflex muscular spasm did not entirely disappear for another week.

I am confident that, in acute cellulitis associated with fracture of the mandible, careful application of
these methods will avoid the radical operation of
reflecting the muscles and exposing the fascial planes.

**GENERAL TREATMENT.**

General supporting and stimulating treatment is
necessary. Constant vigilance must be maintained in
severe cases. The progress chart must be carefully
observed to detect early symptoms of septicaemia, pyaemia
or pneumonia. Exposure to changes of temperature will
greatly increase the risk of the last-named complication.

**(c) ERYSIPelas.**

This complication occurring in connection with a
fracture, is usually associated with a discharging sinus,
but may occur independently of a sinus. It is more prone
to occur in patients suffering from chronic debilitating
diseases, e.g. chronic alcoholism. For practical purposes
it is possible to distinguish an "erysipelas type".

The infection - which is usually streptococcal -
spreading via the lymphatics of the skin, gives rise to a
bright red rash. The skin in the region of the rash is
just sufficiently raised to be perceptible at the margins.

This slight local reaction is associated, usually,
with marked general disturbance, manifested by symptoms of
asthenic fever. If seen in the early stages the temperature
may be only slightly raised. Soon, however, marked symptoms
of asthenic fever are evident, which may be followed by those
of asthenic fever. The disease is particularly liable to
result in tertiary spread - septicaemia and pyaemia.
TREATMENT OF ERYSIPELAS.

The local treatment consists in continually painting the area and a little beyond it with counter-irritants, preferably ichthylol ointment 10%. Aconite and iodine is also effective. It is not always possible to obtain localisation, but if small areas of suppuration occur, careful drainage is beneficial as is indicated by lowering of the temperature. It is sometimes necessary to drain from time to time so that a number of incisions have to be made. Strictest precautions must be observed to prevent infection of the wounds of other patients and also of those handling such cases.

The general treatment is that indicated for the previous acute infective conditions, and since patients suffering from erysipelas are usually debilitated, tonics are requisite. Careful observation of the case is necessary in order to institute treatment for tertiary spread, should early symptoms of this condition supervene.

On subsidence of the condition appreciable disfigurement may result, (although extensive loss of tissue is unusual) e.g. an erysipelas which has involved the temporal region, may be followed by alopecia, or the hair on the affected side may quickly become white.

Spreading furunculosis may originate much in the same manner, and progress in a similar way. Accordingly the treatment is similar to that adopted in erysipelas. The infecting organism in this case is usually staphylococcus aureus but may be staphylococcus albus. Although this is a very stubborn disease there is less danger of tertiary spread.
3. TERTIARY SPREAD.

The symptoms of septicaemia and pyaemia have been previously described (vide page 48). Briefly they include those of severe toxaemia and are distinguished from this condition by:

1. The persistent high temperature of 104-105°F. frequently ushered in by a severe rigor.

2. Extreme prostration of the patient - the patient may become delirious or lapse into unconsciousness.

3. Stage of the disturbance at which the onset of symptoms is manifested.

4. Occurrence of metastatic abscesses.

5. The rapid rising and falling in temperature in the case of pyaemia.

Children, however, frequently develop extremely high temperatures from toxaemia.

The advent of subnormal temperature with feeble and rapid pulse (indicating reduced blood pressure) must be regarded as a very grave sign.

TREATMENT.

1. Thorough local treatment of the primary or secondary focus.

2. General treatment previously indicated for acute infective conditions.


The co-operation of a medical practitioner, preferably the patient's usual physician, should be obtained.
CONCLUSIONS

1. Radiographic examination, as an aid to diagnosis in addition to examination of the clinical symptoms, must be exhaustive. Radiographs should be taken at several angles and in all cases antero-posterior exposures should be made to determine the absence or presence of obscure fractures of the condyles and rami.

2. All splints must be designed to effect the maximum immobilization of the fragments; whilst the least interference is made to the function of the neighbouring tissues.

3. Any method of reduction and fixation must be constructed with due consideration to infective complications, so that access to the site of any intra-oral active infective condition is permitted.

4. The greatest difficulties experienced in the treatment of fractures are those associated with infective complications.

5. A classification of fractures and an understanding of displacements greatly simplify the choice of the best method of reduction and fixation for an individual case. The use of the face-bow is necessary to obtain the correct relation of the maxilla to the glenoid fossae in cases demanding open-bite fixation.

6. All foreign bodies in the site of fracture should be removed at the earliest possible moment irrespective of the degree of inflammatory reaction.
7. Mandibular block anaesthesia is to be preferred as the method of anaesthesia employed during such surgical intervention, or for reducing and fixing the fragments, unless the degree of trismus indicates general anaesthesia.

8. The therapeutic guidance of an acute inflammatory reaction, resulting from infection associated with a fracture of the mandible, presents difficulties not encountered in inflammatory reactions in other parts of the body.

9. Drainage of inflammatory and suppurative products should be obtained intra-orally and extra-orally as soon as possible.

10. The time to effect incision and drainage externally in acute infective complications (e.g. osteomyelitis and cellulitis) is determined—(a) by the degree of fluctuation obtained by digital examination, (b) in the case of deep seated pus formation, from observation of the clinical chart (showing records of pulse, temperature and respiration) together with subjective signs.

11. The maintenance of the drainage is essential. In many cases tube drainage is the most satisfactory method for external use.
12. The method of incision and tube drainage described in the thesis will obviate the necessity for the employment of:

(a) the radical operation of reflecting the muscles and exposing the fascial planes.

(b) free incisions into the swelling.

The resultant cicatricial tissue and deformity will be avoided.

13. In cases of osteomyelitis resulting in necrosis, the treatment recommended is incision and drainage until there is evidence of a line of demarcation between living and dead bone, and the acute symptoms have subsided. Finally removal of the sequestra preferably at intervals.

14. Throughout the treatment of fractures strict attention must be paid to the general health and hygiene of the patient in order to conserve or improve the general resistance and counteract the effects of toxaemia.
Treatment of Fractures by Mobilization and Massage. - Hennell.

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Cunningham's Anatomy.