THE TEMPOR0-MANDIBULAR SYNDROME.

J.Campbell, DDO.,LDS.

June,1953.

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"Yet the methods of the physicist have always remained essentially the same: experimenting, observing regularities, formulating mathematical laws, predicting new phenomena with the help of these laws, combining the different empirical laws into coherent theories which satisfy our sense of harmony and logical beauty, and testing these theories again by prediction."

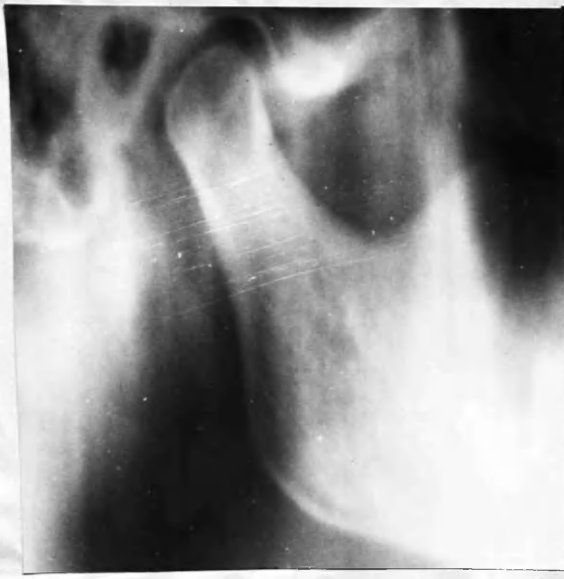
Physics and Metaphysics.

Professor M. Born, F.R.S.

Science News, 17.

Penguin Books.

FRONTISPIECE.



Left. Right.

Among the patients suffering pain whom we have studied, it is fairly common to find radiographic evidence of temporomandibular joint mal-function. Above, an example can be seen. In this case, the condyles consistently come to rest in an asymmetrical position. It may be still rash to conclude that this can be significantly associated with pain, but a technique which attempts to re-position the condyles, has had a fair measure of success.

Did faulty occlusal contact slew the condyles out of position ?

FOREWORD.

It was pure chance that the subjects which I had selected for study in the inter-War period, should prove to be those most suited to stimulate an interest in the temporomandibular joint. Thus it came about, that as early as 1938, I was attempting to relieve pain in the face,by "bite-rehabilitation". Fortunately those early cases were successful, which did much to give me a confidence in the technique which was in contrast with the scepticism pre-valent in the profession at that time. Thus, I gratefully seized the opportunity in 1948, to associate with Dr Gaylor, an eminent neurologist, in an investigation into temporo-mandibular mal-function and facial pain.

Before engaging upon our research, conditions were drawn up. It was decided that the first phase must cover four years, and must be confined to determining the efficacy of mechano-therapy only; that is to say, only splints and similar devices were to be used, so that the evaluation of the treatment might not be complicated by concurrent drug-therapy.

The improvement of the patient was to be assessed on a points scale : to qualify for the maximum five points, the patient must have complete freedom from even the slightest twinge of pain for a minimum period of three months. Four points signified an occasional but negligible pain, and the other points accordingly.

Most clinicians who accept patients suffering from pain which may have begun in the temporomandibular joint, have had their attention drawn to that part by concurrent snapping or locking of the joint. Our approach to the problem was different; we welcomed any patient suffering facial pain for which a cause could not be found. It should be noted therefore, that we accepted patients with Tic Douloureux, whether or not temporomandibular joint symptoms were present. It was anticipated that some patients, supposedly suffering from true Tic Douloureux, would prove not to fall within the exact category of this disease. Results have shown that this anticipation was well-founded.

In addition to the humanitarian hope of relieving pain, the following objectives were listed :-

(1) To study normal structure and function of the entire masticating apparatus, with particular reference to the temporomandibular joint.

(2) To seek specifications which would define normal structure and function.

(3) To study the genetic variations of the part, together with the abnormality which follows injury and disease.

(4) To study normal and abnormal growth-changes in the masticating mechanism, and the degenerations wrought by advancing years.

(5) To study the aetiology and pathology of the temporomandibular syndrome in particular, but all facial neuralgias in general.

(6) To test the hypothesis that occlusal reconstruction might relieve pain, and to investigate the means whereby such relief is obtained. To recognise and classify the painful conditions of the temporomandibular joint.

(7) To refine diagnosis and technique.

(8) To simplify technique as much as possible.

(9) To note and record all relevant data, including data which could not be fore-seen, but which would assuredly declare themselves to the observing student of the condition.

(10) To try to stimulate the body itself to do the "repair-work", rather than allow it to depend on props.

(11) To re-cast, if necessary, the research at the end of the 4 year period, in the light of experience gained.

(12) To report at the end of the interim period.

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When the format of this thesis was planned, a decision was reached to treat the subject comprehensively, rather than to concentrate on certain aspects. Successful management of the cases can only come from a broad vision.

But the broad treatment of our subject has unfortunately necessitated that description must be pruned : while this monograph is large, nonetheless it is an epitome.

By reason of the abstract quality of pain and its subjective nature, we shall prpbably never fully understand it, so that any report of work on pain must be a report of uncompleted research; this account is no exception.

In some instances, I have based my theories on deductive reasoning, but all those reported in this paper, have been confirmed when we checked on the cadaver or actual patient.

In this thesis, no major discoveries are announced, but there is much detail which when aggregated, integrates into a technique which ought not to go unpublished, especially when such a world-wide interest is being displayed on the temporomandibular joint, and so many of us "fumbling in the dark". At this stage in our knowledge, experience must be pooled.

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The reader of this paper is advised to look at the frontispiece, before taking up the text. Here we see laminagraphs of the temporomandibular joint, taken as always, at a true right-angular projection. They show that the condyles rest asymmetrically; probably occlusal contact is responsible. I have built up a proposition on the assumption that this is physiologically unsound. Is this correct ?

ACKNOWLEDGEMENTS.

I wish to acknowledge the help and guidance which I have received from Dr J.Gaylor,MA.,BSc.,MB.,FRFPSG.,MRCP.Ed. His unfailing courtesy and good-humour when dealing with trying patients has been an object-lesson. To my colleagues Dr T.C White, LRCP.,LDS.,DDO., and Mr Hamish Anderson LDS., DDO., I accord grateful thanks for their practical help and for the stimulus of their discussions. It was Mr Anderson who, on a visit to the Dental Schools of USA.,discovered the application of laminagraphy to the tempromandibular joint. I also thank my more recent colleague Mr J.A.Russell, FDS, and our technicians. I thank Mr J.S.Tough,MB.,FRCS. who provided us with post-mortem specimens. I acknowledge the valuable assistance from the Radiological Department of the Glasgow Dental Hospital, and from Dr D.Riddell Campbell,MB., FRFPSG, Medical Consultant.

Many medical and dental colleagues have sent me patients and I wish to thank them, and also the neuro-surgeons who have taken in hand those patients whom we have been unable to help.

Finally, I wish specially to thank Professor J.Aitchison, BSc.,HDD.,DDO.,FDS. who made the opportunity for this research, and whose inspiration has been the compelling force which has prompted me to write this thesis.

CONTENTS.

CHAPTER (21) Conclusions.

Chapter 1.

HOW THIS THESIS IS PLANNED.

A SHORT DESCRIPTION OF CERVICO-FACIAL ORTHOPAEDICS.

It soon became evident in the preliminary stages of this investigation, that the field of inquiry was much wider than had been anticipated, and that the restriction of the study to the temporomandibular joint would be ill-advised.

A clinical research ought to be preceeded by a study of the abnormal as derived from the normal; therefore, an early part of this paper is devoted to a discussion of the Norm Concept.

A great thirst for knowledge of the temporomandibular joint is manifest today, and it is interesting to note the diversity of route by which the various specialists have approached the subject. The surgeon, the prosthetist, the neurologist, the otolaryngologist, the periodontist and the orthodontist all find something of interest in the temporomandibular joint.

In such a situation, there is always a risk that individual specialists are not sufficiently aware of the experience and techniques of the others. This thesis is written, therefore, with the prime intention of integrating a rationale from a diversity of data.

A vast bibliography has been compiled on the temporomandibular joint. On the joint alone, without introducing allied subjects, hundreds of articles have been written, numerous monographs, and at least two full-sized text-books, (1), (2). The subject is big enough and important enough to justify a full post-graduate course of instruction of its own, but in view of the need to economize in space, this paper deals only with selected aspects. In a full course, all relevant material would be given appropriate prominence, but this thesis must be selective; the reader is warned that emphasis is laid on aspects which are either original or not yet sufficiently recognised, rather than upon those which are commonplace and generally accepted.

One of the difficulties of a "multi-start" study such as this, is the regrettable necessity of instructing the reader so far along a theme, then breaking off abruptly to take up another. In this respect, indulgence is craved, and an assurance is given that the thread of the discourse will be picked up again and later woven into the final pattern. An apology is also made for a few repititions which find their way into the text; they are intentionally used to drive points home.

THE SEQUENCE OF STUDY.

There must be a logical order in which this subject may be approached, and this paper is set out as a framework for a short post-graduate course.

Here follows the chapter headings:-

Cervico-Facial Orthopaedics.

Facial pain as a problem.

Neuro-muscular physiology.

Survey.

The characteristics of the temporomandibular syndrome.

Treatment.

Case-histories and Conclusions.

Contents of chapters.

A short explanation is here given as to the contents of the chapters.

Facial pain as a problem. Apart from the pity which it evokes, prolonged suffering poses psychological, social and domestic problems.

Neuro-muscular physiology. The extensive literature shows that much has been written, and that much remains to be written on this important subject. Only a few points which appertain to our main theme will be selected for discussion.

It will be possible to deal only in sketchy fashion with the basic science of anatomy. A few original observations on applied anatomy will be discussed. I have nothing original to contribute on the anatomy of the nerves of the involved parts; the reader is referred to the standard text-books.

Survey. This subject is discussed in fairly extensive manner, beginning with the differentiation of the abnormal from the normal. The study of normality is beset with many confusions, one of which requires that allowances should be made for acceptable variation of structure and of function in the varying age-groups.

A notion is prevalent that most dento-facial anomalies are simply explained by neglect or by environmental influence. But genetic endowment also strongly influences normality. It has even been said with some truth, that normality exists in the eye of beholder: the subject almost verges on the meta-physical!

In this section, some instruction is given on the art of observation; how the eyes can be trained to see that which can be seen, and the finger-tips trained to feel that which can be felt, and how roentgenology and other techniques may be used to ascertain deviation from normality.

The characteristics of the temporomandibular syndrome.

The symptoms of temporomandibular disorder ramify so much, and are so distinctively individual, that they defy categorization. The conclusion was reached that it was impossible to create order from such a group of disorderly symptoms, and that they could not be concisely included in one single chapter. It is expedient therefore, to break down the intended chapter, and deal "piece-meal" with its components.

Treatment. Advice will be given on the practical handling of patients. From a search of literature, it would seem that this side of the study has been rather neglected; the few authors who describe treatment have tended to concentrate on "bite-raising" techniques, and little attention has been given to other methods of repositioning the mandible.

An endeavour will be made to show the wide scope of our speciality.

A keen judgement is needed to distinguish the hopeful from the hopeless case. Many cases of facial pain are not within the province of the dentist, and should be referred to the appropriate specialist; to initiate or to prolong treatment in such cases is unwarranted; undue suffering is caused and the dentist is harassed as well as discredited.

Cervico-facial orthopaedics. As the main purpose of this thesis is to discuss facial pain and masticatory disorder, as shortly as possible, but on a broad basis, it was felt that the subject would be incomplete without including some opinions on the highly controversial subject of cervico-facial orthopaedics. Cervico-facial orthopaedics will be found threading its way throughout the entire paper. It is advisable therefore, to begin this paper with a short explanation of this concept, and its far-reaching significance.

CERVICO-FACIAL ORTHOPAEDICS.

Cervico-facial Orthopaedics is merely an extension of orthodox orthopaedic principles into the narrower field of the head and neck. It embraces mal-posture of the head upon its supporting cervical column, and the mal-posture of the mandible in its relationships with the cranial base.

Cervico-facial orthopaedics begins with the preposition that in general, Nature meant living things to be symmetrical. That exceptions to this rule can be found, there is no denying; flat-fish being one example which leaps to mind: one has only to look at the human viscera to appreciate that even the human body is not exactly symmetrical. Similarly, function will show a preference for unilateral development with consequent structural asymmetry. The symmetry of the human body is marvellous, when we recollect the influence of such things as the intra-uterine position of the baby. It is a miracle that the important endowment of symmetry can be transmitted to the subject in a few protoplasmic shreds called 'genes'. However much an individual may vary from his fellows, very little variation can be detected between his right side and his left side.

Man may not be strictly symmetrical as to the disposition of his viscera, nonetheless, he ought to be symmetrical in weight. Theoretically, his right and left sides ought to counter-balance each other, this places the centre of gravity down his spinal column.

Now, as in all biological contentions, it would be futile to accept this postulate to its utmost detail, but nevertheless, it holds good as a general principle.

Occupational attitudes, games and habits tend to unilateral development of the body and should be watched. Not only are we concerned with structure, but with function. Our main interest being mandibular function, it should be realised that dynamic balance and structural symmetry are indivisible. Truly it has been said that the creed of the orthodontist is "structural balance, functional efficiency, and aesthetic harmony". The reader interested in this subject may refer to the ample bibliography, out of which the following are selected, (3), (4), (5).

Thus far, our description has been confined to a comparison of the right and left sides of the body; let us now consider the centre of gravity of the human body as we see it in saggital plane.

Four-footed animals present no problem as to where lies the centre of gravity; it is certain to be located in the area enclosed by the four feet.

Directing our observation to standing birds, we cannot but admire the admirable arrangement for balancing; the weight of the head and neck is counter-poised by the heavy after-end.

But, as usual, Man presents problems; in this case for having the temerity to erect himself upon his two feet. When standing, he must evoke balancing mechanisms to keep himself poised on the small area of his feet.

It will be seen that if he is well-poised he will make fewer demands on his neuro-muscular balancing control: he will be sparing on his nerve replexes, and consequently more relaxed.

One method of introducing the subject of cervico-facial orthopaedics, is to represent the patient as a geometric figure, in whatever posture he may assume. For instance, a plumb-line ought to pass approximately down his spinal column as he stands. Making use of this device, the observer will be quick to recognise such features as asymmetry of the shoulders, protrusion of the abdomen, or a forward bend in the middle third of the cervical vertebrae, to quote a few examples.

Considering our patient next; as we see him in saggital view-point, we realise that the skull would tend to droop forward, were it not for the stabilising effect of the powerful post-vertebral muscles, (6), (7). In passing, one speculates on their action being abetted by the sterno-cleido mastoid muscle, the origin on which also lies behind the fulcrum.

It would be out of accordance with physiological principles, not to find a group of muscles whose purpose is to balance the pull of the post-vertebral muscles. This is provided in a linked chain of muscles in front of the cervical column, the kinetic chain being made up of two intermediate bones and three muscle groups. The masticating muscles link the cranial base to the mandible, the supra-hyoid group of muscles link the mandible to the hyoid bone, and the infra-hyoid link the hyoid bone to the sternum.

Thus, the means is furnished for maintaining stability of the head and its component parts in every possible posture. Any shift of the jaw in any of the three planes of space, will initiate neuro-muscular activity designed to stabilize the parts <u>during</u>, and at the <u>end</u> of movement.

Furthermore, a change in the position of the mandible will evoke changes in parts remote from the jaw. <u>If the mandible is habitually shifted out of its true position, the associated parts will tend to shift and</u>

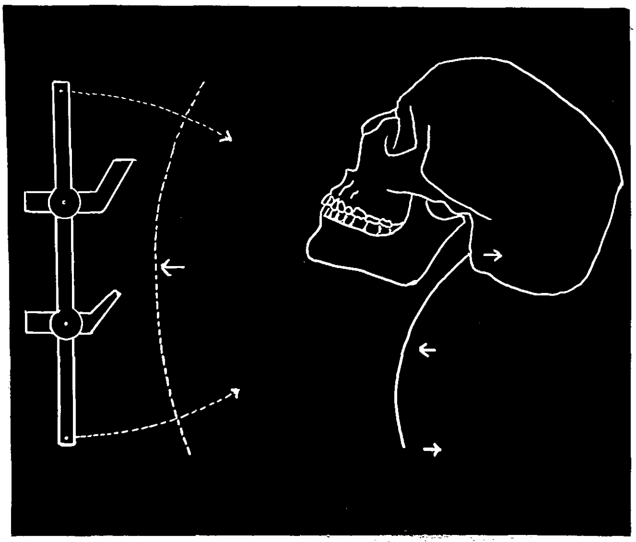

Figure 1. This demonstrates the linked chain of pre-vertebral muscles, which is made up of the masticating, the supra-hyoid, and the infra-hyoid muscle groups. The mandible and the hyoid bones are represented on the chain. The mandible is strained backwards when the middle third of the cervical vertebrae is bent forward.

remain out of true.

Conversely, associated parts which are habitually displaced, will tend to shift the mandible, the teeth and other parts out of normal physiological position.

. . .

"THE LINKED CHAIN" OF PRE-VERTEBRAL MUSCLES.

The linked chain of muscles to which reference has been made, will behave like any other chain which is fixed at each end, and then placed in tension; the links will line up on the shortest line between the fixed end-points. We extend the analogy to imagine that two bones, the mandible and the hyoid, are fixed to the chain. Now, if the upper end of the chain is swung back while the lower end remains fixed, the two intermediate bones will move back, Fig. 1. Please note the backward bend in the cervical vertebrae.

Let us apply this analogy to the human head. Let us imagine that we examine an adolescent girl, who has stooped over her home-lessons too much. Her thoracic vertebrae bend forward, and by way of compensation, she tilts back her head a little, thus bending the middle of her cervical vertebrae forwards, Fig. 2. The habitual assumption of this posture, as seen on the illustration, will tend to displace the

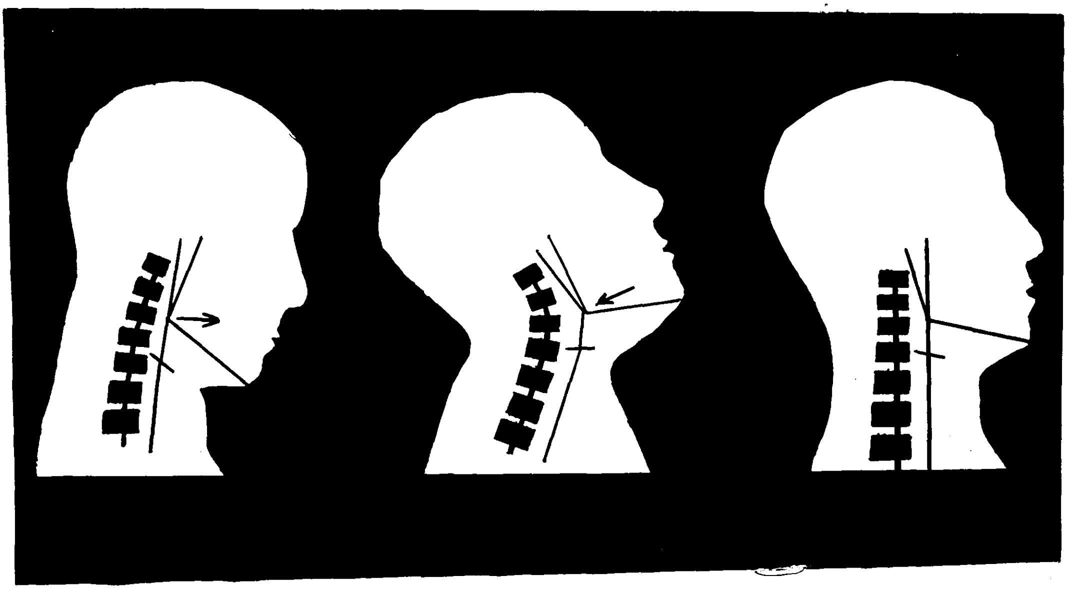

Fig. 2. Shows the effect of habitual cervical posture on the growing mandible.

mandible distally. The resultant of forces is seen in the illustration.

The reader should be warned against taking an over-simplified view-point of this hypothesis. It would be fatuous to lay down by a hard and fast rule, that the mandible shifts invariably in the manner described. Other factors exist which could readily off-set any such rule: for example, if the patient were to carry the neck habitually in extended fashion, or hunched-up, then the theory would be completely unfounded.

Conversely, if the distance between the cranium and the sternum is habitually shortened, then the chain of muscles will sag; perhaps closing the inter-occlusal space, perhaps allowing the mandible to drift forward. Nove (8) has said that hunch-backs usually have protruding mandibles. I would qualify this observation; if the hunch-back tilts his head backward to bring his eyes level again, then theoretically this ought to drag his chin back, not forward.

This hypothesis must be considered in terms of three dimensions: the head, neck and their bone components, can shift habitually in every conceivable direction, symmetrically or asymmetrically. For example, the mandible can shift closer to the maxilla, it can slew horizontally, or it can cant vertically. If the right shoulder is habitually carried higher than the left, the neck muscles on the left side will be in slightly greater isometric tension than on the right side, where the neck muscles will tend to sag. It seems reasonable to say that the bone development of the left side, in such an instance, ought to slightly out-pace the right.

It is unwarranted, at this early stage of investigation, to claim that there is significant correlation between structural asymmetry and predisposition to facial pain or any other disorder. Nevertheless, a rather convincing argument could be advanced to prove that structural asymmetry of the jaws and mal-alignment of the teeth, follow habitual mal-posture of the neck. The greatest structural distortion will occur in childhood, when bone-growth is active. I have been struck by the number of patients who have pain at the back of the neck associated with facial pain. Probably they hunch their shoulders tensely as they crouch "on guard" against the facial pain, and thus disturb posture.

If these theories are solidly founded, a

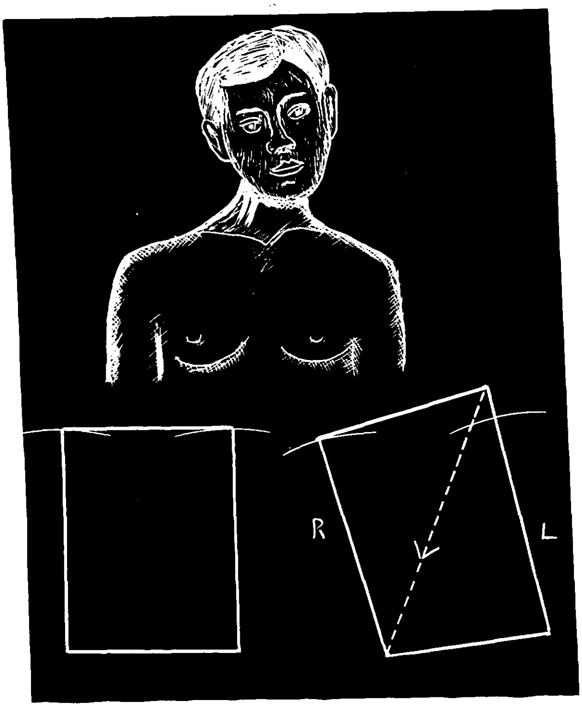

Figure 3.

As explained in the text, congenital torticollis may influence the growing bone of the skull. Indeed, any abnormal posture of the head and neck may produce some degree of structural asymmetry.

child with a permanent wry neck should grow up with skeletal asymmetry of the skull: the tight sterno-mastoid muscle, say, on the right side, should slacken the other neck muscles on the same side, and place the muscles of the opposite side in slight tension. Therefore, according to Wolff's law (9), these more active muscles should stimulate greater bone-growth on the stretched side, than on the slack side.

An investigation would entail the use of antro-posterior roentgenograms, accurately taken in a head-holding jig. The roentgenograms would be repeated from time to time, and by comparing the sides, the bone-growth would be measured. Many years of study must pass before this problem is elucidated.

If the foregoing reasoning is correct, it follows that there ought to be dental evidence to confirm it. We continue to discuss the previous example, that is, torticollis on the right side with the left skeletal face longer than the right: surely this must be accompanied by a greater distance between the basal maxillary bones (upper and lower) on the left side, than on the right, Fig. 3. If so, it means that the teeth on the right side erupt a shorter distance before meeting their occlusive counter-parts: in other words, there is a "crush-up", to use Nove's expression (10). The evidence which purports to substantiate this claim is flimsy, and could never be sustained on clinical observations alone. It is intended during the next few years, to check these contentions by roentgenegraphy, and by the use of precisely oriented upper and lower models.

There remains another aspect of cervico-facial orthopaedics to be discussed. So far, we have paid regard to the effect of habitual mal-posture upon the jaws, but could we reverse the concept and claim that mandibular displacement might affect the posture? I am bound to say that this seems to be reducing the theorem to absurd minutae; nevertheless, an alert eye will be kept for any proof.

A mandible can be displaced in many ways, but the interference of a cusp against a cusp as it searches its way into closest occlusion, is the commonest source of mandibular deflection.

Our vision would be limited, were we only to think of the displacement of the mandible and the teeth; the muscles too are displaced, in such a case.

The research workers are now beginning to become interested in the abnormal demands made upon muscles displaced in this manner. There is reason for believing that muscles which are thus strained out of position, will become habitually fatigued and ready victims of rheumatism.

The bones of the masticatory face are moulded out of available ingredients into a shape which is determined partly by a genetic intelligence within the bone cells (11), which serves to fulfill Nature's plan, and partly by the influence of muscle pressure. If the soft bone of an infant is continually pressed in a certain direction, it will tend to be moulded accordingly. It is important therefore to intercept any abnormal muscle force.

The teeth will tend to arrange themselves in a similar geometric plan, within the usual limitations of genetic endowment. It is reckoned that the long axes of the upper teeth should intersect to form a cone, the apex of which is located about 4 - 6 in. from the occlusal surfaces, above christa galli. This does not signify that occlusal wear must inevitably take the shape of the well-known Monson spherical curve. The full meaning of this point will be brought out later; in the meantime it should be observed that teeth as well as bone, take up a geometric arrangement dictated by genetic instincts which are modified by muscle forces.

Cervico-facial orthopaedics opens up another new vision; it teaches one to be cautious in accepting the present position of a patients's mandible as the correct position. When explaining the linked chain of muscles, a hint was given that the jaw might be persuaded out of its best position. Must we accept this new position of the patients's mandible without question? It can be said here that in most cases there is no choice but to accept the new jaw relationships as irretrievable; to try to true it up is likely to invite trouble. Repositioning of the mandible must be taken in hand with extreme caution, having observed all the factors involved. However, I am more convinced than ever, as a result of fifteen years experience of the technique, that many cases of facial pain are caused by temporomandibular joint disorder, which, in turn, is caused by structural and dynamic imbalance. I am convinced too, that if these cases are treated by a bio-mechanical technique, designed to reposition the mandible, many hitherto undiagnosed neuralgias will be relieved.

Dart (12), Welsh (13), and Nove (14) have drawn attention to the influence of posture on dental mal-occlusion, and have inferred that correction of mal-occlusion may improve child health. Taking the example of the retruded mandible, they believe that the muscles attached to the mandible must also be sagged back. If such a jaw can be induced permanently forward, so much the better, but they believe that if an appliance will open up the air-way by night, the child will breath more oxygen during his sleep. These claims are difficult to prove, but Nove has published a paper claiming much success in the treatment of asthmatic children by these methods (15).

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(4) Angle, E.H. Classification of Malocclusion. Dent. Cosmos. 41 : 248 1899.
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Chapter 2.

PAIN.

Facial pain is commonplace to the practising dentist. Scarcely a day passes but a diagnostic problem is brought to him for solution and each is accepted with a confidence founded on much previous success. But occasionally a problem arises which defies his skill and knowledge. By way of illustration, the case of an unfortunate hypothetical patient is here related. His pathetic story begins with his seeking aid from his doctor, perhaps from his dentist, or it may be that he initially consults a specialist such as an otolaryngologist. Each having done his best, the patient is passed from one to the other, until he loses hope. Where now, can he turn for relief? What does life hold for him? Must he accept his fate and live in dread of the next attack, hoping for the few hours or the few days of relief which are characteristic of his disease?

His physician may have referred him to the specialist neurologist, who finds that the central nervous system is sound, but still the dreadful pain goes on. The neuro-surgeon may be next consulted and it may be considered necessary to inject the gasserian ganglion with alcohol. In many cases the pain is relieved by this measure, although always at the price of a varying degree of anaethesia. Sometimes injection gives initial success but pain recurs within the year. Should a succeeding injection be contemplated, it should be borne in mind that it is not likely to be so effective, on account of the barrier of scar-tissue formed by the first injection.

The story of failure goes on. Instead of the gasserian injection, the neuro-surgeon may choose to inject with alcohol, a more peripheral branch of the Vth.nerve, commonly the infra-orbital branch, but the period of remission may be even more evanescent.

As another alternative, the surgeon may completely evulse the nerve, dragging it out of the infra-orbital foramen; but another disappointment awaits, the nerve has remarkable powers of regeneration, 1 - 5 mm. per day. Attempts have been made to prevent regeneration by plugging up the infra-orbital canal with plugging-gold, but even this drastic measure usually fails. Sung (16) (1941) claims that this operation has a chance of success, if the neuralgic condition is not too thoroughly established. I have met one patient who obtained 25 years freedom from infra-orbital pain by the operation of evulsion. Unfortunately the pain recurred.

We must be similarly pessimistic to another alternative operation, concerning which these is scant reference in the literature, namely alcoholic injection or nerve resection at the inferior dental foramen. In the two cases in which we tried it, this injection gave relief, but only for a few months. Alternatively, where a length of nerve has been resected, there are two possibilities apart from success (1) regeneration of the nerve with recurrence of pain before a year has passed, or (2) involvement of the nerve-endings in the painful tangled mass of nerve-ending and scar-tissue which is known as neuroma, for which so little can be done.

NERVE RESECTION

Two controversial views on nerve-resection are here quoted:- "Trigeminal neuralgia is one of the easiest pains to relieve because of the certainty of cure following section of the nerve". Glaser (1939) (17).

On the contrary, Harris (18), who is credited with originating the alcoholic injection of the gasserian ganglion, says, "An occasional difficulty - even impossibility - in producing total anaesthesia and cure of third division neuralgia, either by injection or by surgical resection ....". "I have given the names of the surgeons who did their best to help me, so that there can be no doubt that the operations were done with the utmost skill .... It is, however, a further illustration of my thesis that occasionally the mandibular nerve is extremely difficult, if not impossible, to destroy".

Following on such a pessimistic account, it is only fair that the patient should be informed as to his future hazards. One patient has been met who claims that she was not warned to expect the post-operative anaesthesia; she had apparently forgotten the pain she had originally suffered, but her post-operative thoughts concentrate on self-pity and in extravagantly expressed hate of her surgeon. Her life has become a misery to herself and to her family circle.

A patient should always be given a choice of refusing the gasserian ganglion resection; after all, in some neuralgic cases, periods of remission from pain occur. Then again, the threshold to pain varies; to one person a pain can be so devastating as to drive him to suicide; whereas in another patient with higher threshold, the pain may be so negligible as to be forgotten during periods when attention is diverted. In this connection, I try to assess the intensity of the pain, by ascertaining what response is obtained from the popular sedative drugs. The intensity of pain is hard to assess, being subjective, but the diagnostician is in possession of a "yard-stick" to measure it, if he knows that the pain can be controlled by, say, two aspirins.

The other point which emerges from the story of failure which has just been related, is that occasionally the pain may originate in a part which is not supplied by the Vth.nerve, and therefore will not be cured by resection of the Vth.nerve root. In later pages, cases will be quoted which give cause for the belief that other than the Vth.nerve can convey pain impulse from the temporomandibular joint.

It has been my privilege to have had under my care three patients who have undergone differential root-resection of the Vth.nerve, only to be left with the pain worse than ever. In two of the cases, the operation was done a second time. Conservative treatment of the temporomandibular joint has been able to help two of these three patients. The lesson to be learnt is that conservative treatment of the joint in the first instance, may have been all that was necessary.

PAIN

In this monograph it would be futile to

use space in a wide, philosophical discussion on pain; it has been well done in the ample literature. In this paper, it is proposed to confine the discussion to a few selected aspects. Discussion will be more or less limited to the facial pains which originate in the temporomandibular joint.

There should be little need to stress the tragedy of facial neuralgia. The suffering is not always confined to the victim; I have known cases where domestic happiness has been ruined and homes broken up. The agonies of facial pain have been described and portrayed over the centuries. The gargoyles of ancient Wells Cathedral are said to have been inspired by the facial contortions of victims of neuralgia, and Robert Burns excels in "Ode to Toothache"; his description even included the secretory response to facial pain.

HISTORICAL REFERENCES TO FACIAL PAIN

The records show that facial pain was recognised by Avincenna in 1,000 A.D. The condition was aptly described by Schlichtung in 1748. Andre, in 1756, made first use of the term "tic douloureux". At first sight it may be thought irrelevant to quote from descriptions of tic douloureux in a thesis which purports to deal with facial pain originating in the temporomandibular joint, but the pains closely resemble one another. True it is that tic douloureux is an entity of itself, the cause of which is still unknown, but which is certainly not a disorder of the temporomandibular joint. But with experience it becomes more and more apparent that very accurate perception is required to discriminate between these two conditions.

At one time it was thought that a flashing, searing pain characterised tic douloureux, but now we know that temporomandibular pain may also be flashing and searing. Diagnostic points will be described in later pages which will help to separate the two types.

In order to bring home to the reader the magnitude of the problem which confronts the clinician who expresses willingness to treat these patients, the following description is quoted from Benjamin Hutchison 1822:-

"The pains vary in their degree of intensity, at one time exciting the most piercing cries and distracted writhing and motions in the patient, while at another they are more bearable. When at the acme of their violence the parts affected are often convulsed and sometimes various contortions and grimaces are observable. These are distinct from the convulsive twitching of the muscle with which the diseased nerves communicate, which are occasioned by the irritation from excessive pain. While the contortions and grimaces are voluntary, being caused by the patient's writhing and twisting from the agony of his torture and may be prevented by firm resolution, or by firm impulse not to shrink from the attack, it barely gives warning of approach and frequently the first sign of attack is the patient starting up in a state little short of frenzy. In this condition some patients beat the parts with violence or forcibly rough them with some coarse substance till excoriation takes place and in some instances they have thus succeeded in diminishing the pain's intensity. The pains are more frequent during the day than in the night, probably from there being at this time fewer sources of irritation, and they are more frequent during conversation than in silence, and still more so at the time of mastication when attacks succeed each other with such rapidity as to appear like one continuous paroxysm, with scarcely an interval of cessation. In general only one side of the face is afflicted with this dreadful disorder but as there are cases recorded in which both sides suffered at the same time, we cannot lay down as a certain characteristic of the disease that it is unilateral. When the disease continues for a great length of time with increased violence, the patient cannot obtain respite either by night nor by day, his appetite fails and as may be expected there is some degree of pyrexia. This, however, but rarely happens and only in cases of the utmost severity".

This accurate piece of observation is as true today as it was at the date of its writing, a hundred and thirty years ago. The reader's attention is directed to the aggravation of the pain by masticating. Is it possible that Hutchison had encountered patients whose neuralgia originated in the temporomandibular joint?

Glaser 1929, described tic douloureux as follows, (19) ".... probably one of the most severely painful conditions known to medicine ...... It is confined to the second and third divisions, rarely to the first. The onset of the pain is usually sudden and violent. The pain may then leave and the patient be pain free for months or even years. After the disease has once established itself, the patient has acute paroxysms of sharp, lancinating, knife-like pains, occurring in attacks of a few seconds, with intervals of freedom. The period of repeated attacks may last from several days to several weeks, and then a remission of from months to years may occur. As the time from the original attacks increases, the intervals of freedom are lessened and the morale of the patient is lowered, so that he is in constant fear of an impending attack. The attacks are brought on by contact or by draughts of air. Occasionally, relief from pain is obtained by going to bed in a dark room and abstaining entirely from food. Trigger zones, or certain sensitive areas in the face are characteristic of the disease".

Serious thought should be given to three points in this quotation, (1) the relief obtained by abstaining from moving the jaw, (2) the avoidance of draughts with which advice I thoroughly concur, and (3) on going to bed in a dark room, wise counsel to give also to the migrainous patient. It may be said here that I believe that a type of patient exists who is prone commonly to migraine and to facial neuralgia. Indeed, the link between these two conditions is so strong that the onset of one type of pain will often lead to an attack of the other. Some observers actually designate the condition, "Migrainous Neuralgia", with some justification.

ATYPICAL NEURALGIA.

The foregoing quotations exactly describe tic douloureux, but attention has been drawn to a few points which could stand further investigation in the light of present-day knowledge.

Sharp, lancinating pain is not exclusively characteristic of tic douloureux. At a certain stage of acute dental pulpitis, this type of pain can come on with stabbing suddenness.

The subjective symptoms of dental pulp-stones are not unlike the stabs of tic douloureux, but on a minor scale. Occasionally a vague, but rather low-pitched neuralgia can be initiated by hyper-cementosis.

The diagnosis of tic douloureux can only be reached at the end of an extremely exhaustive examination. It cannot be diagnosed positively; we only arrive at the diagnosis by eliminating every other possibility. It is probably true to say that it is a rare disease; certainly it is much more rare than the so-called atypical neuralgia. As diagnostic methods become more and more refined, fewer cases are designated tic douloureux. It should not be inferred that the disease does not exist as an entity. It does exist, even though the pathologists have not yet been able to demonstrate the nerve lesion.

As to the facial pain which falls within our province, the research worker finds himself in a highly unsatisfactory position, in that he too must diagnose many of his cases by a similar process of elimination. Of course, most of our patients have positive temporomandibular joint symptoms such as crepitus, but some have only vague pain, and only arrive at the temporomandibular specialist because no other explanation can be found. The research worker is forced into the false position of designating the condition "atypical neuralgia", because it does not conform to any known pattern.

The title becomes even more ill-chosen when we presume to make a <u>type</u> of <u>atypical</u> patient, by classifying the characteristics! In addition, the use of this term implies defeatism, by suggesting inability to diagnose. I believe that with the sharpening of our perceptions and with improved knowledge, the future will see less justification of the designation 'atypical neuralgia'.

The patient who attends our clinic will often describe a sharp, lancinating pain, but on the contrary, just as many will complain of a deep boring pain. Frequently the latter is aggravated by occasional stabs of severe pain. Strange to say, we have successfully treated these three types by the same methods. The conclusion, therefore, has been reached that little diagnostic reliance can be placed on the characteristics of the pain.

To confuse us still further, it can be said that a pain which is suffered at one stage of the disease may change its characteristics in a later stage. We hear many patients describe the pain as "burning".

It should not be taken from these remarks that I deprecate the value of subjective symptoms, indeed, we make careful notes. The point is that an exact diagnosis cannot be made on the description of the pain alone.

REFERRED PAIN, AND LOCALISATION OF ITS ORIGIN

The Vth.nerve is more commonly affected by neuralgia than any other nerve in the body, but it is by no means the only one. As far as the face is concerned, there is sound reason to suspect that other nerves are involved in the pain mechanism, such as the 7th., 9th., 10th., and sympathetic nerves, perhaps the 3rd, Gaylor (20).

To-day there seems to be less enthusiasm to associate painful skin-areas with specific visceral lesions. Many workers (21) have advanced plausible hypotheses, and have mapped out such associations, but experience has taught me that these theories are only true up to a point. This is not to imply that a lesion in the course of a nerve cannot change sensation in the distribution of that nerve; to argue to the contrary would be fallacy: but I am sceptical of placing full reliance on specific skin areas of the face indicating the cause of the pain in individual teeth.

However, the research worker cannot dismiss these theories readily, and must apply himself to the study of nerve pathways, cerebral, spinal tract, ganglionic or reflex.

The solution of some of our problems as to association of painful deep and superficial regions, may come from studies of the embryo, or from comparative anatomy, or perhaps from the phylogeny of man.

The researches of Head, 1894, deserve mention. He tried to link the pain-causative visceral area and the painful cutaneous areas. He based his reasoning on the observation that in the lower vertebrates and in the early developmental phases of the human embryo, each spinal nerve which itself was formed by the union of two nerves, again divides. One branch goes to supply the skin and muscle of the back. The other branch divides; one branch goes to supply to body wall while the smaller goes to supply the internal organs.

Stones makes this comment on Head's hypotheses:- "It has been postulated that a somewhat similar analogy might be drawn with regard to the cranial nerves. Thus, with the Vth.nerve, those branches which supply the teeth are analogous to the visceral branch, while the sensory branches supply the skin of the face. Head claimed that each tooth bore a definite relationship to one or more surface areas, and that with inflammation of the nerve of the tooth, the skin of the area in question became tender. He mapped out each of the areas with its related tooth". Stone's comment is in accordance with present-day opinion, "It must, however, be pointed out that the facial areas have not been much used for diagnostic purposes". (22)

Many other workers have contributed to

our knowledge of nerve distribution by studies in embryology, comparative anatomy, and phylogeny. Lubosch 1928, Dixon 1896, Allis 1897, Valleix, and Behan are representative.

Concluding his definition of referred pain, Behan said:- "Referred pain is felt, not at the original source of the pain, but in a cutaneous area which is innervated through the same posterior ganglia or nerve root as that from which the original diseased area is supplied. In the ganglia or cord the stimuli may also be transferred from the fibres of the neuron primarily involved to those of a secondary neuron in whose distribution area the pain is felt. An example of this is ureteral colic, in which the pathological symptom is ureteral spasm that is felt as being present in somatic (surface) areas of the body".

Brodie Hughes (23) used phylogenic arguments to associate the IIIrd. and Vth.cranial nerves, "The trigeminal nerve appears to be a composite nerve comprising the old fifth nerve, originally of two roots only, and the sensory root of the third nerve. This sensory nerve supplies, in the lower animals, the pain-sensitive tissues of

the snout and nose, and is presumed to have been amalgamated with the fifth nerve and its ganglion. There is evidence, however, from comparative anatomy that the nasocillary nerve and the sphenopalatine system represent in the human being the remnant of this frontal nerve, and conform to the deep ophthalmic nerve of the lower animals (Kingsley 1926). This deep ophthalmic is easily detectable in the lower animals (Allis 1896) and has been identified in human embryos as a separate sensory ganglion associated with the third nerve (Dixon 1896). It is presumed, therefore, to be largely submerged in the various branches of the nerves mentioned above which are distributed to the deeper structures in the orbit and nose, while its cutaneous functions have been taken over by an outgrowth of the maxillary division of the original fifth nerve, known in the human as the ophthalmic nerve or first division.
It is interesting to speculate, and it cannot be more than speculation at the present time, that the atypical neuralgias described above are neuralgias affecting this remnant of a primitive deep ophthalmic nerve. Since this nerve is lying coronally to the fifth nerve, one would expect its sensory root

in the medulla to lie below that of the ophthalmic division. This would, in fact, bring it into close proximity with the dorsal horn cells of the upper cervical cord and it is easy to suppose that spread of stimulation from this sensory root would come to affect the distribution of the upper cervical nerve roots, namely the occipital region of the head, neck and upper arm. It should be clear that there is no proof of this theory, for the pathological aetiology of true trigeminal neuralgia is still unknown. If histological evidence of pathology in this condition within the trigeminal nerve could be found, then it might be expected that similar evidence of pathology in this archaic system of nerves would also be found, but such evidence, it must be stressed, is still totally lacking". (The italics are mine)

In connection with this quotation from Brodie Hughes, I have dealt with patients who have had occipital and even arm pains. Some of these bizarre pains have been cured concommitantly with the temporomandibular pain.

Some workers try to attach importance to the pain-sensitive cutaneous areas known as "trigger-spots". My only contribution to this subject is to say that most of the trigger-spots have been in the distribution of the mental branch or the infra-orbital branch. The suggestion is made that the emergence of these peripheral branches from their respective foramina has something to do with the creation of trigger-spots. It is well known that where the patient has been edentulous for many years, the alveolar ridge may have resorbed so much that the mental foramen has come to be presented upwards to the pressure of the denture. While this reasoning does not apply to the infra-orbital branch, nevertheless a similar bone resorption may form the trigger-spot.

PERIPHERAL NERVE-INJURIES

The neuro-surgeons who study peripheral nerve injuries have contributed to our knowledge of pain-causation. Behan (24) says, "Projected pain may be likened to the pain of a trigeminal neuralgia which may be felt in the teeth as a toothache some time after the teeth have been extracted. It is best exemplified by the pain apparently felt in an amputated limb a long time after the limb has been removed".

Post-extraction pains are usually traumatic, the pain disappearing as the bone heals. If pain continues unduly the cause may be found elsewhere, but always in that side of the mouth. I hold the theory that many of these post-extraction pains are sustained beyond normal duration by the disturbance to the temporomandibular joint by imbalance of occlusion. Extraction of permanent molars is the usual cause. However, the body is wonderfully adaptive to changes, especially in childhood when bone-growth is active, and the pain is usually transient.

But we return to the amputated stump pain, which is felt "in the leg that is not there". It is believed that this projected pain is due to the pinching of nerves in the scar. Is it not possible that post-extraction scars in the gums may also nip nerve-endings? That there is some justification for this speculation, is seen in the fact that patients with persistent neuralgia will often point to a painful area which shows a scar on the gum.

I am unaware of any research work done by dentists on the involvement of nerve-endings in gum scars, although Gairns and Aitchison (25) made a valuable contribution on the distribution and characteristics of the nerve-endings in normal gum. The hope is here expressed that this study will be entended to include gum scars. Weddell and his co-workers (26), studying leg-amputation scars in patients suffering from projection pains, came to the conclusion that there was significance in the space distribution of the nerve-endings snared in the scars. The continuance of the work of Aitchison and Gairns to investigate space distribution of gum-scar nerve-endings, would be welcome.

If anything significant should be derived from this suggested study, then the research might take up the histological investigation of post-herpetic scars.

POST-HERPETIC SCARS

Herpes Zoster is nowadays said to be caused by a virus infection, (27) which may have entered the body many years previously and may have remained dormant, its well-known clinical manifestations only becoming evident under the influence of an exciting cause, (or an aggregate of exciting causes) such as a draught on the face. It is a painful disease and may leave scarring which is permanently painful. Using the biopsy technique, the post-herpetic scarring should be investigated for the type of nerve-endings and their space distribution.

In making the suggestion that post-herpetic scars may cause pain, we bear in mind the ganglionic nature of the disease.

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Chapter 3.

THE PATIENT.

DANGERS OF OVER-ENTHUSIASM

The clinician who undertakes the treatment of the temporomandibular joint, must be vigilant for the first signs of frailty in his approach to facial pain. Facial pain is not all due to the temporomandibular joint. He must safeguard against over-enthusiasm. When a new patient consults him with a facial pain, there will be a natural tendency for his thoughts to jump to the joint. But many more evident probabilities exist, which can cause pain, and they should be eliminated first.

While it is true that a dental pain is usually progressive, I have known cases where a pain of dental origin has retained the same characteristics for years. However, it is a wise policy to investigate the most common cause first, namely, the teeth. We cannot take it for granted that the teeth are sound, just because the patient has been referred by a reputable dentist. A full-mouth roentgenographic examination is invaluable.

Even though the patient presents with a creaking joint, the clinician should defer temporomandibular treatment until all dental lesions are corrected. On occasion, the pit-falls will trap the best of us. For example, a recent case might have been taken in hand quite fruitlessly. The jaw locked and there was ipsilateral pain. The teeth appeared to be in good order, and the lower wisdom tooth was well-erupted. However, the X-ray disclosed a fourth lower molar pressing against the distal root of the normal third molar. These offending teeth have been recently extracted and we look forward with confidence to cessation of pain.

THE HANDLING OF PATIENTS IN FACIAL PAIN

Other flaws in the mental attitude of the clinician towards his patients may show up. He should take himself to task every so often, in the critical sense. Has he exhausted every possibility of treatment for Mrs. So-and-so, who is not responding? Is he becoming impatient with Mr. Blank, who demonstrates completed breakdown of morale? Many of these patients are difficult to handle, but who could blame them. After years of pain and searching everywhere for a cure, future life for them is grim. The sympathy of their relatives is commonly lacking; no wonder their behaviour is sometimes irrational. On occasion, we suspect that the pain has no organic reality; that it exists only in the mind: (psychalgia). It would be wrong to read into this that the patient does not suffer; indeed they do. But if such react favourably to treatment, the treatment has been psychological, and as such has no value in our research; we have no right to claim a success for mechano-therapy in such a case.

It might be argued that treating these cases is justifiable; it maybe produces a good result. But at the present stage of investigating the temporomandibular syndrome, we are really trying to establish the efficacy of bite-rehabilitation, uncomplicated by a semblance of faith-cure. If we have inadvertently talked the patient into a cure, we have only deceived ourselves.

The majority of the patients whom we have treated have been of the high-strung type, rather given to extremes of emotion; many are unusually intelligent, and in general pattern, conform to the type which recruits so many of the migraine patients; which again gives a hint that the pain-mechanisms may not be dissimilar. In a word, the patients must be treated with kindly understanding and with patience. Even those who suffer psychalgia will benefit if their problems are explained with kindly comprehension.

Bite-rehabilitation sometimes produces quick results, but sometimes improvement is slow. In the latter, the patients are inclined to become depressed, if not down-right sceptical; they must be sustained over this awkward period; the clinician must project his confidence to the patient, so that the treatment is not prematurely abandoned. Many of these sufferers are so depressed after years of searching for remission from pain, that they simply will not credit that there is hope.

NON-CO-OPERATIVE PATIENTS

As a result of experience, I now regard each patient, at the initial visit, as a potentially non-co-operative patient. That is, I give each a little talk at which I explain that no operation is contemplated provided, of course, that a reasonable certainty exists that the pain is of temporomandibular origin. Old roentgenograms are shown to the patient, and a simplified version given of the principles of treatment. If it can be arranged, a new patient will sit in the waiting room with another patient who has been cured of pain; they usually get chatting, and confidence is inspired.

It might be thought that the unco-operative side of the human nature is being exaggerated, but the facts speak for themselves. I have received a number of letters sent by medical practitioners and consultants in other hospitals, to introduce patients. In each case an appointment is made by writing but the patient sometimes does not attend.

Another group is met with; the patient gives a case-history and is given the usual routine assurances; an appointment is made to have a roentgenogram taken, but the patient does not return. In the last two years, this class amounted to about 6% of our total patients. I intend some day to present this interesting side-line of our study to a psychiatrist for his observations: it seems so utterly irrational that a patient who complains of "unbearable pain" will not avail himself of a chance of relief.

Another small group failed to return after the splints were supplied, about 2.5% of the total number of patients treated. Another 6% broke off treatment before 2 months had passed, and it can be said that no case could be considered a failure at this early stage of treatment. Often, adjustments must be made to the splints before any benefit is reached; the first new orientation of the jaw may only be the first step in the correction of a mandibular displacement.

I do not usually make any endeavour to have these recalcitrant patients return; if an appointment is broken, another is made by post-card, and if this too is ignored, then that is the end of it, and the patient is tentatively classified as sceptical, or not actually suffering severe pain. However, as a test, one patient of this class was sought out after 18 months, and it was discovered that he had worn the appliance for 8 months: the pain being gone, he discarded the splint with no return of pain.

CASE HISTORIES

As pain is subjective in character, we can only evaluate its intensity by skilled questioning; patients seldom have an exact appreciation of the weight of their words. This point is by no means negligible, as I have met patients who have submitted themselves to serious operations attended with permanent handicaps, to be relieved of a pain, which has subsequently been confessed to have been trivial: the patient has paid a heavy penalty for inexactitude of description.

Similarly, the patient's report as to the results of splint treatment must be scrutinised carefully. For example, at the end of a few weeks of treatment, when the first signs of improvement ought to be showing, the patient may deny benefit, but close questioning may establish that the pain has gone for, say, several hours of the morning after wearing the appliance all night. Another patient may look miserable and relate a pessimistic story, but questioning may elicit the fact that the present attack is the first in several weeks, a very unusual state of affairs in her history. Her present misery has effaced the memory of the previous remission of pain.

As to over-enthusiastic reports which come suspiciously early, they must be treated with the same reserve. Some of our patients would seize any 'cure' with equal assiduity, and would give a glowing report as to its efficacy, if for no other reason than to please the clinician.

From beginning to end, the whole research must be treated with scientific objectivity. The clinician himself, should be free from any tendency to assess his results with bias.

Chapter 4.

DISCUSSION OF ABNORMALITY.

DISTINGUISHING THE ABNORMAL FROM THE NORMAL

The serious student of the physiology of mastication has not long embarked on his research before he is assailed with uncertainty. The question arises, where lies the border-line between the normally functioning temporomandibular joint and the joint which functions abnormally? It is evident that normality cannot be easily defined and that it merges by degree into abnormality. When does the function of the masticating apparatus become "patho-mechanical", to use the descriptive phrase of Markowitz, (28)?

Abnormality implies a contrast with a norm, and we invade deep waters when we attempt to define normality. Such masters as Darwin, (29), Wetzel, (30), Hellman, (31), and Simon, (32), have written on the subject, although none of their studies directly concerned the temporomandibular joint. It appears that normality in one person would be abnormality in another, therefore normality connotes the functional efficiency of <u>individuality</u>.

Mershon (33) states, "For this reason, no amount of analysis of the bite or correlation of data can give us a hard and fast rule for all patients. Statistics cannot be used to determine the ideal bite for all individuals". While this reasoning concerned occlusion, it nonetheless is applicable to the temporomandibular joint. An individual's finger-prints are characteristic of no other, his face has no exact counterpart, his manner of walking is his own, and similarly his temporomandibular joint, either in its shape or in its usage, will never be exactly repeated in any other person, and as he grows older it is likely to diverge further and further from the common pattern. That is to say, a certain amount of individuality is proper, but there comes a time when individuality becomes so marked as to earn the designation of abnormality.

Intercourse between the peoples of the Earth has facilitated intermarriage, so that a human being shows an increasing trend to variation, that is, if it is right to assume that he is an assemblage of body parts. As the race continues, the heritage of an individual, as it concerns the dimensions of the components of his body, will range wider, because the permutations are infinite.

Environment is another influence which is causing man to differ from his neighbour. The environmental complexities of life are bound to produce variability in the race, in the form of the body and in its functions. Clearly, the individual stone-age man differed less from his fellows than does modern man.

On the other hand, there is a school of thought which seems to believe that phylogenic forces are actively moulding the human race into a common pattern. Zeuner (34) quotes the example of the diverse racial stock which immigrated to America, emerging in a few hundred years into a common ethnic breed.

The question remains unanswered; when does normality pass into abnormality? The most delicate perception is needed to solve this doubt, and to the end of his days, the clinician will be in difficulty to distinguish between individual normality and abnormality. Some practical examples will be given later which bring out the importance of this philosophy. In the meantime it may be said that, on the one hand subjects were found with bizarre temporomandibular joint function who were free from pain, while on the other hand, subjects had pain in the joint but had no objective symptoms. Markowitz and Gerry, (35) state, "of a group of 700 selected individuals 28 per cent had some sort of temporomandibular abnormality and 6.4 per cent had sufficient temporomandibular pain that they had at one time or another sought treatment, while more than half the abnormal group (16.4 per cent) had objective signs of abnormality but no actual subjective complaints".

ASYMMETRY

The natural occurrence of asymmetry also tends to obscure the issue. The claim has been made that no baby has yet been born that did not show some degree of structural asymmetry, (36). Intra-uterine pressures and postures have been hypothecated as causative agents. Bennett (37) claims that structural asymmetry of the cranium and jaws may follow a delayed passage of the head through the birth canal, especially if forceps be used, or even if the passage is assisted by pressure on the jaw by the hand of the mid-wife.

On the contrary, Trevor Johnson (38) quoting Professor Yoffey, says that the latter has never seen, nor expects to see, any marked degree of birth injury causing asymmetry.

Brash, (39), and Baker, (40), have also contributed notably to the study of cranial asymmetry. Brash quotes Darwin's experiments with the lop-eared rabbit, and finds in Darwin's report a remarkable parallelism of wording with Baker's report on the cranial asymmetry which followed unilateral interference with the occlusion of experimental animals. Baker took a pair of animals of varying species; leaving one untouched as a control, he took the littermate and ground down the occluding surfaces of the teeth on one side of the mouth. After some months, during which the young animals grew, he sacrificed the pair and macerated their skulls. The asymmetry which followed the disturbance of occlusion was not confined only to the jaw, but could be seen involving most cranial bones. In this respect it should be remembered that the jaw muscles have cranial origins, so that the unilateral functionless mandible will drag less on the cranial bones at the origins of the muscles, and thus there will be less stimulus to bone-growth, Wolff's Law, (41).

THE NORM OF THE INDIVIDUAL

From the foregoing discussion it will be seen that an initial step in diagnosis of the temporomandibular syndrome is the envisaging of a norm for the individual. A contrast is made between the patient and his idealised self and the extent of the departure from individual normality assessed.

Illustrating the norm of the individual and its variation from person to person, it can be said that the stocky individual has a broad, shallow palate and is likely to have good lateral excursion in his masticatory function, whereas the "bird-faced" types (vogel gesicht) generally have high, narrow palates, with a tendency to a hinge-like condylar movement, and a steep distal slope of the eminentia articularis. In passing, the opinion is here expressed that this latter feature predisposes to the temporomandibular syndrome.

Sir Arthur Keith (42) states that the overlapping of the upper incisors over the lower has only comparatively recently appeared in the human race. It should be understood that overlapping incisors restrict horizontal excursion of the mandible in the act of chewing. If the incisors overlap, it follows that the masticating stroke must be up and down. It is interesting to note, in this sense, that Aitchison (43) declares that the typical Anglo-Saxon dental arch was manifesting itself as early as a thousand years ago.

AGE-CHANGES IN THE TEMPOROMANDIBULAR JOINT.

The research worker lacks data on the changes in the temporomandibular joint, wrought by advancing years. Sillman (44) states that at birth, the rudimentary condyle is slung under that part of the bone which will be the future glenoid fossa, which is still flat. Sillman's study was anatomical and was derived from a comparison between skulls. There seems to be scope for a study of age-changes in individuals throughout life. Such a study would be clinical and radiological, although some difficulty can be anticipated with the latter; it has been our experience that laminagraphic radiography of the temporomandibular joints of young children presents unexpected obstacles, one reason being the soft nature of the condylar bone.

This projected study of age-changes in the temporomandibular joint would embrace alteration of function, and some attention would be devoted to the ability to correct mal-function.

THE ABILITY OF THE TISSUES TO ADAPT TO MAL-FUNCTION

While bone-growth activity continues, the prospects of accommodating to mal-function are good. That is to say, in a child, the occlusion may be thrown out of balance by the extraction of a permanent molar, but the osteoblastic and osteoclastic activity going on in the temporomandibular joint, will provide for the altered stresses by rearranging the shape of the mechanism.

Continuing this thought-process, it will be appreciated that such tissue changes, occurring during the age of bone-growth activity, may evolve a balance of shape and function which finally becomes the most suitable compromise in the circumstances. Consequently, in many cases it is best "to leave well alone", and serious consideration must be given, before embarking on any treatment designed to alter form and function in an adult, that is, provided that there has been no pain nor locking.

The experienced practitioner never ceases to marvel at the temerity of more naive practitioners who set about in youthful enthusiasm, the bite-rehabilitation, in an adult, of a pain-free orthodontic anomaly, by building up to an empirical height every tooth with gold inlays. Such methods can be expected to upset the compromise of physiological adjustment which has been attained during the growing years, and it is likely that the condition will no longer remain free from trouble. One has seen cases where the onset of neuralgia has coincided with the insertion of bridges, partial dentures and with tooth-grinding to relieve periodontic disorder.

The warning sounded in the previous paragraph does not imply that corrective measures are harmful. Indeed, in the literal sense of the word, "corrective" can never be out of place, but the clinician must be certain that his treatment is, in fact, corrective.

This warning applies more to techniques which alter occlusal relationships abruptly, rather than to slow, progressive methods such as orthodontic treatment, and, of course, does not concern children and adolescents, in whom adaptive bone-activity can still be utilised.

The investigator of temporomandibular function should interest himself in the changing pattern of function in the growing child who has not suffered mutilation of occlusion. My observations on this point are too recent and too few in number to justify firm conclusions, but it seems that a small minority of the population will develop a condylar hinge-axis opening of the jaw, and that this pattern is set in early childhood. A child who is going to develop in this manner will, in infancy, resemble other children in his ability to protrude the mandible horizontally, there being little obstruction neither in the shape of the eminentia articularis, nor in the form of cusp-interference. But a few cases have been seen where cusp-interferenc could not account for the loss of ability to protrude, and it is reasoned that the temporomandibular joint supplied the answer: either the distal slope of the eminence had become too steep to be "jumped" by the condyle, or that some restrictive element had appeared in the ligaments or in the muscles. The age of 10 seems to be critical in this respect; one has observed children of this age who could no longer protrude horizontally although no occlusal lock could be detected.

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Chapter 5.

THE QUEST FOR A CRITERION OF PHYSIOLOGICAL MASTICATION.

NORMAL PHYSIOLOGICAL MASTICATION: WE SEARCH FOR A CRITERION.

A prime object of this thesis has been to specify physiological mastication. If we were able to recognise physiological mastication when we saw it, then likewise we would be able to recognise malfunction. In the pages of this paper, the act of mastication will be studied and a definition will be laid down as to correct function. But we seek a living subject whose masticating equipment, and his manner of using it, would provide a model criterion against which we might match our patients. But the search for such an ideal is a Herculean task. Most of the adult mouths which we see have reached the "broken-down" stage; it is doubtful if Western civilisation can provide us with many examples of perfect mastication.

True it is that a few can be found with a caries-free dentition; fewer still with perfect alignment: but I hold the opinion that the lower third of the face of present-day man is commonly reduced in vertical dimension, to a degree which is prejudicial to the whole masticating complex.

In addition, modern man is showing a racial trend, which causes his dental arches, especially the lower, to be set more and more lingually relative to the basal bones, in both profile and frontal view-points. In profile, particularly, many of the Anglo-saxon types show the lower alveolar bone displaced distally, leaving a sharp chin-prominence, which is the fashionable facial beauty of present day. I have seen skulls where the bone which carries the lower molars, is so lingually set, that the apices of these teeth project through the bone, below the mylo-hyoid ridge.

THE POLAR ESKIMOS.

The masticating apparatus of the Eskimos attracts the dental anthropologist, because these peoples act in the role of "living fossils", to use the descriptive phrase of Huxley. That is, these tribes who obtained their sustenance from out of the seas around the Magnetic pole, had been able to preserve unbroken their primitive indentity, until the beginning of this century. Their food and the manner of its consumption must differ little from that of their stone-age ancestors.

But in recent years they have taken to eating "white man's food", with consequent deterioration in physique, in teeth, and in mandibular bone configuration. Dental anthropologists who have studied this interesting race are Waugh (45), Pederson (46), Aitchison (47), Stewart Ross (48), and Selmer Olsen (49). Waugh shows the dramatic transformation in the size of the masticatory bones during two generations; the mandible especially shows great dimensional reduction. These observers engender the belief that Western Greenland can no longer furnish us with a criterion to be used as a "yard-stick" to measure against abnormal masticatory structure and function.

To our 20th Century eyes Eskimo jaws were massive beyond normal, but surely the explanation is that we have become so accustomed to looking at deficient mandibular bone-structure, that we think that deficient jaws are normal. In a land of one-eyed men, a two-eyed man would be odd! But the two-eyed man would really be normal, not the men who had lost one eye.

The caries-free teeth of the Eskimo were beautifully aligned, and <u>were set much higher</u> from the basal bone than is commonplace today.

The characteristic heavy occlusal wear is accounted for by three factors, (1) gritty food, (2) powerful three-dimensional chewing, and (3) the utilitarian purpose to which their teeth were applied, such as softening leather by chewing. The women especially wore down the occlusal surfaces in this way and in doing so incapacitated themselves for their continued existence. When they could no longer justify their purpose in life, they were left out on the ice to die.

Discounting the filth on the Eskimo teeth, these people were more likely at the beginning of the century, than Western man, to provide us with a "target to aim at" in a search for ideal of mastication.

ANCIENT SKULLS.

It is outwith the scope of this paper to furnish the reader with a list of all the defects which are possible in the masticating apparatus of Man, other than to say that the deterioration of the teeth goes hand in hand with temporomandibular degeneration.

As we look at the strong bone and the caries-free teeth of ancient skulls, we come to realise that factors were operative in those far-off days which do not obtain to-day. It may be that the diet of ancient man provided nutritional ingredients which are not available to modern man. The simpler life of ancient man would induce more active metabolism, and his vitamin supply would be more assured.

It will be seen, therefore, that the study of the temporomandibular joint and its disorders, properly begins with the building of the body, a point of view to which I am becoming increasingly converted. That is to say, having witnessed much suffering, I try to intercept the factors which gave rise to the suffering. Therefore, as deficient bone-growth and dental caries are the basic causes of temporomandibular disorder, our concept of interception would be incomplete were we to omit reference to them. This is a big subject and can only be indicated in this paper.

Can we learn anything from the study of ancient skulls? I suggest that we can. For one thing, we receive confirmation that the occlusal plane ought to be set further from the basal bones, than is usual in modern man. As in the case of the Eskimos, the cusps were worn off rapidly, but this point should be seen in proper perspective, because cusps can wear away much before the masticating apparatus is incapacitated. When the cusps wear from the human dentition, it can still act in a manner similar to the elephant's molars, and it must be admitted that these make a very effective chewing mechanism for the elephant. The dentine surface of the ancient human tooth, with its islets and surrounds of enamel, made an effective food-mill. The action was a horizontal shear which shredded the food to pieces.

Two shearing actions exist in the human mouth, the horizontal shearing action just described, and the vertical shear which bites off food. Making use of the analogy of scissor-blades, in one case the shears cut off vertically, while in the other the shears are turned through a right-angle to operate horizontally.

It must not be read into the fore-going that cusps are useless appendages; the loss of the cusps means a drop in masticating efficiency; the loss of the sharp incisal edge is not completely replaced by the horizontal shear which also bites off food.

Another purpose of cusps is to inter-lock the occlusion, so that the jaw cannot wander; each closure of the teeth brings the jaw back to its correct occlusive relation. Later, when the behaviour pattern of the jaw muscles has been thoroughly established, these latter can be relied upon to maintain occlusive relation.

Some observors hold the view that the vertical height of the face is reduced as the cusps wear away. Others counter this argument by claiming that continuous eruption of the teeth, makes up for the loss in height, (50).

However, the lesson to be learned from ancient skulls is that they provide readable signs which tell us of the masticating habits of the owners. But, before taking up that subject, first, a few words of explanation are due on the Monson spherical curve, and the anti-Monson curve, or pitch as it is sometimes called.

THE MONSON SPHERICAL CURVE.

The Monson spherical curve evolved out of the antro-posterior curve of Spee, who claimed that the mandible could be protruded to, and returned from closed protrusive excursion, while maintaining occlusive contact. To-day, this theorem is regarded as of greater academic interest, than of practical value.

Hall (51), and Monson (52), and many others who developed the concept still further, contend that occlusal surfaces are always arranged - if normal - on the segment of a sphere, and further, that they will wear down to a spherical curve. The spherical segment is extended backward to include the condyles.

Unfortunately for the theory, very few ancient skulls show the Monson curve, and fewer modern ones.

Comparative dental anatomy helps us to under-

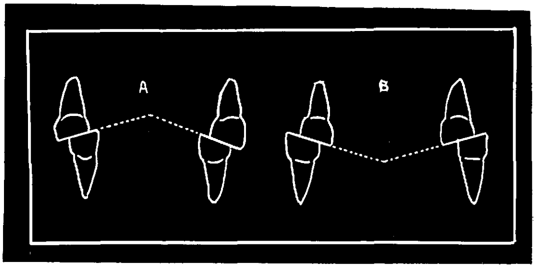

Fig. 4.

Fig. A represents the type of dentition which is seen in herbivorous animals; the upper dental arch is wider than the lower. Mastication tends to wear down the occlusal surfaces into an anti-Monson pitch. Fig. B shows the Monson pitch.

stand how these curves come to be "generated", to use the term of the engineer. Fig.4A represents the dentition of the herbivore. It will be seen that the upper dental arch is much wider than the lower, so that in habitual occlusion, the outer parts of the lower molars habitually rest on the inner parts of the upper occlusal surfaces, and abrade them during mastication. Most of the abrasion - but not all- is done during the return of the jaw from closed protrusive excursion. As the attrition goes on, an anti-Monson curve will generate, the pitch depending on the difference in arch-width, the bigger the discrepancy the steeper the pitch.

But, on the other hand, if the upper is narrower than the lower, a Monson curve will generate, Fig.4B.

Pleasure (53), and Avery (54), claim that the presence in a mouth of an anti-Monson curve signifies that the masticatory function has been correct. Pleasure examined thousands of skulls, and concluded that where arch relationship and masticatory function are sound, an anti-Monson pitch ought to develop.

THE CYCLE OF MASTICATORY FUNCTION.

Pleasure's theory confirms my observations as to the cycle of mastication, which is as follows:- (1) The jaw opens until the food can be placed between the posterior teeth, the jaw simultaneously is swung to the working side. At the same time, it is protruded slightly to place the cusps of the lower teeth immediately below those of the uppers, (2) the crushing of the food, during which the jaw swings back part of the way to habitual centric, (3) the continuance of the previous movement, but altering the direction to a retrusive and abrasive slide. Now in the possession of this knowledge, we are in a position to deduce the masticating habits of ancient man from the evidence of his occlusal wear.

DEDUCING THE MASTICATING HABITS OF ANCIENT MAN FROM HIS OCCLUSAL WEAR.

Up to a point, it is possible to deduce the masticatory function of ancient man from his occlusal wear. For instance, persistent uni-lateral chewing would cause obvious one-sided wear, with a contra-lateral deposit of tartar.

Symmetrical wear was the standard pattern in ancient man, clearly showing that his jaw ranged over a wider traverse than is to be seen to-day. He had no cusp interference to lock and prohibit lateral excursion.

Moreover, the claim is here made that when ancient man placed his posterior teeth together, his condyle never was in a strained position, and even less so when we put food between his back teeth. An ancient skull which was reported by Aitchison (55), was examined from this point of view. It was found that when the worn occlusal surfaces were placed together in any possible excursion, the condyles did not touch bone anywhere in the region of the glenoid fossa. Howbeit the teeth were placed in occlusal contact, or howbeit the jaw was placed in excursion or protrusion, bone could not touch bone. Both condyles could slide out of the glenoid fossa without actually touching even the highest part of the eminence. Other skulls have been found which showed this feature.

This observation conduces to Robinson's theory, (56) which described the jaw as a "non-lever mechanism", to use his phrase. In simple words, this indicates that no stress falls upon the temporo-mandibular joint during physiological mastication. It is not a lever of the third class with the fulcrum on the joint; it resembles a lever of the second class when the bolus of food is being compressed between the molars.

Therefore, we have gleaned some evidence from ancient skulls which can be built into our concept of normality, namely, (1) that the occlusal plane, or the functional level of mastication, should be set further from the basal bones than is commonly found, (2) that mastication ought to be more vigorous, especially during the childhood days of active bone-growth, and (3) that mastication ought to be three-dimensional and uninhibited by cusp obstruction. Such function promotes and maintains pericemental health, temporomandibular health and indeed systemic health. Conversely, the up-and-down masticating stroke sets the scene for temporomandibular disorder.

Where strong three-dimensional mastication exists, the distal slope of the eminentia articularis will be relatively flat, but the slope will incline to the vertical when mastication is up-and-down. The range of protrusion and of lateral excursion need not be greater than 6 mm.

Any interference with free three-dimensional chewing will tend to mould the temporomandibular bone so as to perpetuate the dental anomaly in the joint. Consequently, if dental interference to free excursion

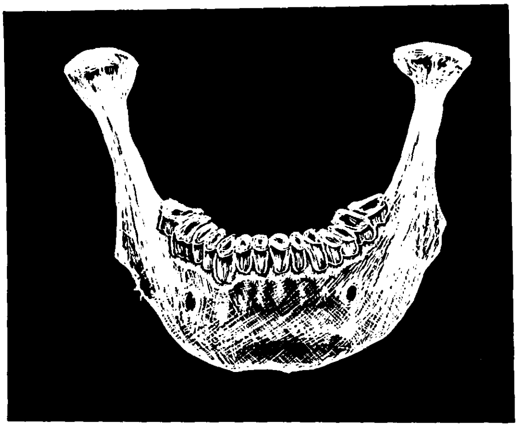

Fig. 5.

Here can be seen the anti-Monson pitch from the incisors as far back as the first permanent molars, behind which the Monson pitch commences.

is recognised and then eliminated, it is too much to expect immediate correction of the mal-function: nevertheless, a general trend back towards normality will declare itself.

I believe that a child whose chewing has been three-dimensional from his earliest days, is likely to have wider nasal passages and a slightly wider cranial base, than a child who chews his food in "up-and-down" manner. The reason is that bone will be stimulated by the outward pull of the muscle, to grow in the direction of the pull. Where lateral excursion is customary, the upper ends of the muscles will drag outwards.

It may be said in passing, that conventional table manners are detrimental to optimal bone development. The cutting of food on the plate instead of in the mouth as Nature planned, and "small mouthfuls", are evidently more suited to the adult denture-wearer than to the growing child with a caries-free mouth.

MONSON AND ANTI-MONSON PITCH CO-EXISTENT IN THE SAME MOUTH.

It is a fairly common experience to find both anti-Monson and Monson pitches present in the same dentition, Fig.5. Where it exists, the pitch from the incisors back to the first molar is always anti-Monson; at least I have seen no other. At the first molar, the pitch reverses and becomes Monson. Fig. 5.

This feature is not easily explained. At first thought, the explanation might be found in a change in difference in arch width, at this site, but in the skulls which I have inspected, this was not the case. The explanation which is offered is that our ancestors had a chewing action which differed from ours, in that the anterior part of the mandible on the working side, swung outwards from the first permanent molar forward, while the working side from here to the rear swung inwards. In other words, the vertical axis of lateral excursion for each side lay through the first permanent molar.

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Chapter 6.

FUNCTION.

MUSCLE CONDITIONING IN MANDIBULAR MALFUNCTION.

Can mal-function of the muscles be corrected? The previous chapter hinted that muscles can become set in their ways very early, but is a muscle ever set irrevocably? The newly-born child is well-endowed with suckling muscles, and theoretically he ought to have a suitable set of masticating muscles by the time he begins to masticate, but it would be fallacious to conclude that the pattern of usage is fixed at that age. Ample evidence is available that muscle function can adapt itself to adverse conditions; can the reasoning be reversed and can wrongly conditioned muscles be corrected? Let us take an example. Perhaps a child may originally close his teeth together using proper muscle action: then comes some impediment to the correct pattern of occlusion and the muscle is required to change its action. For instance, cusp-interference may slew the mandible out of true: to begin with the synergia of mandibular muscles may try to bring the jaws together as originally, but when this is no longer possible, the jaw is brought to the new occlusive position directly without a step in the path of closure. The student of mandibular function, encountering for the first time the concept of cusp-interference, expects to see the mandible approach the maxilla in a certain direction, only to be shot off in another direction, in the last phase of closure. If he expects this he will be disappointed, because the reflexes become conditioned to avoid the interference and to bring the jaw into final occlusion with the least warning from the proprioceptive sensory mechanism of the pericemental membranes.

Now, if it be thus conceded that muscles can be conditioned to adapt themselves to a degenerated occlusion, surely it is not too much to claim that they can be reconditioned at least partly in the direction of re-habilitation. But I am bound to say that the power to rectify a faulty muscle pattern declines with advancing years. An analogy is the case of a golfer who has a "grooved" swing, having taken up the game in his childhood; but a golfer can anticipate that his muscles will learn to co-ordinate more reluctantly should he begin in his late forties. Only with difficulty will he be able to synergise the golf muscles. Nevertheless, I believe that he has an easier task to learn new muscle habits than the patient with an over-closed and displaced mandible, especially if the latter be grossly under-developed.

THE IMPORTANCE OF THE MASTICATING AND FACIAL MUSCLES TO THE TEMPOROMANDIBULAR JOINT.

It is only possible here to give a sketchy survey of the aatomy and physiology of the muscles related to the mandible. Selected aspects will be described, greatest space being allotted to points of view not generally appreciated. Many of the opinions expressed are unorthodox.

The muscles of facial expression are dismissed with the short statement that they play a minor but not negligible role in the act of mastication. Aided by the tongue these muscles place the bolus of food between the upper and lower posterior teeth in preparation for the chewing stroke. They also take part in speech, in swallowing and in other functional acts which entail movement in the temporomandibular joints.

SWALLOWING.

The study of the act of swallowing has received great impetus of recent years, but it must be confessed that it is still dimly understood. While unable to describe it in full detail, we sense the importance of the act: there is much muscular power evoked and as it is so oft-repeated each day, speculation is rife as to how it may influence growing bone for better or for worse. Conversely, abberation of the jaw bones may affect the act of swallowing.

However much this postulate may be disputed, there can be no denying that young patients with diminutive mandibles often have restless lips, puckered out of harmonious shape; and the continuous posturing of the lips often results in over-growth and wrinkling of the mentalis muscle. When swallowing, a typical patient of this type will place his tongue on his teeth before "triggering off" the act.

Assuming once again that a proper muscular function is a necessary stimulus to optimal bone-growth, and remembering that the most persistent growth-centre in the body is located in the condylar head, then we have gone some way towards explaining why the mandible of modern man compares so unfavourably with his neolithic ancestor: soft food has perverted the swallowing act.

MANDIBULAR GROWTH IN ANKYLOSIS.

A few patients have been seen whose retarded mandibular development has been attributed to birth-injury, that is to say, to damage to one of the growth centres on the condylar head. Many authors have reported cases including Rushton (57). In severe cases the affected side does not grow larger than its size at birth, i.e. from the period of arrest of development. But, is it possible that milder cases of retardation are more common than generally suspected? Could that continuous form of traumatism to the joint tissues which follows displacement of the jaw, set up a mild but chronic inflammation which causes the under-developed mandible so rife in Western civilisation.

DIET AND THE UNDER-DEVELOPED MANDIBLE.

While we may speculate as to the damage done to the temporomandibular joint by low-grade inflammation, a more logical opinion is that the prime factor is the increasing softness of our diet, which may also lack essential ingredients - vitamins and amino acids - and which may have suffered from prolonged storage. The student of temporomandibular function must be discouraged from viewing his specialty from too narrow a vantage; the full picture can only be filled in by an acquaintanceship with preventive dentistry, dietetics, soil preservation and the social sciences. A full discussion is outside the scope of this paper.

I personally suspect that there is some inherent weakness in the bone of the mandible. It does not seem to be so able to withstand 'deep X-ray therapy' as well as other bones, McLennan (58).

The alveolar bone of the mandible particularly seems to be undergoing a racial reduction in height and it is being set further back relative to the basal bone as generation succeeds generation.

This discussion is relevant to our main theme in two respects, (1) it brings out that occurrence of dento-facial anomaly is increasing with consequential higher incidence of temporomandibular disorder, (2) the trend to the racial reduction of the mandible causes degenerative influences to be more potent than regenerative influences: in short, temporomandibular breakdown is difficult to re-habilitate. Or in other words, more influence will be brought to bear by a factor which "flows with the current", rather than by a factor which "swims against the current" of phylogeny.

MANDIBULAR BONE-GROWTH AND THE ANTICIPATORY POINT OF VIEW.

If the theorem be granted that inadequate stimulus - or wrong stimulus - is responsible for mandibular under-development, then the clinician would be failing in his duty were he to neglect to watch for the earliest signs of mal-function.

BRUXISM.

Already reference has been made to lack of repose in the muscles of the face, usually to be seen in high-strung people, who incidentally are liable to have a low threshold to pain. Instead of being composed, the face is tense and agitated; the lines indicate the tensions most commonly set in the face. I believe that a study is overdue on the facial wrinkles, how they are caused, and how characteristic wrinkles are caused by habitual tension or relaxation of certain muscles. This proposed study would take into account that most wrinkles are due to the loss of the fat in the cheeks and lips.

Just as wrinkles are the end-result of muscular habits, so too is the occlusal wear associated with bruxism, sometimes to be seen in anteriors, sometimes on the posteriors. Although the observer can often see the "pulsating masseter", the habit reaches its culminating point when the subject is asleep, when the noise of the grating teeth can be astonishingly loud. No opinion is here expressed concerning the old-fashioned belief that tooth-grinding denotes tape-worm infestation of the intestinal tract. But the tooth-grinding habit can have a systemic as well as a local origin; perhaps it is a manifestation of a general systemic muscular hyper-tension. If so, local treatment would fail, or at least be inadequate. In such cases the services of the physician or the psychiatrist would be needed to deal with the systemic or emotional aspects.

It is more probable, however, that the cause of the habitual chewing habit is to be found in a defect in the masticating apparatus.

I feel that much knowledge remains to be gathered on mandibular and systemic muscle tensions, and electromyography places in our hands a research tool, the potentialities of which are not yet appreciated. The problem as to whether a patient's mandibular tension is derived from a generalised state could then be readily answered.

Jensen (59) states that the masseter muscle is especially responsive to a generalised disorganised muscular activity, so that this muscle should be scrutinised for signs of unusual activity.

OTHER EXAMPLES OF UNUSUAL FACIAL EXPRESSION.

A flickering of the face, usually in the middle third, can occasionally be seen in patients who are suffering pain. This flickering must be differentiated from that which is to be found in the eye-lids of normal persons who lack sleep. Flickering is an objective sign; subjectively the patient will describe in varying phrases, crawling sensations such as "worms crawling under the skin".

A few patients have been encountered whose chins tremble abnormally, which must be distinguished from the generalised agitation of Parkinson's Disease. If the cause is strictly local, the trembling can be attributed to lack of occlusive support.

Sometimes there is to be seen a mask-life facial expression, which also may indicate some generalised systemic degeneration such as disseminated sclerosis; indeed, although it is too early to express a positive opinion, a surprisingly high number of patients under our treatment are found by Dr.Gaylor to be suffering from this disease. Gaylor (60), and Harris (61), have drawn attention to the fact that facial neuralgia is often one of the first symptoms of disseminated sclerosis, which may declare itself positively many years later.

However, it would be wrong to say that all of these cases of mask-like faces have a systemic origin; the cause may be a diffuse swelling of the cellular tissues of the cheek, perhaps reflex in origin. I have seen on several occasions a patient in severe pain, certainly not septic in origin, visibly swollen over the cheek, the swelling disappearing with the cessation of the neuralgic pain. The swelling could be described as edematous, and in a small number of cases there was perspiring and flushing locally over the painful area, which suggest involvement of the autonomic nervous system. Their manifestations lead one to the belief that pains of this type are exhibited through the neuro-vascular system. This opinion is strengthened by the occasional occurrence of "pins and needles" on the face; when "pins and needles" occur in the leg, the cause is almost certainly vascular.

One hesitates to make use of the term "bruxism" where all the teeth have been lost, but it seems justified as we have been regarding the accompanying occlusal wear as an expression of muscular restlessness. Therefore the extraction of all the teeth is no certain cure for the pain which is sometimes experienced in these cases. Indeed such a facial neuralgia can be worsened by extraction, as the increased closure of the vertical dimension may aggravate the pain of a displaced condyle.

The continued presence of the natural teeth, even though they be of poor quality, is helpful for another reason; they offer suitable landmarks for determining the degree and direction of jaw displacement, and they may show a particular type of attrition which supplies the clue to the "pathomechanical" force.

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Chapter 7.

THE PHYSIOLOGY OF NERVE AND MUSCLE.

MUSCULAR DISHARMONY AND NEURO-MUSCULAR CONSIDERATIONS.

Mention has been made of bruxism and the harm which it may do to the teeth, but continual muscle agitation may cause injury in another respect. The human jaw, like any other bone under the influence of muscle, will lie in a position of rest at which opposing muscle groups will balance. Let us suppose that a person must over-close to place his posterior teeth together; further, that he has been continually doing so for years. This means, in terms of muscle physiology, that the masticating muscles (the closing group) are shortened more often than not, or over-relaxed, while the muscles which open the jaw are repeatedly in excessive tension. Now, in muscles and tendons are to be found stretch-reflex receptors: can we assume that this nerve mechanism is unduly activated? Up the afferent neurons will pass an inordinate amount of nerve impulse, to be succeeded by the firing of excessive motor stimuli. Is it fair, in this context, to quote Samson Wright (62), "If motor nerve stimulation is repeated for a sufficient length of time, fatigue develops". It is not unreasonable to assume that the accumulation of metabolites around the motor end-plates in the muscle fibres might instigate a relay of afferent and efferent impulses of greater intensity than is found in a normal relaxed subject. Furthermore, these excessive impulses may be reverberatory, that is, throwing back into both local and higher ganglionic circuits, thus building up a vicious circle of impulse in the nerve arcs. Wright defines reverberation:- "Reverberation or sustained activity so produced in the nerve centres leads to after-discharge of the motor neurones and offers opportunities for facilitation or central summation". Summation is defined by Langley and Cheraskin (63) "Because the refractive periods are so brief, skeletal muscle may be stimulated again during the contraction phase. If a second stimulus is given during this phase, one wave of contraction is added to the other and the total tension so produced is greater than the force of contraction of either one alone".

TEMPORAL SUMMATION.

The same authors describe summation in time and in space. "Temporal summation:- Some fibres are incapable of transmitting an impulse of sufficient amplitude to excite a secondary neuron. Such inadequate stimuli are called subminimal or subliminal. It is believed that such subminimal stimulation (in itself incapable of firing the next neuron) nonetheless produces a change in the succeeding neuron - a change resulting in a greater or easier excitability of such a neuron. The increased excitability of the secondary neuron or the state produced in that neuron is called the <u>central excitatory state</u> (c.e.s.). Theoretically at least, a second subminimal impulse could fire this now more excitable neuron".

<u>SPATIAL SUMMATION</u>.

These authors define Spatial Summation:- "If two fibres each conveying a subminimal impulse converge upon the same post-synaptic fibre, the simultaneous firing of both will result in activation of the secondary neuron. As the two impulses are not separated in time (temporal summation) but in space, this phenomenon is called <u>spatial summation</u>. Precisely how this mechanism works is still unknown. It is possible that the sum of the two sub-threshold stimuli produces a minimal stimulus adequate for activation of the secondary neuron ...... On the other hand, the first stimulus may create a central excitatory state and the second stimulus may take advantage of the decreased threshold and activate the post-synaptic neuron. The phenomenon of spatial summation is the basis for <u>facilitation</u>, which simply means that one impulse has aided or facilitated another impulse. This concept has fundamental significance ......".

The significance to our theme is that while temporomandibular disease may not be entirely responsible for a facial pain, it may be a contributory factor. That is to say, the subminimal stimuli passing up the neuron from the disordered part, may not of themselves be sufficient to record as perceptible pain, but may facilitate co-existent stimuli from another source, either in time or in space. The effect is additive.

A simple analogy is here used to convey the lesson. We imagine that a child opens his box of playing bricks, and he begins to place one on top of the other. He finds that three bricks, for example, are needed to rise to a certain level, or threshold. But one brick could reach up to the threshold too, if it were big enough. But normally it takes more than one brick piled on top of others to reach the threshold. But in other circumstances, the threshold could be very low and easily over-topped.

The analogy is too trite to need interpretation.

THE NERVE SUPPLY TO THE TEMPOROMANDIBULAR JOINT.

I have no intention of using the space of this paper in a discussion of the nerve supply to the temporomandibular joint, other than to say that scant attention has apparently been paid to it, or alternatively, that the problem has been beyond elucidation so far. Even Gardner,

who has written so extensively on the nerve supply to diarthrodial joints, has apparently not yet tackled the temporomandibular joint, (64), (65), (66).
He is here quoted, :- "and there have been relatively few experimental studies of other functions of these nerves. The reception of painful stimuli is undoubtedly one of these functions, and it seems certain that receptors in and around the joint are important in the position sense". "It has been known for years that nerves can be traced to most of the joints in the body. On this account, it is generally assumed that our knowledge of this distribution is detailed. Yet a survey of current text-books of human anatomy reveals how incomplete this knowledge actually is".

In his study of the knee-joint, he traces the nerve supply, showing its complexity, and then says:- "It is thus made obvious that section of a single nerve for arthritic pain might very well fail to relieve that pain".

Many of the conclusions of this research worker, which he has drawn from the study of other joints, might apply to the temporomandibular joint. For example, in connection with the knee, he states that all the nerves which supply the muscles which can bring about major movements at the knee, send branches to the knee joint. Dare we assume that the same reasoning can be applied to the temporomandibular joint?

MUSCLE BALANCE AND THE SKELETAL FORM.

Where the edentulous mandible is over-closed, with consequential imbalance of the opposing muscle groups (flexors and extensors), even the remote mimetic muscles may be influenced. It is well-known that these are truly muscles of expression; that they portray the physical and emotional states. But if the mandible has been shifting consistently closer to the maxilla, thus sagging the masticating muscles, the mimetic muscles can be expected to sag too. A deep in-folding of the lower lip is commonly seen, so deep that the lip is often inverted.

This closure of the vertical dimension or "concertinaing" of the lower third must inevitably be accompanied by changes in the facial expression. Indeed, the sagging of the muscles over the inadequately developed bone on the jaws suggests the analogy of a tiny man wearing a suit of clothes belonging to a large, stout man!

MUSCLE BALANCE.

Let us examine more closely the theories of muscle balance. In 1925, Sir Charles Sherrington said:- "Muscles are sensitive to stretch and automatically (reflexly) adjust their activity to changes in tension and stretch". It is a reasonable thesis, therefore, that there must be a position of inter-jaw relationship at which the forces of the opposing muscle groups come to a balance. A school of thought, headed by Thompson (67), Niswonger (68), and Bennett (69), believes that this inter-maxillary relationship is constant throughout life for the individual and is genetically endowed; the word "predestined" has been used.

This implies that the pattern of muscle behaviour is also transmitted in the genes, i.e. that the length of the muscle, its resting tonicity, its maximum and minimum tensions and all the behaviour patterns of his muscles are genetic. This theory does not invalidate the other theory that muscles may be conditioned. The literature has been searched and a geneticist consulted for confirmation of this former theory, without success. The real essence of this unorthodox concept is the separate inheritance of the muscular and skeletal patterns; that the shape of the jaw bones and the lengths of the jaw muscles are not always in accord. Such a conception would seem to contradict the common belief that the prime duty of the muscles is to actuate the bony framework of the body, and that the length of the muscle by some means adjusts itself optimally to the dimensions of the bony framework. Some confirmation for the unorthodox opinion here expressed is furnished by the fact that the development of facial bone lags behind the development of infant muscle. I believe that there is a tendence for muscles to adjust their lengths to bone, but it is a very slow process.

CLOSURE OF VERTICAL DIMENSION BY EXTRACTION OR OTHERWISE.

It should be noted that the extraction of teeth is not the sole cause of the closure of the vertical dimension of the lower third of the face. If we can accept the postulate that sagging muscles indicate "inadequate filling-up of the vertical dimension", then we have seen many children as well as adults in possession of a full set of natural teeth (admittedly not in proper position), with a closed vertical dimension. In passing, the observer must not allow himself to be deceived by the "puppy-fat" which is to be seen on the faces of most children. The explanation seems to be that many people do not develop enough height of alveolar bone. Phrasing this thought differently, it might be said that the muscles are more in accord with the "blue print" of the human race than the under-lying facial bones. Therefore, the muscles supply the clinician with a more reliable index as to the correct shape of the face, particularly length.

The question arises, why is the bone more likely to be affected by degrading influences? Maybe the answer is to be found in the phylogeny of the race; muscle, being more primitive than bone, became biologically fixed earlier than bone and consequently is more resistant. On the other hand, may reduced access to high-quality nutrients, be the sole reason for the reduction in size of the modern mandible?

To sum up this point:- Muscles are often out of accord with the facial bone; they can be "physiologically longer" than is optimal for the underlying bony framework, which does not promote maximum physiological efficiency. Furthermore, a faulty muscle pattern may be seen in cases where the muscles are pushed aside (perhaps on one side only) by some feature in the mouth which interferes with structural balance. It should be clear that the term "muscular balance" does not only infer functional symmetry, i.e. a comparison of right to left, but also the balance between the flexors and extensors of the jaw.

I wish to attract serious attention to the possibility that muscles can be displaced as well as bone.

In an article in the Dental Record, I used the analogy of a tug-of-war contest to represent the flexors and extensors, (70). The teams might keep the forces balanced even though heaving powerfully against one another, or on the other hand, balance could be maintained even though they merely leaned on the ropes.

It would be wise to point out that muscle imbalance is not the sole cause of facial pain; nevertheless it is one of the pillars in the foundation of our subject.

MUSCLE IMBALANCE AND STRAIN.

Perhaps it was unfortunate that our study of muscle balance began with those which are inserted into that most complicated of human bones, namely the mandible. The leg muscles present easier material for study. Floyd and Silver (71) describe electro-myographic experiments for investigating how the leg operates in the maintenance of body balance in standing posture:- "Without any muscle balance at all, the body, theoretically, can be stood upright in a position of balance, just as a pencil can be balanced on its point. The position is, however, an unstable one, and the slightest displacement from the position of balance would cause the body to fall over. In practice, there are continual slight swaying movements in the normal upright position ....".

These workers based their study on the fact that electro-potentials can be recorded from contracting muscles, whereas relaxed muscles are electrically silent. They recorded graphically the continual muscle adjustments required to keep the body upright.

Here I make a suggestion; let us ask the subject who is holding this standing pose, to tip over on to the outside of his foot. Soon fatigue, cramp and pain would supervene. Are we warranted in assuming that painful jaw muscles caused by disordered jaw relationships could furnish an explanation of one type of facial pain? It is not suggested that the jaw muscles become clogged-up with fatigue metabolites, like the muscles of an athlete at the end of his race, but I believe that continual over-strain of muscle may, under certain conditions, contribute to pain-causation.

One reads with interest of the experiments of Pruzansky (72), Carlsöö (73), and Moyers (74), who have made electro-myographic recordings of mandibular function. Among the wealth of information derived, was a point which may have deep significance: patients with a natural pre-normal mandible demonstrate electro-disturbance in the masticating muscles. It can be confidently expressed that this observation will be valuable to the orthodontist and may have its application to the treatment of pains originating in mal-function of the mandible.

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Chapter 8.

ELECTRO-MYOGRAPHY.

ELECTRO-MYOGRAPHY.

It is considered necessary, in view of the promise which electro-myography holds for the research worker, that a short exposition of the underlying principles be given here.

To auscultation, a relaxed muscle is silent, but a rumbling noise can be heard in an amplifying stethoscope, at the moment of its contraction. Similarly, a relaxed muscle ie electrically silent, but the contraction of the muscle can be recorded as alteration of electric potentials. The apparatus used by the observers of mandibular function is evolved out of that which has been utilised by the physiologists, and it is not unlike the well-known cardiograph. The electro-potentials can be recorded either in form of ink-writing, or, better still, by cathode-ray oscillograph.

On the skin, over the muscles under survey, the electrodes are fixed by 'sello-tape'. Such a method can only be used in the case of muscles near to the surface, so that needle electrodes must be inserted into the deeply-seated lateral pterygoid and medial pterygoid (internal pterygoid) muscles. This electrode consists of a thin wire insulated co-axially from the hypodermic needle which supports it. Unfortunately for accuracy, the insertion of a needle through a muscle causes a slight spasm.

Essentially, the apparatus consists of the electrodes and an amplifying device. The diagnosis of neuromuscular disease consists in making a comparison between the electro-recordings of known normals and those of the patient who is clinically suspect.

The variation may show as an alteration in amplitude or in the appearance of interference-patterns. For example, the patient may suffer from a generalised weak muscular state (myasthenia), or on the other hand, systemically the muscles may be normal, but certain mandibular muscles may be weak. In generalised weakness, the graph would show that every muscle in the body recorded a low amplitude pattern, whereas, a local muscular weakness, or even a hypertension, would contrast with the normal muscles elsewhere. Characteristic amplitude and time-sequence patterns have been worked out for such conditions as Parkinson's disease, myasthenia gravis, residual effects of bulbar poliomyelitis, and tumor in the vicinity of the motor root of the Vth.nerve.

Prusansky (72), Moyers (74) and Carlsöö (73) have applied the instrument to the study of mandibular function. Carlsöö separates the action of the temporalis into two arbitrarily declared sectors; the other two investigators declare three sectors. All are able, by using surface electrodes, to record separate muscular activity in the sectors. That is to say, the temporalis, because of its breadth and its fan-shape, changes the direction of its fibres from front to back by about a hundred degrees; so that separate groups of fibres running in different directions can move the mandible in different ways. For example, the coronoid process may be pulled backwards, or upwards, or even slightly forwards. This ability of electro-myography to fractionate the activity of a single muscle, as well as to inform us as to the detail of muscle synergia, holds great promise.

Prusansky conducted his experiments with four electrodes on the working side, one fixed over the masseter, and one over each of the three declared bellies of the temporal muscle, i.e. anterior, middle and posterior. His data was collected under three sets of mandibular function, (1) the chewing of gum and recording ipsilaterally, that is, recording on the same side as the working side, (2) recording contra-laterally, that is, recording, for example, on the right side while gum was chewed on the left, (3) on this occasion the gum was chewed exclusively by the incisors.

The conclusions were impressive. A distinct pattern which came to be recognised as representative of normality, showed that on the working side, each recorded muscle part, discharged synchronously and with equal amplitude. This ideal graph could only be produced by a person who had uninhibited ability for lateral excursion of the jaw; that is to say, if there was any impedance to lateral excursion in the form of cusp-interference, so causing the patient to perform an "up and down, chopping" masticating stroke, this could be recognised on the graph in characteristic abnormal amplitude and synchronisation. It was pleasant, thus, to receive this substantiation of previously-held theories which were based on clinical observation.

In contra-lateral recording, the masseter on this balancing side was seen to perform practically no service, whereas it is reckoned to be the most powerful of the working-side muscles. This suggests that on the non-working side (the so-called balancing side), the masseter is functionless, and that the balancing condyle is swung widely downwards and forwards by the action of the lateral pterygoid muscle together with some slight assistance from the other masticating muscles. When the balancing condyle is thus swung forward, only the horizontally disposed distal temporal fibres record activity. What does this signify? In another page, the assertion is made that the lateral pterygoid muscle pulls forward the neck of the condyle, in this instance, on the balancing side.

Then on the condyle being required to return to rest position, the lateral pterygoid muscle relaxes rather "reluctantly", by this means keeping the condyle and its meniscus in firm sliding contact with the distal slope. In other words, the continuing muscle tension protects the capsular ligament.

Now, are we at liberty to conclude that the tension of the lateral pterygoid muscle is that which is indirectly recorded on the electro-myograph? The fact that the backward-pulling temporalis fibres record activity demonstrates counter-activity in the direct antagonist, the lateral pterygoid muscle. This conclusion has only been reached by reasoning; up to date, Prusansky has not investigated this point. It would be studied by inserting a co-axial needle electrode into the lateral pterygoid muscle, then recording the activity of this muscle, simultaneously recording the distal temporalis group.

RECORDING OF INCISION (PRUSANSKY).

When the incisor teeth were used exclusively for chewing, and with the electrodes in the positions described, only slight activity was recorded in the temporal muscle and that was in the anterior fibres. But the masseter demonstrated short bursts of high activity.

SUMMARY OF ELECTRO-MYOGRAPHY.

A full discussion of electro-myography is outwith the scope of this monograph. The technique holds out high promise. Because it is a basic and factual branch of the science of physiology, it enables us to break down for study one of the most complicated of muscular synergias.

Should characteristic neuro-muscular patterns prove to be associated with particular dento-facial anomalies, in the future we may be able to link cause with effect, and putting our new knowledge to practical application so intercept the development of the more gross anomalies. For example, should we find an electromyographic pattern in a young child which has been previously and significantly associated with a mandibular protrusion, then appropriate dissection of parts of muscle during the years of continuing bone-growth might abort further disorder.

Electro-myography is being used in fields wider than dentistry. Many disease conditions exist which manifest themselves by neuro-muscular disturbances. This new research tool offers a means of determining the particular level at which the exciting cause is located.

As the years go by, I have become increasingly persuaded that one of the dominant factors in the study of facial pain is to be found in the neuro-muscular system of the head and neck. From whatever facet of dentistry the subject is approached, whether from the study of occlusion, of pericemental trauma, or of the anatomy of the temporomandibular joint, the investigator eventually finds himself led to neuro-muscular physiology.

Chapter 9.

FUNCTIONAL ANATOMY OF THE TEMPOROMANDIBULAR JOINT.

THE FUNCTIONAL ANATOMY OF THE LATERAL PTERYGOID MUSCLES.

It is essential to a full understanding of this thesis that the functional anatomy of the lateral pterygoid muscle be appreciated. (Old terminology, external pterygoid). Space limitations concentrate the text upon this muscle while regretfully neglecting the other muscles.

The significance of the insertion of the lateral pterygoid muscle into the neck of the condyle and into the meniscus, must be emphasised.

As to the functions of the lateral pterygoid muscle, it must be confessed that so far there is no settled opinion, despite the fact that Ferrein initiated in 1744, the age-old controversy. The point at issue is whether the lateral pterygoid muscles solely protrude the mandible horizontally, or whether they are the prime movers in the act of opening the jaw. The standard text-books of anatomy are uniformly non-committal on this point (75), (76), (77), (78). Venturing an opinion, I believe that the lateral pterygoid muscles are the most powerful muscles that enter into <u>both</u> the protrusive and the opening movements, but that different results are achieved by the manner in which other muscle forces are applied. As an illustration, contraction of the anterior fibres of the temporal muscle, together with the lateral pterygoid muscle, would hold up the chin and so protrude the jaw horizontally.

Sicher (79) claims that a muscle never operates alone, that tension in one muscle signifies relaxation in an opponent. Furthermore, while one single muscle may conceivably initiate a movement, the action is soon shared by others, indeed it may be completed. Thus physiological muscle action is smooth and flowing, and not jerky as it would be were one muscle to act alone, or as it is, in certain un-co-ordinated movements which accompany systemic nervous disorders.

One marvels at the perfection of the neuro-muscular reflexes which make the synergia of the mandibular and facial muscles such a miracle of co-ordination.

LATERAL PTERYGOID MUSCLES OPERATING IN UNISON.

At the present stage, it is proposed to exclude from discussion uni-lateral function of the lateral pterygoid muscles, and to confine the observations to the contraction of these muscles in unison.

Reference to the cadaver will show that the lateral pterygoid muscles are almost horizontally disposed; their fibres run backwards and outwards. When both sides contract simultaneously, the condyles, together with their cap-like meniscii, are pulled forward down the distal slopes of the articular eminences producing either opening of the jaw, or

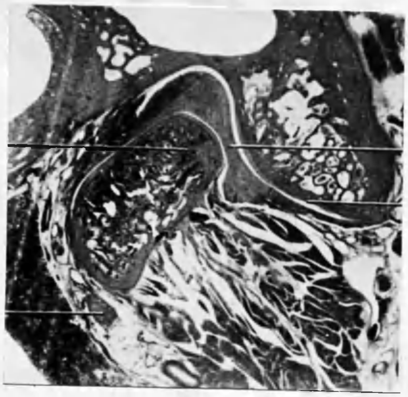

Plate 1. from Sicher.

Shows the histological appearance of the meniscus as seen in saggital section. The eminentia articularis can be seen at the right.

protrusion, as already explained, When the clinician places his finger-tips over the joint, the condyles can be felt acting differently in these two acts; in wide opening the condyle has a wider range of excursion.

Other duties of the lateral pterygoid muscles will be described later.

It is expedient at this stage to correct any possible misconception that the temporomandibular joint acts in the fashion of a "ball-and-socket" joint. It is easy to understand how this mistaken concept arises, when museum skulls are set with their meniscus-free condyles up in the depths of the glenoid fossae. But in actual fact, there is only approximate conformity between the shapes of the fossa and the condyle.

If a comparison is made between the angles of the long diameters of the fossa and the condyle, it will be seen that there is a disparity of about 8 degrees.

SHAPE OF MENISCUS, OR DISC.

The thinnest part of the meniscus lies between the head of the condyle and the distal slope, these bone surfaces nearly touching. In an adult the thinnest space is approximately 2 mm., although in a child it is thicker. The rim of the disc is thicker all aroung, especially distally, where it fills in the discrepancy in shape between

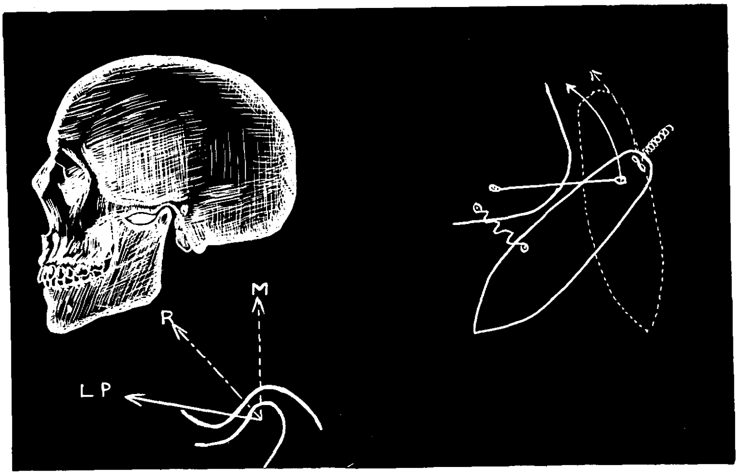

Fig. 6.

It is here argued that little stress falls on the deepest part of the glenoid fossa during physiological mastication : the load is borne on the strong buttress of bone which makes up the articular eminence. But this surface slopes away from the generalised stress of mastication, so that in action, a powerful lateral pterygoid muscle is needed to hold the condyle from slipping up the slope. If the muscle is sufficiently strong, little stress will fall on the temporomandibular ligament.

By way of illustration, we imagine that a ship is about to draw away from a pier using its propellors. First the bow hawser is slackened, but the after one is held taut: without elongation, this latter swings "pendulum fashion", and the ship pivots axially. The after hawser represents the physiological temporomandibular ligament.

fossa and head. Plate.1.

THE LATERAL PTERYGOID HOLDS THE CONDYLE IN FIRM SLIDING CONTACT WITH THE DISTAL SLOPE.

Another duty falls to the lateral pterygoid muscles. Acting in unison, they hold the condyles against the slopes when the thrust of mastication is taken. Only a strong muscle could thus resist the tendency for the condyle and disc to slide up the slope during the masticating stroke, which itself is powerful. As discussed elsewhere in this paper, the bone between the cranial vault and the glenoid fossa is thin: from its thin structure it can be contended that the depth of the glenoid fossa was not meant to take stress. On the contrary, the strong nature of the bone which forms the anterior wall of the glenoid fossa, suggests that this is the part intended to receive masticating strains.

Reference to Fig. 6. will explain the forces which are borne on this part during physiological mastication. The parallelogram of forces shows the resultant. Surprisingly, the thrust is forward and upwards. Now, here is an important point. Should the lateral pterygoid muscle be weak, the temporomandibular ligament only, protects the condyle from distal displacement. In the continuation of over-load the ligament will break down and the condyle will become displaced.

Summarising this point, it may be said that the design of the temporomandibular joint appears at first sight to be mechanically poor. It requires that the thrust of mastication is borne on a falling-away slope, but the strength of the lateral pterygoid muscle takes most of the weight of the masticating stroke on the muscle, not the bone. When the jaws close over the bolus of food, the lateral pterygoid muscle yields little by little and the condyle retires to its resting position, keeping firm sliding contact with the eminence. The whole action takes place in a fraction of a second.

The reader of this paper will find that we put to practical application, both in diagnosis and in treatment, the observation that normal resting position of the condyle is halfway up the slope of the distal surface of the eminence.

LOSS OF THE LATERAL PTERYGOID MUSCLES.

One would have thought that should a case be presented where the lateral pterygoid muscles were thrown out of commission by the excision of the condyles, the age-old controversy would be settled, and definite evidence produced as to the role of these muscles in the act of opening. It was my good fortune to study such a case, a report being published (80). After the operation of condylectomy, the patient could open mouth with no apparent difficulty; consequently, either the lateral pterygoid muscles are not indispensible, or alternatively, other muscles can take upon themselves the task of opening the jaw. The suspicion that the supra-hyoid muscles had now become the prime movers could not be confirmed by palpation, which is not surprising considering their slim girth, their deep situation, and the relaxation of super-imposing soft-tissue which occurs when the jaw drops.

This patient demonstrated an interesting point: the operation rendered her incapable of protrusion or of lateral excursion, which seems to prove that the lateral pterygoid muscles were put out of action. The question may be asked, "the condyles having been removed, entailing the loss of the forward bracing effect of pterygoid muscle and temporomandibular ligament, did the upper end of the amputated ascending ramus drift backward?" The reply is that is drifted forward; perhaps due to the slight obliquity of the masseter and internal pterygoid muscles.

THE ACTION OF MUSCLES IN OPENING THE JAW.

The lateral pterygoid muscles do not enter into the act of opening the jaw until translation of the condyle is called for: in the less wide ranges of opening, the condyle does not stir. The jaw can open from the fully closed centric position as far as rest position, by a hingeing action, the axis of rotation being through the condyle; if the action is symmetrical there is an inter-condylar hinge-axis. Observations lead to the conclusion that many subjects can open the jaw considerably beyond rest position, before the condyle begins moving down the slope. Roentgenography has proved that some people can separate the incisors as much as half an inch before the commencement of translatory movement. It is safe to say that the condyle will not change position until the rest position of the mandible has been passed. This point is of practical importance and will be elaborated in a later page.

The hinge-axis movement is effected by the condyle rotating around its polar axis, on the under-side of the meniscus, the mechanism being admirably designed for rotation. At any position of the traverse of the condyle, hingeing on the under-side of the disc can take place.

It may be said that a small minority of the population have a strictly limited condylar excursion, and a few have none at all. Whether this unusual action is physiological or pathological, is difficult to say.

Another class of subject may have a condylar hinge-axis throughout the entire opening on one side of the jaw, but normal translation on the other. Others exhibit hypermobility on the other, but such a case must be pathological. Unilateral function will be studied further under the heading of 'the Bennett movement'.

The earlier description of muscle synergia made it clear that it is fallacious to attempt to separate muscle action into single functional components; rather we should think of integrated function. For example, the protrusive and opening acts can be merged. This can be seen if a given point in the mandible is watched when the subject is performing the most extreme protrusions, openings and other mandibular functions. The observer can watch the movement of infradentale (point between lower incisors). Tracings have been made of these movements (81). If a smoked glass be fixed to the upper face, in profile, with a stylus fixed to infradentale, tracings of its pathway of excursion can be recorded. Every possible saggital movement can be delineated by this diagramatic technique, which has been designated 'the border movements technique' by Posselt (82).

Posselt elaborated the technique to embrace all mandibular movements into a solid, three-dimensional graph.

RATIO OF CONDYLAR MOVEMENT TO DIMENSIONAL MOVEMENT OF INFRADENTALE.

Markowitz makes the statement that the dimensions of condylar movement to those of lower incisor movement are as 1 : 6.. This appears to be a generalisation; surely the proportions will depend on the lengths of the lever arms and the situation of the fulcrum. Nonetheless, the principle has merit in drawing attention to the appraisal of the dimensions of backward displacement of the condyle, by assessing the extent of over-closure.

The condyle can be displaced horizontally backwards, no leverage being here involved. Therefore, there is no need for proportional calculations; if incisal contact shoves the tips of the lower incisors backward, then the condyle will move horizontally backwards exactly the same distance.

THE INTER-OCCLUSAL SPACE BETWEEN THE DENTAL ARCHES.

Another jaw movement which has received scant attention, can be observed. Sir Norman Bennett likened the opening of the jaw to a rolling hinge, but the action more closely resembles a shifting hinge, that is to say, at any stage of its traverse, the condyle is capable of hingeing on the under-side of its capping meniscus, but mostly the meniscus and the condyle move forward as one unit. Nor, if the jaw is carefully watched as it opens, it will be seen that the occlusal gap between the molars is almost as large as it is at the incisors. This is caused by the posterior part of the jaw dropping, as the condyle descends the distal slope; the parallelism between the dental arches reminds one of the opening of parallel rulers.

When the general dental surgeon encounters this type of patient, he finds that he gets easy access with hand-pieces to the posterior part of the mouth, whereas he finds difficulty with the patient whose condyle hinges without the normal traverse.

(75) Gray's Anatomy, ed. Johnstone and Whitles. 13th Ed. Longmans.
(76) Cunningham's Anatomy, ed. Brash. 9th Ed. Ox.Med. Publications.
(77) Buchannan's Manual of Anatomy, ed. Wood Jones, 8th Ed. Bailliere, Tindall & Cox.
(78) Shapiro's Applied Anatomy of the Head and Neck, 2nd Ed. Lippincott.
(79) Sicher, H. Address at XIth International Dental Congress, London, 1952.
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(81) Swenson's Full Dentures, 2nd ed. Henry Kimpton.
(82) Posselt, U. Studies in the mobility of the human mandible. Acta. Odonto. Scand. Vol.10. Sup. 10. 1952.

Chapter 10.

THE JOINT LIGAMENTS.

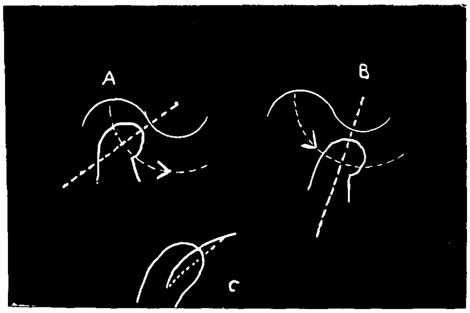


Fig. 7.

This portrays the physiological traverse of the condyle. The straight dotted line in A and in B represent the general direction of the fibres of the temporomandibular ligament. It will be seen that the descent of the condyle is effected by the "pendulum swing" of the fibres. Study of the capsular ligament suggests that no group of fibres lies in such a direction as to invalidate the theory. This concept furnishes us with a specification of the physiological travel of the condyle ; if it is found outwith the physiological arc, it must be regarded as "pathomechanical". Similarly, if it is discovered beyond the end-points of permissible travel, then it must be suspect.

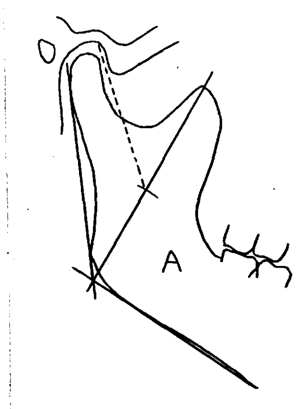


Fig. 7A.

On opening, the jaw pivots at insertion of sphenomandibular ligament.

THE ROLE OF THE LIGAMENTS IN THE WIDER OPENING OF THE JAW.

While it is true that in the smaller ranges of opening the jaw hinges entirely on a condylar axis of rotation, there comes a stage when this hinge-axis itself begins to shift, so that the middle extent of jaw opening requires that the condyle be transposed, although commonly there is a final condylar hinge-axis after further translation is stopped by the condyle coming to its fullest protrusion in front of the articular eminence. Just as soon as the condyle starts to shift forward, the axis of rotation drops lower down the ascending ramus finally locating itself at the mid-ramus insertion of the spheno-mandibular ligament. Craddock (83) claims that the change from one imaginary hinge-axis to the other is abrupt, but I do not believe that the hingeing of the condyle on the under-side of the meniscus completely stops at the moment when translation begins, therefore change in axis is gradual.

Lord (84), and Aitchison (85) justify their belief that the hinge-axis of wider opening is sited near to the lingula, by indicating that while the condyle goes forward and downward, the gonial angle moves backward and upward. Fig.7A illustrates this action. It will be appreciated that the jaw does not neatly pivot on this axis in the manner of a mechanical axle, but the flexible sphenomandibular ligament bends. Also it would be an over-simplification should these ligaments be regarded as free-swinging links; in actual fact they are thickened portions of fascia, but nevertheless they can swing to a certain extent. We leave the sphenomandibular ligament to return to it shortly.

The temporomandibular ligament is now discussed. In an earlier page a postulate was stated that the forces of mastication were taken on the tense lateral pterygoid muscle which braced the condyle and disc against the strong bone at the anterior lip of the glenoid fossa. The muscle tension yields relatively slowly as the condyle passes back to close the occlusion. Now, the action of this muscle is re-inforced by the temporomandibular ligament, the fibres of which are seen to run obliquely backwards and downwards. The temporomandibular ligament is a thickened external band of the capsular ligament.

THE ANATOMY OF THE TEMPOROMANDIBULAR LIGAMENT.

This section of the paper begins with a description of the temporomandibular ligament from 'Gray's Anatomy':- "The temporomandibular ligament is placed on the lateral side of the joint and is intimately related to the capsular ligament. It is attached, above, to the lateral surface of the zygomatic process of the temporal bone and to the tubercle on its root; below, to the lateral surface and posterior border of the neck of the mandible. It is broader above than below, and its fibres are directed obliquely downward and backward". (30th. Edit. 442.)

THE TEMPOROMANDIBULAR LIGAMENT SWINGS RADIALLY AS THE JAW OPENS.

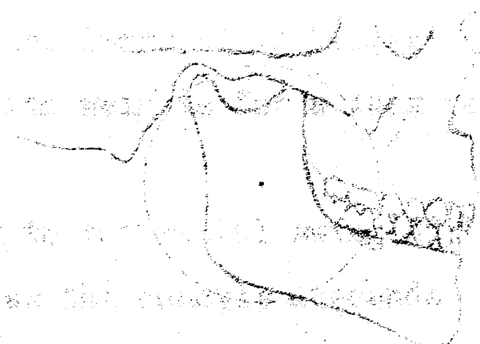
The theory now about to be described begins with the axiom that ligaments are inextendible. Here again Gray's Anatomy is quoted, (Page 437):- "All ligaments are tough, inelastic and unyielding, but at the same time flexible and pliant, so that they offer no resistance to normal movements. On the other hand they are designed to prevent the occurrence of excessive or abnormal movements, and every ligament becomes taut at the normal limit of some particular movement. They are not designed to withstand *prolonged tension, and pain always results when they are subjected to it*". The reader should note that the italics are my own.

If the capsular and temporomandibular ligaments cannot yield, how then does the condyle descend the normal pathway? I submit that it does so by swinging through a few degrees of "pendulum" motion. That is to say, the condyle scribes an arc, of which another concentric circle is the distal slope and a small part of the crest of the articular eminence. Fig.7B.

It will be seen that these unyielding joint ligaments re-inforce the lateral pterygoid muscle in maintaining firm sliding contact of the condyle together with its meniscus, against the distal slope. It will be further seen that in a case where the lateral pterygoid muscle has become weakened, excessive strain will fall upon the temporomandibular ligament, perhaps stretching it, perhaps tearing it. Need we search any further for an explanation of the pain-mechanism? Barnes (86), and Hutchinson (87) give the assurance that ligaments contain sufficient nerve-endings to cause the exquisite pain of a stretched ligament with which the orthopaedic surgeon is so familiar.

This is not to suggest that we must discard the older theories of pain-causation in the temporomandibular joint, such as pressure on the auriculo-temporal nerve.

I have used the phrase 'stretched ligament', which would seemingly contradict the quotation from Gray's at the beginning of the chapter. By way of explanation, two sets of circumstances are conceived. (1) When a heavy force is suddenly applied to a ligament, the subject is violently informed by his proprioceptive mechanism that he must at



mandibular ...

slope, Fig.7. shows ...

reader is warned ...

... likely to refute ...

During its functional movements, the condyle is held against the eminence by the forces which are described in the text. The meniscus intervenes. The thickness of the meniscus varies from 2 mm. in the case of an adult, to 4 mm. in a child. If the laminagram shows that the gap is not uniform at every stage of condylar travel, then the movement can be regarded as "patho-mechanical". The condyle is outwith the arc of physiological movement.

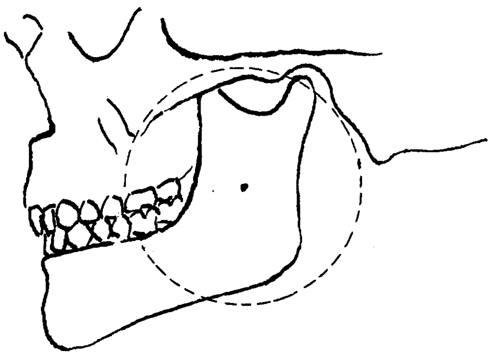


Fig. 8.

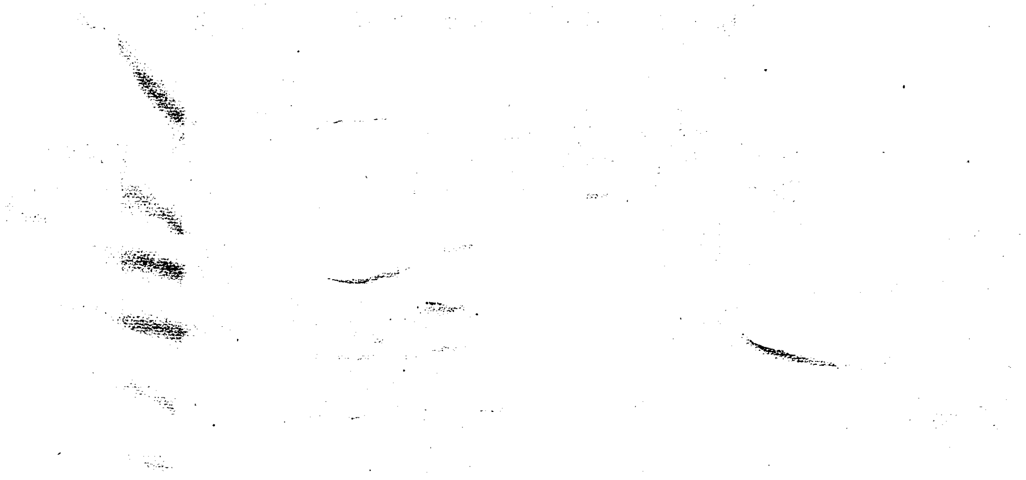
According to Lord, the mandible opens by a pivot-movement around a mid-ramus point. As the condyle swings forward, the gonial angle swings back.

I suggest that this is only possible, if the point of rotation shifts backward.

all costs avoid further harmful force, and stress is quickly relieved by a change in his position. (2) The much less severe application of stretching force, almost a gentle force, applied continually, perhaps for years. No avoiding action is taken and the pain is of a less severity.

I am unaware of any physiological experiments designed to test this latter submission. A piece of fresh ligament could be immersed in Ringer's solution in a dish, and loaded with weights for a long period to see if it would yield.

Returning to the radial swing of the temporo-mandibular ligament as the condyle descends the distal slope, Fig.7. shows diagramatically the action. The reader is warned against taking an over-simplified view of this movement; it is clear that all the fibres do not swing in such an accommodating action. For instance, the anterior fibres of the capsular ligament start off from a horizontal and taut state; they can swing too, and there is nothing here to invalidate our theory. The distal fibres are more likely to refute the theory, because their general direction is already forward, but we recollect that this part of the capsular ligament is loose and the fibres puckered (88). Therefore, the forward translation of the



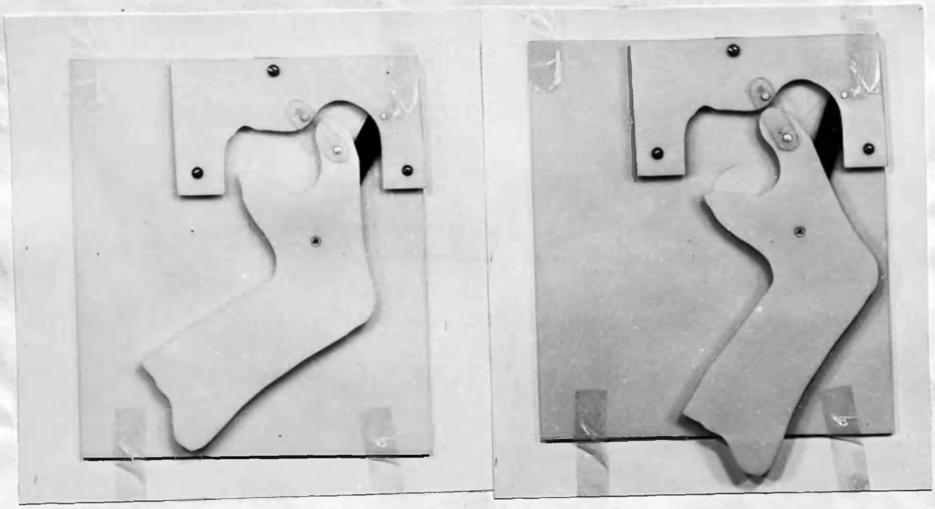


Fig. 9.

Photograph of a plastic model in different positions. The model carries two links, the black one represents the sphenomandibular ligament, and the clear plastic link represents the temporomandibular ligament and the fibres of the capsular ligament. As the plastic jaw opens the links swing. Each swing pivots on an axis. Three pivoting movements can be recognised :- The mandible opening by rotating around Lord' point. The condyle swinging around the eminence. Lord's centre swinging at the lower end of the sphenomandibular ligament.

condyle merely takes up the slack. The normal condyle has a forward bend in the neck of the condyle. The capsular fibres wrapped round this curve from above downwards, consequently have slack to take up when the condyle travels forward, Fig.7C.

INTEGRATION OF LORD'S THEORY WITH THE SWINGING TEMPOROMANDIBULAR LIGAMENT.

We examine the possibility of combining Lord's theory with the immediate foregoing. We remember that Lord claimed the condyle swung through an arc, the centre of which was sited at a mid-ramus point near to the lingula. He further claimed that this point is the point of "least movement" of the mandible, and that the entry of the blood vessels and nerve at this point is in keeping with the physiological principle that nerves and vessels always enter muscles and bone at the point of "least movement".

As we place the two theories side by side for critical examination, an apparent incongruity arises: how can the two arcs be made to coincide when their centres are almost diametrically opposed? Fig.8A.

But all this difficulty disappears if a third radial swing is envisaged, that is, if Lord's point itself shifts backward! Fig.8B. To test this new theory, a piece of mechanical link motion was constructed. Fig.9.

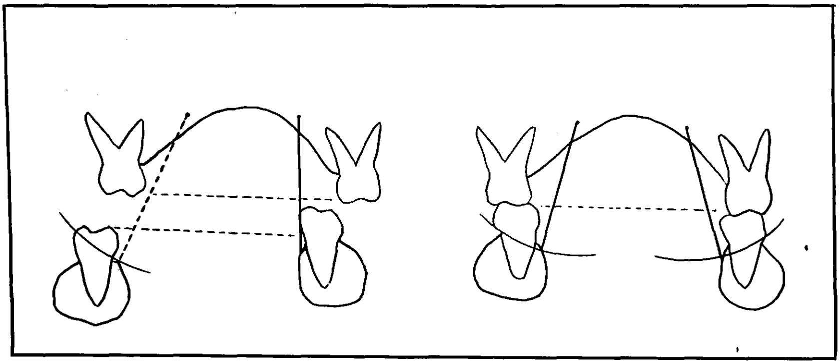


Fig. 10.

Shows why a jaw can open in a case where the medial pterygoid muscle has spasmed. As seen on the right-hand figure, the pair of muscles lies normally. As seen on the left-hand figure, the jaw has opened without actually stretching the spasmed muscle : it has swung to its nadir.

This reasoning also applies to the jaw ligaments.

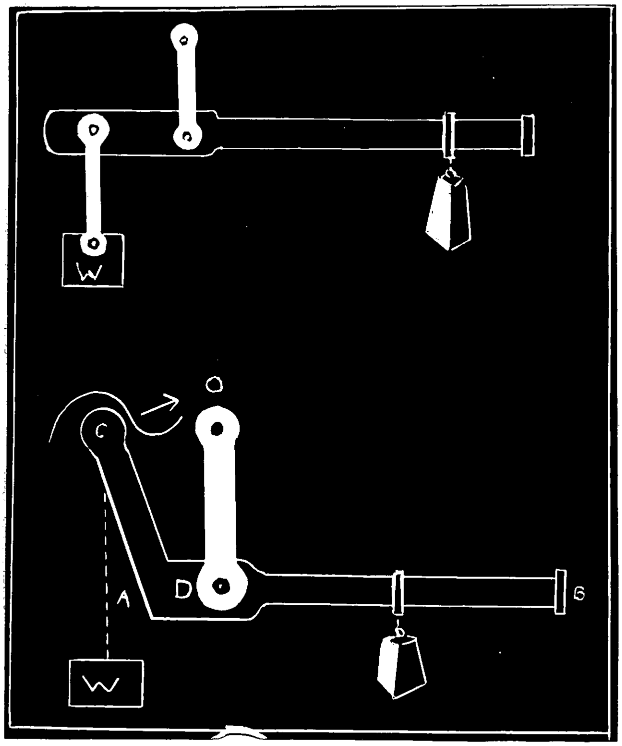
Three radial swings can be identified, (1) the condyle swinging on Lord's point, (2) the condyle swinging on the temporomandibular ligament, and (3) Lord's point swinging backward on an arc which centres on the origin of the sphenomandibular ligament.

Of course, mandibular movements do not depend on a neat rotation on an axis located at the end of a ligament, but on a slight bend in the flexible ligament.

SWINGING LIGAMENTS FROM THE ANTRO-POSTERIOR ASPECT.

So far, in this paper, only the saggital aspect of swinging ligaments has been given consideration, but the principle applies to muscles and ligaments also, as we view them from the front. Making use of the medial pterygoid (internal pterygoid) muscle as an example, it will be seen that when the jaw swings over to one side the ipsilateral muscle acts in the radial fashion just described. Without elongating it drops to a vertical nadir, while the contra-lateral muscle extends slightly more than normal. Fig.10. This is the type of mandibular function that attends a trismus caused by a carelessly administered inferior dental block anaesthetic. Trismus is relevant to a study of temporomandibular disorder, and a few words will be given in a later page.

The observation is not without interest in



A.

Fig. 11.

B.

Fig. 11A shows the "English steel-yard".

Fig. 11 B shows a slight alteration of the above, without alteration of the principle, to demonstrate the stress-bearing mechanism of the human mandible. The white-coloured link represents the sphenomandibular ligament, with the jaw suspended on Lord's point. Under stress this ligament takes much of the load, both in the acts of mastication and in opening the jaw. In opening, a slight stress falls on the eminence, not the depths of the glenoid fossa. In mastication, where a bolus of food lies in front of Lord's point, this is a fulcrum, and so little stress is applied to the temporomandibular joint.

another respect, as it suggests that the swinging of the lower posterior cusps immediately below the uppers, does not entail stretching of the masticatory muscles on that side.

Thus far, in the discussion of the ligaments inserted into the mandible, two have been omitted, namely the stylomandibular ligament and the pterygo-mandibular raphe; but these do not bring any material evidence to bear on our problem.

JAW MOVEMENT. THE THEORY OF THE SUSPENDED LEVER.

I now wish to draw attention to a theory of mandibular movement which does not seem to have been investigated,and for our inspiration we turn to the lever which is known as the "English steel-yard". In this instrument, the pivoting point was suspended, but the principle of leverage was as usual. I suggest that students of jaw function who have considered the leverage involved, have focussed too much on the "fixed-point" fulcrum, to the exclusion of the fulcrum which is suspended. Fig.11A.

Now, let us apply the analogy to the human jaw. It can be appreciated that the jaw is slung, not only on ligaments but on a central node of muscle equilibrium which I have already likened to the mark on the rope of the tug-of-war contest; this node can shift about according to the will or the reflexes of the subject. But the point would be simplified, should we concentrate on the spheno-mandibular ligament for purposes of illustration.

Fig.11B demonstrates the principles involved. Hanging from O is a link, the other end of which D is the pivoting point for the lever AB. One end of the lever arm is bent up to terminate at C. Now, this figure is analogous to the human jaw; O is the origin of the spheno-mandibular ligament which is OD. AB is the horizontal ramus, and C is the condyle.

Weights are now applied to the lever arm; the masticating muscles which open the jaw pull the front part of the jaw downward. Now, it might be possible that the fixed-point fulcrum at C takes the entire load, and I concede that in patho-mechanics that it does so, but we cannot overlook the fulcrum which is created when the spheno-mandibular ligament is stretched. That is to say, as the anterior part of the jaw is forced downwards, the condyle is forced up. Even if the spheno-mandibular ligament itself swings, the principle still holds good.

It should be noted that there is nothing in this theory which nullifies any points which I have made in respect of other jaw functions; for example in physiological mastication, no matter how the jaw pivots on point D, the force applied to C does not divert it from its true pathway, but because C is driven upwards and forwards; it maintains that firm sliding contact with the distal slope of the eminence, to which previous reference has been made.

THE SUSPENDED LEVER WITH FOOD BETWEEN THE TEETH.

To study the dynamics of mastication still further, we now visualise a bolus of food between the teeth. If it is between the incisors, the bolus itself forms a fulcrum, and persistent mastication with the incisors may injure the temporomandibular joint. But when the bolus is placed between the molars, the joint is protected. In this case, the suspensory ligaments at the rear of the jaw will be stretched and a lever constituted, so that the crushing of food will pivot the jaw on the insertion of the suspending links, and the condyle will not strain back into the fossa. Also, of course, the bolus of food could act as a fulcrum of its own accord.

(83) Craddock. Review of Costen's Syndrome. B.D.J. 91 : 199-204. Oct.16th 1951.

(84) Lord, F.P. Movements of the jaw and how they are affected. Int.J.of Orth. and Or.Surgery. 23 : 557. (June) 1937.

(85) Aitchison, J. Dental Anatomy and Physiology for Students. Staples.

(86) Barnes, Roland. Personal Communcation. Reader, Orthopaedics, Glasgow University. Consultant, Western Infirmary.

(87) Hutchison, H.E. Personal Communication.
Consultant Pathologist. Glasgow
Western Infirmary.
(88) Braus, (illustrations in Shapiro's Applied
Anatomy of the Head and Neck. Lippincott)

Chapter 11.

THE CAPSULAR LIGAMENT AND THE JOINT TISSUES.

THE DAMAGED MENISCUS.

Plate 2.

A.

B.

A. shows condyle in front of eminence.

B. shows condyle not only in front, but vertically displaced in front of the eminence.

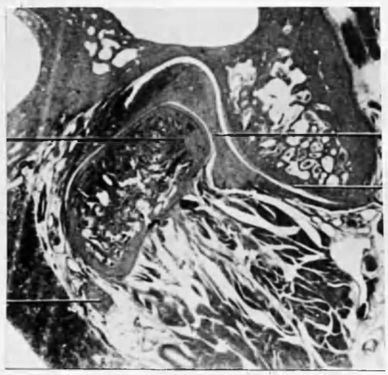
APPEARANCE OF THE CAPSULAR LIGAMENT AND ITS FIBRES.

The capsular ligament is a funnel-shaped ligament, attached at its lower end to the neck of the condyle, and at its upper end to the rim of the glenoid fossa. The surface of the bone which it surrounds, is covered by fibro-cartilage, which offers support to the contention that this area delineates the limits of physiological excursion of the condyle. This gives us a definition of how far forward and how far back the condyle ought to travel, that is, from a little in front of the crest of the articular eminence, to a position in front of the petro-tympanic fissure. In terms of the distance travelled by the lower incisors, I believe physiological excursion to be about 6mm.

Plate 2A shows a laminagram of the condyle lying well in front of its proper open position; in this instance the condyle is displaced horizontally. Plate 2B shows another forward displacement but in this case the condyle has risen up in front of the eminence, which theoretically ought to fit into the classis picture of dislocation of the jaw, but an assurance can be given that in neither case did the patient find any difficulty in returning the condyle to the resting position. However, one speculates on the possibility of rupture of the anterior fibres of the capsular ligament. I suggest that the term "pseudo-dislocation"

Plate 1. (from Sicher).

Condyle.



Meniscus.

Eminence.

Shows saggital section of the temporomandibular joint: eminentia articularis to the right. Please note the taut horizontal fibres of the capsular ligament at the front, and the loose capsular fibres at the distal part.

should be used to describe this condition.

Plate 1 from Sicher (89), shows a saggital section of the temporomandibular joint. The cartilaginous part of the meniscus is seen to merge into the loose fibrous tissue which makes up the rear of the capsular ligament. That is to say, the cap-like meniscus is not bound down so securely by the distal fibres of the capsular ligament, as by the anterior fibres. But, perhaps this is an example of good design rather than bad, because such an arrangement permits forward excursion of the condyle; we recollect that the theory of the pendulum-like swing of the fibres only applied to the majority, not to the distal fibres. In short, the remote attachment and the puckering of the distal fibres is mechanically efficient during the forward passage of the condyle, but inefficient during its backward travel.

On the other hand, examination of the histological elements of the temporomandibular joint shows that when the condyle is at rest the anterior fibres of the capsular ligament lie horizontally, and that they are taut when in this position. From this observation two points emerge: (1) the condyle cannot go back further without damage to the anterior fibres, and (2) the meniscus is bound down to the condyle

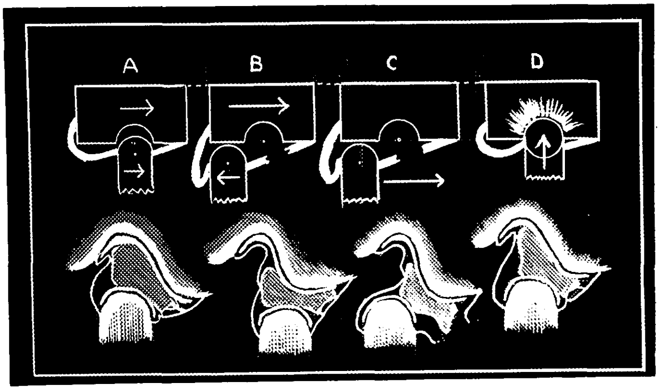


Fig. 12.

Diagramatic representation of the meniscus which has been loosened from the condylar head. (A) shows normal tightly attached disc. The taut anterior fibres of the capsule hold the disc on the head during forward travel of the condyle. During backward travel there is a tendency for the disc to trip over, because of the slack distal fibres. (B) when the anterior fibres are stretched or torn, the disc may remain in front while the condyle goes back and rises up on to the rim of the disc. (C) this shows the condyle starting forward, and (D) shows the condyle snapping off the rim of the disc with the characteristic click.

tightly in forward movement, so that the whole arrangement is well-fitted for holding the condyle onto its seat as the mouth is being opened.

Let us imagine a case where there has been consistent over-closure for years, with consequent slackness in the attachment of the meniscus. When the condyle is moving forward only a little slack in the anterior fibres must be taken in before the meniscus is again firmly held on the head of the condyle, whereas in backward travel, much more slack must be taken in before the disc moves with the condyle. Fig.12.

This reasoning would seem to explain why the meniscus becomes folded. (90) This can be pictured if one visualises the analogy of a walking-stick being trailed along the ground, then if the direction of the trail is suddenly reversed, the walking-stick tends to trip over.

THE MENISCUS, OR DISC.

The capsular ligament surrounds the joint and everything inside it, including the disc, which is attached all round its periphery to the capsular ligament. Fibres of the lateral pterygoid muscle are said to pass through the anterior sheet of the capsular ligament, to become fixed to the disc.

Above and below the cartilaginous part of the disc are synovial sacs, but both sacs and the thin part of the disc are all contained in a space which in an adult is not much greater than 2mm. This offers a true appreciation of their size.

But the disc becomes much thicker around its rim, especially distally where it fills up the discrepancy between the fossa and the head of the condyle. The meniscus conforms on its under-side to the shape of the condyle. The under-side of the disc is remarkably smooth and the observer is impressed with its adaptation to its purpose, which is to form an easily-running socket for the free rotation of the condyle.

The disc is attached directly to the condylar head by short bunches of fibres of the capsular ligament, only to be found at the ends of the long diameter of the condyle, otherwise the anterior and posterior fibres which hold down the disc are remotely attached. These short fibres do not yet appear to have received a proper designation, and I suggest that they should be termed 'polar fibres'.

It will be seen that the whole arrangement of fibres integrates into a fitness for purpose which could be scarcely improved.

THE LOOSE MENISCUS, AND THE METHODS FOR ITS STUDY.

It is probably true to say that the surgeon, confronted at operation with an open temporomandibular joint, is in the most advantageous position for discerning looseness of the disc, and its behaviour when passive movements are applied to the jaw. However, it is doubtful how much reliance can be placed on conclusions derived from such circumstances: in the first place, the incision through the external capsular ligament (the temporomandibular ligament) may also detach the external polar ligament, and the meniscus may be loosened forthwith: secondly, passive movements applied to the jaw do not bear comparison with the beautifully counter-poised muscular movements, performed by the conscious patient.

The same doubt arises in the study of jaw movements on the cadaver. Nevertheless, Posselt (91) observed jaw movements under the following conditions, and found little difference in the "border movements" scribed by infradentale. (1) With the patient sitting upright and with passive movements applied to the jaw, (2) sitting, but patient moving his jaw volitionally, (3) patient lying back, passive movements, (4) patient under a general anaesthetic, curare being used. The pathway tracings made thus of the saggital excursion of infradentale, were closely comparable to those made in previous studies on the cadaver. However, in general, the "border movements" appear to have little other than academic interest, because the common mandibular functions take place well within the limits of "border movements".

Berry (92), working on the cadaver made an interesting approach to the temporomandibular joint, entering from the cranial vault by means of a little trap-door. One must differ from his conclusion, however, that the meniscus remains behind in opening, while the uncapped condyle descends the distal slope of the articular eminence. Certainly it can remain behind, but only in the pathological joint. I strongly contend that in physiological movement, the meniscus sits on the condylar head.

ARTHOGRAPHY.

Norgaard (93), and Toller (94) have injected radiopaque liquid into the temporomandibular joint, before radiography. Their pictures are most interesting and appear to substantiate the claims that they can at will place the tip of a hypodermic needle into the upper or lower synovial sac. My own attempts at injecting the temporomandibular joint make me think that my needle could not have been steered with similar accuracy; let us recollect that adult joint-space is about 2mm. at its narrowest, and within this dimension are to be found two synovial sacs, together with a disc the overlapping external rim of which also tends to obstruct the entry of the needle. I am sure that when I injected, the loose tissue at the distal aspect aspect of the capsular space was entered.

Amer (95) after putting arthography to test came to the conclusion that it was "unservicable".

TORN DISCS.

Supposing that the meniscus remains behind, perhaps bound back by adhesions, then what happens to the meniscus itself when the lateral pterygoid muscle attempts to drag it forward? We remind ourselves that some of the fibres of this muscle are directly inserted into the disc. There can be only one result; the disc must be torn.

Surgeons have found torn discs at operation. However, we must be careful in accepting this as evidence that the tear existed prior to the operation: despite the skill of the surgeon, menisectomy is not the easiest of operations. The measured distance from the surface of the skin to the deeper pole of the condyle must be nearly an inch, and the aperture is narrow. Even though

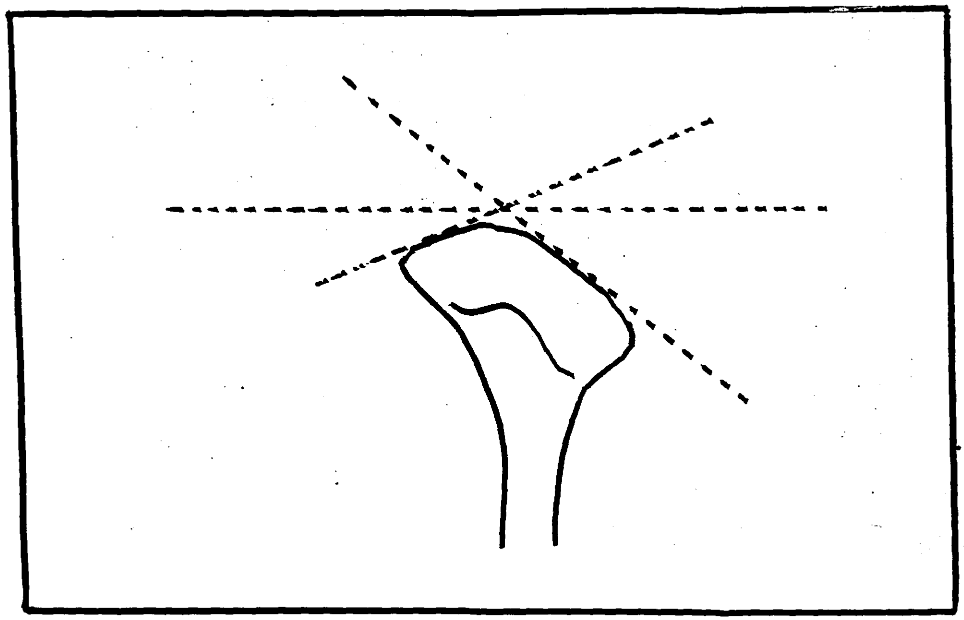


Fig. 13.

The condylar head as seen from frontal view-point. Occasionally it can be bi-bevelled, but not normally.

manipulation opens up space between the head of the condyle and the glenoid fossa, the surgeon is required to dissect out a meniscus through this narrow access. In addition, the head of the condyle may be bi-bevelled, as seen in Fig.13. Consequently, the disc may be torn without the surgeon being aware.

MENISECTOMY.

The removal of the meniscus has been proposed as a means of relieving pain, but such a procedure is unjustifiable unless the diagnostician is positively certain that the (1) cause of the pain is in the joint, (2) that the meniscus is responsible.

Convincing figures as to success have been published by advocates of this operation, (96). Perhaps their success followed the removal of discs which had been damaged beyond repair; perhaps, as Middleton (97) says, the opening of the capsule effected the cure by the subsequent formation of scar-tissue, or perhaps the pain was cured by the breakdown of adhesions.

However, the removal of a disc without investigating the reason for its damaged condition seems illogical, and can be likened to a physician treating a symptom, while neglecting the cause.

One patient has been treated who had previously undergone menisectomy; she received benefit for a few months, but the pain returned worse than ever after the operation. We treated her with success by conservative means; in two years there has been no recurrence.

However, an open mind must be kept; time and experience may convert me to become an enthusiastic advocate of menisectomy.

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Chapter 12.

LAMINAGRAPHY.

Fig. 14.

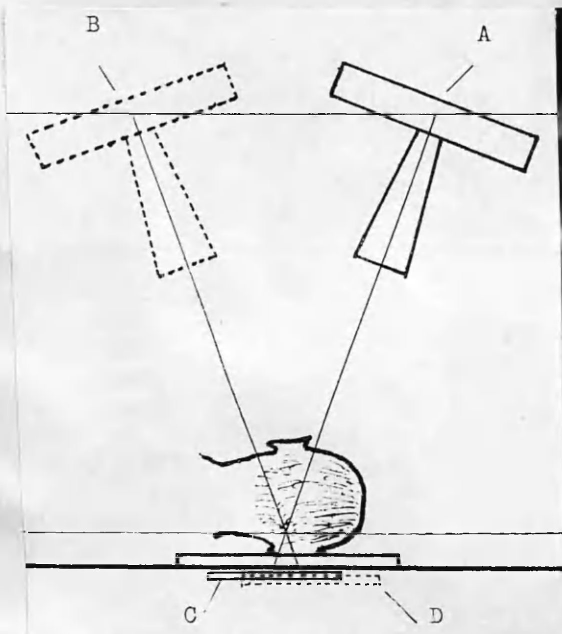

Plate 2.

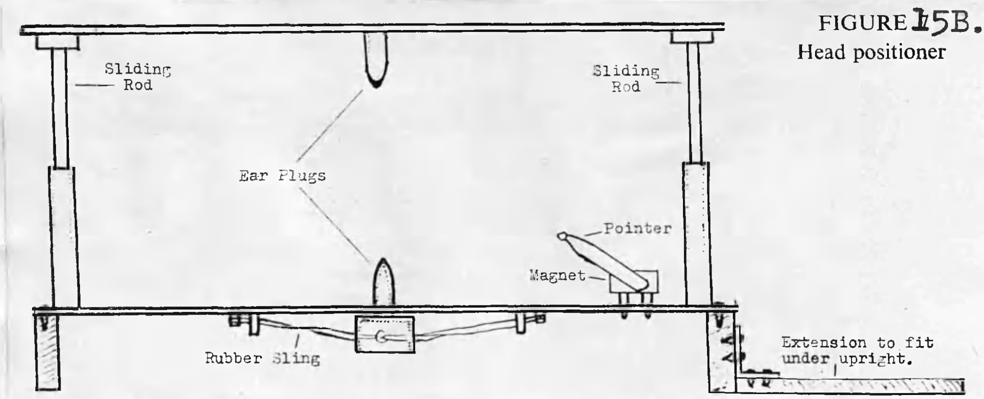

FIGURE 15B.
Head positioner

Fig.15B.

Fig. 15A.

LAMINAGRAPHY OR PLANIGRAPHY, OR TOMOGRAPHY.

It has been found necessary at this stage to interpolate some brief instruction on laminagraphy which is a specialised technique of roentgenography. The technique has evolved out of the chest physician's tomography. When adapted to the temporomandibular joint, the exposure is made during the passage of the tube around an imaginary centre at the temporomandibular joint, Brader (98), Ricketts (99), Staz (100), White, Campbell and Anderson (101). As the tube swings, the film moves in reciprocal direction, Fig.14. The only part of the picture which is recorded clearly is the part where movement is least: all else is blurred into invisibility by the travelling tube. Plate 2 is an example of the negative that can be obtained.

The patient is located in such a manner that his trans-meatal axis is at right angles to the film. This type of roentgenegram is oriented in the true saggital plane, and therefore conveys a fairly exact representation of condylar relationships. Fig.15A.

HEAD-HOLDING JIG.

The staff of our radiological department have made laminagraphy a spectacular success.

My head-holding jig, Fig.15B, was described

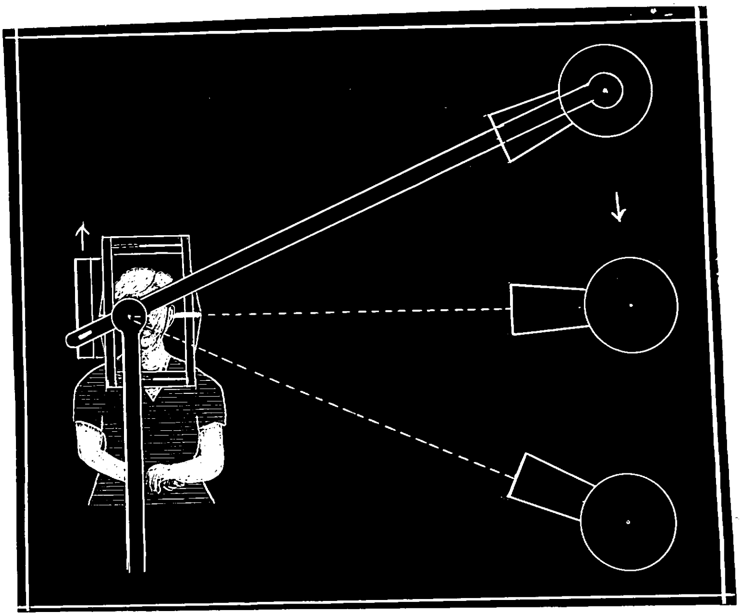

Fig. 16.

Demonstrates the principle of a new method of temporomandibular joint laminagraphy. The tube swings vertically downward as the cassette rises vertically from the shoulder. The patient sits comfortably upright and roentgenograms of rest position are more reliable than when the patient lies down on the couch.

An experimental apparatus has been built and is successful, but the refined detail of design has to be worked out.

in the Dental Record; a feature is that no metal is used which may show up in the negative, the plastic plugs which locate the external meatii being spring-loaded by elastic bands. The ear-plugs can be sterilised.

POSSIBLE IMPROVEMENTS IN LAMINAGRAPHY.

It is hoped to improve the design of the apparatus, difficulties having been encountered. The greatest shortcoming is the need to lay the patient on the couch under the tube. To get the ears fitted to the plugs and at the same time to get the condyle as near as possible to the cassette, requires that the patient assumes an awkward attitude which strains his neck. Consequently it is impossible to get a reliable rest-position record. Surely the answer is to seat the patient upright and have the tube swing vertically downwards, while the cassette rises from his shoulder. Fig.16. An experimental apparatus of this type is in being.

When complete it is hoped that the improved apparatus will serve in a dual capacity, (1) laminagraphy, and (2) cephalometry, which is the saggital roentgenography used by the orthodontist for cranial analysis. The proposed apparatus could be made to work in this secondary role, by fixing the tube with

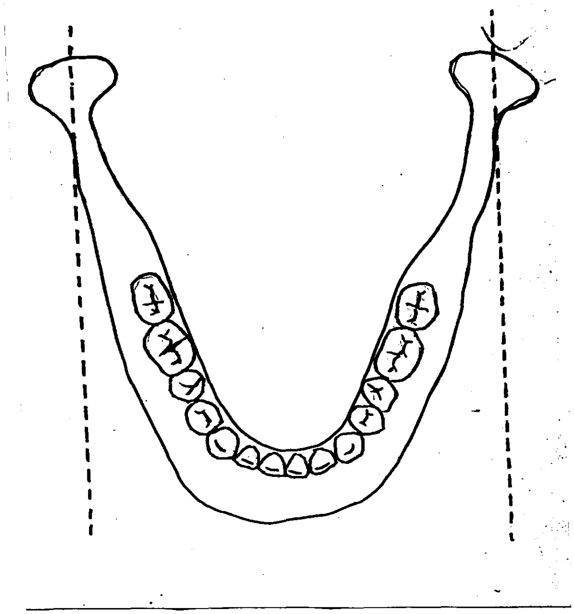

Fig. 17.

This illustrates why the laminagraphic roentgenogram of the condyle cannot show the teeth with equal clarity.

a stop, so that the central ray is directed along the Frankfort plane of the patient.

In a personal communication with Brodie (102), he informed me that he and Ricketts (103) have been working independently on a similar design.

The possibilities of laminagraphy are virtually unexplored. Concentrating the clarity of the picture as it does on pre-determined levels, it could be used to locate foreign bodies, cavities, cerebral tumors and other features which require a knowledge of the depth of the lesion. We have already experimented with it in a small study of the styloid process.

When first introduced to laminagraphy, a stranger is inclined to be critical of the loss of detail in every feature except the temporomandibular joint, but he soon realises why the condyle and the teeth, for example, cannot be seen with equal clarity; they are not on the same saggital plane. Fig.17.

Another series of experiments have been conducted with the hope of improving the sharpness of detail on the negative. For example, the direction of the traverse of the tube relative to the patient has been altered. It can be reported that no benefit accrued; in fact, as could be expected, when the tube

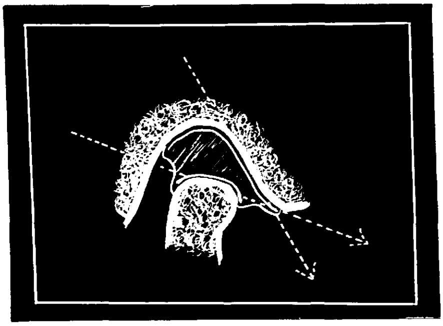

Fig. 18.

Demonstrates a possible discrepancy between the inclination of the actual travel of the condyle, and the inclination of the distal slope of the eminentia articularis. If the meniscus sits consistently upon the condylar head during travel, then its path ought to be exactly the same angle of inclination as the slope of the bone, the angle being measured from the laminagraph in its relation to the Frankfort plane. If the pathway of travel can be reliably measured by a tracing device, and if the inclination is found to be a smaller angle than the former, then can we conclude that the condyle travels independently from the meniscus which remains behind?

swung along the line of the zygomatic arch, the condyle was obscured.

DIFFERENCE BETWEEN THE ANGLE OF THE DISTAL SLOPE OF THE EMINENCE, AND THE CONDYLAR PATH WHICH HAS BEEN TRACED BY INK-WRITING PEN.

To illustrate this point, a hypothetical case is imagined. With the trans-meatal axis at right-angles to the film, a laminagram has been produced which shows the true relationships of the condyle. Two measurements are taken (1) the angle of the distal slope of the articular eminence, as measured from the film, (2) the angle of the condylar path which has been traced by an ink-writing pen attached to the lower teeth; both angles are measured relative to the Frankfort plane. Now, it is possible that the two angles do not agree; if the difference is material and if the traced angle is flatter, then I suggest that the meniscus has been left behind as the condyle travelled forward. Fig.18. The sketch provides the explanation. It will be seen that the meniscus is thin near to the distal slope but thicker to the rear; therefore if the condyle translates over an immovable disc, its path crosses from the thick part to the thin part of the disc, so that the inclination is flatter than it would be were the meniscus to travel with the condyle, in which case the condylar path would be the same angle as the distal slope.

This reasoning is only true up to a point. It depends on what reliance can be placed on the roentgenogram. Does it give an accurate measurement of the inclination of the distal slope of the articular eminence? Does it give an accurate picture of the length of the slope? Discounting the fact that all laminagraphs are enlarged projections, the shape of the distal slope varies anatomically according to the level at which it is sectioned, and we recollect that a laminagram is a radiographic section. Reference to skulls will show that a little tubercle sometimes hangs from the zygomatic arch, this being, in fact, part of the distal slope of the articular eminence. This is the steepest part, and as we pass inwards to that part of the distal slope which is in the squamous portion of the temporal bone, the slope is less steep. If measured where the inclination is steep, and again further in, the difference in angle may be considerable.

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Chapter 13.

JAW MOVEMENTS.

REST POSITION AND OCCLUSAL RELATION.

MASTICATION AND THE BENNETT MOVEMENT.

So far, in this paper, the discussion has been limited more or less to the saggital movements of the jaw when the sides operated in unison. Especially in the case of mastication, it must be quite exceptional to have symmetrical function, in fact, it is safe to say that there is no such thing.

It is virtually impossible to chew simultaneously on both sides of the mouth, hence the use of the terms "working side" and "balancing side". There can be no questioning the validity of these terms when the complete denture is under discussion, but a lengthy argument could be evoked as to whether the term "balancing side" is in order, in the case of a patient with a full natural dentition. However, it is safe to say that the non-working side shares some of the stresses of mastication, the doubt exists whether the load falls on the joint or on the teeth; it is more than likely that the joint, not the teeth, acts as the balancing agent. If this statement is true, we arrive at an appreciation of the task of the full denture prosthetist who endeavours to balance his prosthesis on the occluding teeth, a conception radically different from Nature's mechanism.

This discussion brings out an important point; the clinician who sets out to treat temporomandibular pain will be called on to treat edentulous patients, as well as those with natural teeth, therefore he should familiarise himself with the techniques of all specialists.

For the present discussion we envisage an idealised subject with full natural dentition, in such good occlusion that perfect physiological mastication is habitual. He is about to contend with a piece of food. On the working side, the condyle descends and the occlusion opens sufficiently to accommodate the ball of food. A slight lateral swing of the jaw places the cusps of the lower teeth immediately below their counter-parts in the upper. This lateral swing does not seem possible unless the balancing condyle comes forward more than that of the working side, in fact, some observers say that the working condyle may actually move back, (104). Whatever happens to the condyles, the food is crushed, during which the jaw centralises itself, both condyles returning to 'centric', ready for the next stroke of the cycle. This is a most complicated movement, involving not only joints and teeth, but also muscles, ligaments and nerves, and it all takes place in a fraction of a second.

The lateral movement of the condyles just described is still dimly understood, and is that which has come to be known as the Bennett movement, after Sir Norman Bennett, who in 1908 published a paper on another subject, but touched briefly on this aspect of mandibular function to which his name has now become attached.

Frank (105) has made a careful roentgenegraphic study of the Bennett movement, recording the position of the condyle in its various stations. He believes that the lateral swing of the jaw is aided by a sideways shift of the entire jaw together with rotation on the under-side of the meniscus. As I see it, the weak feature of his study is the need to stop the subject under radiographic survey, in the various stations of mastication. Any sort of posing is bound to create artificiality.

Lindbloom (106), whose work on 'bite-rehabilitation' and on temporomandibular joint roentgenography is so meritorious, demonstrated an excellent method of studying condylar action, at the XIth International Dental Congress, 1952. This took the form of a cinematic radiographic analysis. Unfortunately, each sequence of action only lasted for four seconds, during which time the observer had difficulty in picking out the condyle from a confusion of superimposing bones. But this technique of analysis of mandibular function is only at the stage of its crude beginnings, and is bound to develop. Not only will it add to our knowledge of physiological movement, but may help in the diagnosis of the pathological joint. Klatsky (107) furnishes us with the data of this cine-fluoroscopic technique.

Reference has just been made to the difficulty of getting the eye attuned to the shadow of the condyle, so that the hope is expressed that this study will evolve into a selected series of 'still' pictures of the condyle in its various stations, so that a less hurried appraisal may be made.

THE REST POSITION OF THE MANDIBLE.

Only in recent years has the dental profession become aware of the importance to aesthetics and to functional efficiency, of the vertical dimension of the lower third of the face. We have now become convinced that it is our duty to ensure that this part of the face shall attain its fullest possible development, and that its optimal dimensions shall be maintained throughout life, even in the difficult days of denture-wearing.

Fully to appreciate this concept, it must be understood that while the framework of bone which supports the teeth is the most important factor in maintaining the optimum vertical height, nevertheless, the jaw is slung at rest under the cranium at a position stabilised in distance from the maxilla, in a "hammock" of muscles. As long ago as 1908, Sir Norman Bennett (108) drew attention to this fact, and more recent studies by Niswonger (109), Thompson (110), Craddock (111), and many others have written convincingly on it. Modern opinion is that, where inter-maxillary relationship is optimal, the teeth are normally held apart about 2 - 3 mm., this gap being technically known as the 'free-way space', Landa, (112).

The exact determination of the dimensions of free-way space is difficult; it becomes doubly difficult to judge what is correct for a child or for an adult, when the teeth are in bad alignment; it is virtually impossible where the patient is edentulous. Advice as to the elucidation of these problems will be given under the appropriate headings.

In the meantime the question is posed:- Can we rightfully assume that the resting position of the jaw, is the starting point of mandibular movement, and the position of the termination of the masticating act?

SOME DOUBTS CONCERNING THE REST POSITION HYPOTHESIS.

Thompson and Craddock have used cephalometry in their researches on the rest position of the jaw. While their evidence is, at first sight, convincing, I am inclined to agree with Landa, (113), and Gwynne Evans, (114) who claim that the jaw has several rest position, according to its gravitational position. The jaw of an old man usually sags open in his deep sleep; it sags in death. Rest position changes when the subject stands on his head; it changes slightly as he lies on one side or the other. I suspect that in a state of high muscle tonus, gravity can be disregarded, but not in a state of poor muscle tonus.

OCCLUSAL RELATION. DIFFERING POINTS OF VIEW.

Centric relation has been defined as "the most retruded unstrained position of the heads of the condyles in the glenoid fossa at any given degree of opening", (115). First, this definition will be subject to critical analysis, then the pit-falls of the practical registration of centric relation will be discussed.

It is probably true to say that the orthodontist has approached the subject of occlusal relationship from a differing aspect to the prosthetist. The strong influence of Angle (116) on orthodontic thought, was possibly responsible for inducing the orthodontic world to define centric relation as the manner in which the teeth meet when

Fig. 19A

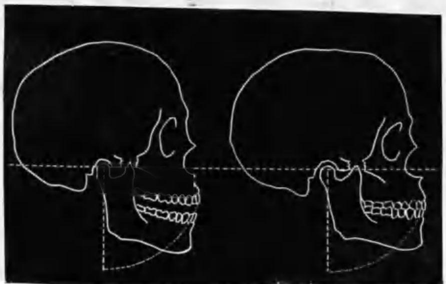

Fig. 19A. Shows normal path of closure of infradentale.

19C.

19C.

Fig. 19B.
Cusp-interference shifts condyle.

Fig. 19C.
Patient avoids badly occluding crown and shifts the condyle.

full closed, rather than the manner in which the lower jaw rests relative to the upper. Practical confirmation of this point is seen in the approach of the by-gone orthodontist to his examination of the patient. The first instruction was "Close your teeth". Nowadays, he notes how the mandible lies at rest, then he watches the natural movements as the mandible approaches the maxilla. He notes whether the lower incisors move to the uppers with a normal upwards and forward arc of movement, Fig.19A, or, on the other hand, through a different pathway. He notes if the jaw is diverted by cusps striking prematurely, Fig.19B, or diverted by the occlusal interference of a restoration such as an inlay, Fig.19C.

The prosthetist's concept of occlusion was not so restricted by interlocking cusps. He always had the vision of the condyles before him, especially in the case of the edentulous patient. Perhaps he too, neglected the muscles and their ability to "sling" the jaw. Nowadays, the two points of view are practically indistinguishable.

But the orthodontist would naturally be more disinclined to accept the definition that 'centric relation is the most retruded unstrained position....' He sees many young patients whose lower incisors do not meet the upper incisors in a forward and upward arc as they move from rest position to a so-called centric. He has seen many jaws pushed backward, or forward on this final closure. True it is, that initially this was a strained final closure, and thus would comply with the definition. But the point is, that while the closure at the beginning was strained and deflected, after a time in a growing child, while it still remained a deflected closure, it was no longer strained. The adaptive changes in a young child soon re-arrange bone and muscle to accommodate new circumstances. This point must be emphasised; in an adult whose muscle pattern is set and whose bone-cells are only reluctantly adaptable, occlusal disturbance by extraction or otherwise is more liable to cause temporomandibular pain than in a child. In other words, the muscle pattern of a child can recover more easily from strain than that of an adult. This is not to suggest that we should be regardless of tooth-extraction in a child.

DISPLACEMENT OF MANDIBLE.

It is well to remember that the jaw can be displaced in all three dimensions of space, that is, backwards, forwards, sideways and over-closure. Any combination of these prime displacements is possible, such as a complete slew of the mandible, a tilt or an infinite variety of shift.

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Chapter 14.

SURVEY.

DIAGNOSTIC MODELS, AND ANATOMICAL ARTICULATORS.

It would be idle to suggest that mal-function of the mandible could be diagnosed from models in the absence of the patient; nevertheless, properly articulated models can convey a lot of information which is not easily obtained from inspection of the actual patient. For instance, there can be no denying the fact that it is easier to see the lingual view of the occlusion on models, than on the patient.

The Scandinavian school make liberal use of mounted models for "bite-analysis", as they term it (117). When this method is used, the models are mounted upon an anatomical articulator, and this instrument so adjusted that it is capable of reproducing all physiological movements of the mandible; that is to say, the lower model can be moved around the upper in the same manner as the patient's lower jaw moves around his upper jaw. The paths of opening, closing, protrusion and lateral excursion are made re-producable by suitable mechanical devices on the apparatus. The path of a point between the lower incisors, 'infradentale", is recorded as it travels in all these acts.

I would like to extend the range of recordable movements of the articulator to include the path of movement of infradentale as it passes from the resting position of the mandible to the closest occlusion. If such an articulator could be made, then it would render "bite-analysis" more precise and more easy. This project presents mechanical problems.

Present-day anatomical articulators are designed so that only the end-points of movement are recorded in the mechanism, but not the irregular path between the end-points.

What is known as centric occlusion is first recorded and the models are mounted on the instrument in this registration. The patient then advances his jaw into protrusion; this too is recorded on the instrument; and in similar manner the lateral excursions are registered and made reproducable by the instrument. The face-bow which accompanies the anatomical articulator is utilised for mounting the models in relation to the condylar hinge axis.

The manufacturers of anatomical articulators are to be congratulated on the ingenuity and precision of their instruments. Noteworthy examples are Dentatus (118), Hall (119), Gysi (120), Precision Co-ordinator (121), Hanau (122), Stansbery (123), McCollum (124),

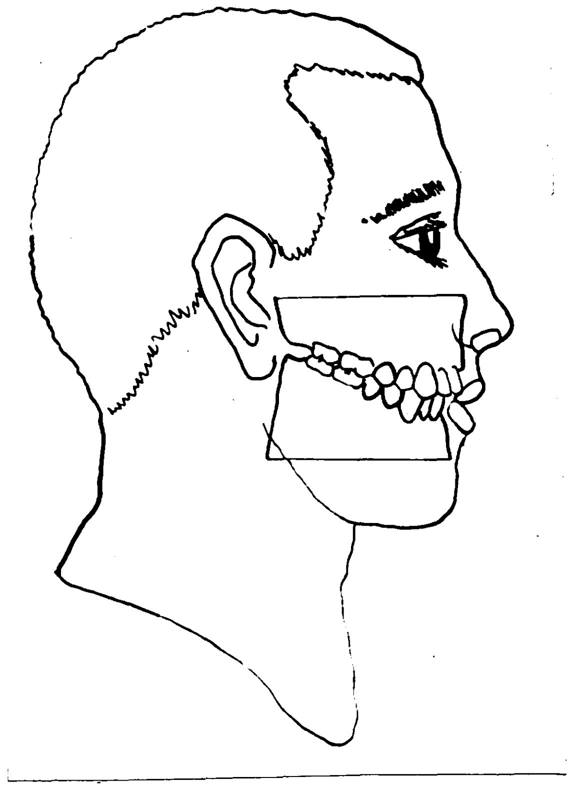


Fig. 20.

Shows the theoretical orientation of the plaster models in relation to the skull.

Stoll (125), and Sears (126). These articulators are mostly used in denture construction but are readily adaptable for bite-analysis. However, we are unaware of any instrument which will record the pathway between the Physiological Rest Position and the position of Habitual Deflected Centric. With such an instrument the fouling of occluding teeth could be quickly detected. A view of the teeth from the rear, as they pass into occlusion, would show up cusp-interference.

THE TRIMMING OF DIAGNOSTIC MODELS.

If diagnostic models are to be used to full advantage, then they ought to be accurately trimmed to a standardised pattern. Oliver, Irish and Wood (127), describe a method of model-trimming which requires no elaborate apparatus; a pair of dividers is used to mark off the base of the model in such a manner that the trim is equilateral. Kemble (128) describes the use of a joiner's "shooting-board" for the same purpose. Simon (129) utilises an ingenious technique, so that the model base represents the "Eye-Ear", or Frankfort plane of the patient and in addition the model is marked to show the orbital plane. Fig.20. The orbital plane is an imaginary plane which drops vertically from the lower edge of the bony orbit, at right-angles to the Frankfort

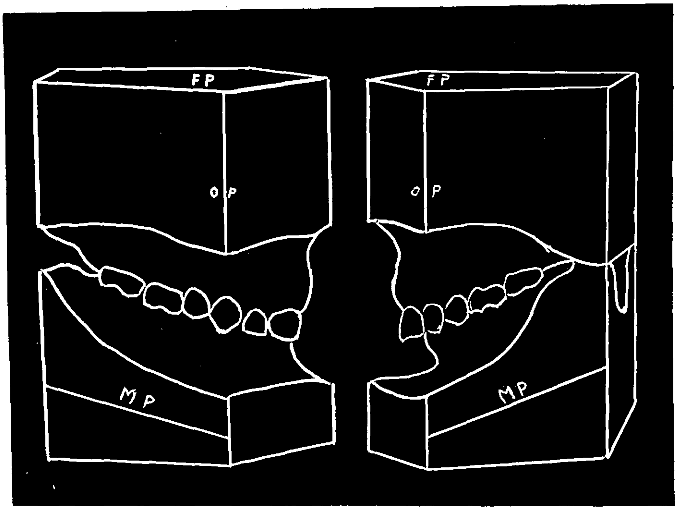


Fig. 21.

Illustrates how plaster models may be arranged to carry the following land-marks :- F.P., the Frankfort plane (eye-ear plane), O.P., the Orbital plane, and M.P., the Mandibular plane.

plane. The mid-saggital plane should also be registered on the model. A model of the upper jaw prepared in this manner, bearing registration points in all three planes of space, is useful, not only for interference-analysis but also for appraising the relations of the jaws to the cranium. Among the many authors who have contributed to this study is Logan (130).

REGISTRATION OF FACIAL LANDMARKS ON THE LOWER MODEL.

The recording of landmarks on models should be extended to include the lower model. I suggest that the side of the base of the lower model be marked with a scratch which indicates the lower border of the mandible (Mandibular plane) Fig.21.. This plane is of great diagnostic value to the orthodontist, and presumably could also assist the temporomandibular diagnostician. Instruments are used in the orthodontic department of the Glasgow Dental Hospital for measuring the angle of the Frankfort plane relative to the mandibular plane (131), (132). With a little modification they could be made to transfer the line of the mandibular plane to the lower model.

Summarising this point, let us imagine that we have a pair of models trimmed in this fashion, sitting upon a bench before us. They are not mounted on an articulator. The flat top of the upper model reproduces the eye-ear plane; the middle line of the model lies in the mid-saggital plane, and both model bases are trimmed to form an angle which represents the orbital plane. Fig.21.. If everything has been properly recorded, it is possible to measure off the distance of any tooth from the eye-ear plane, from the mid-line and from the orbital plane, thus we can recognise dental asymmetry, or indeed, any departure from the normal. Another advantage of this method is the ability to transpose on to graphs, these measurements in three dimensions.

Now, this upper model, so far described, has been sitting in occlusion upon its lower model which has had a plaster base added to make the base parallel to the base of the upper model, i.e. to the Frankfort plane. Lines are marked on the sides to show the mandibular plane. If properly done, the diagnostician can visualise the facial appearance of his patient: he knows the angle of the mandible relative to the upper jaw and hence to the cranium.

In addition, such models would attract attention to a mandibular asymmetry. A line connecting the lower edges of the orbits ought to be parallel to

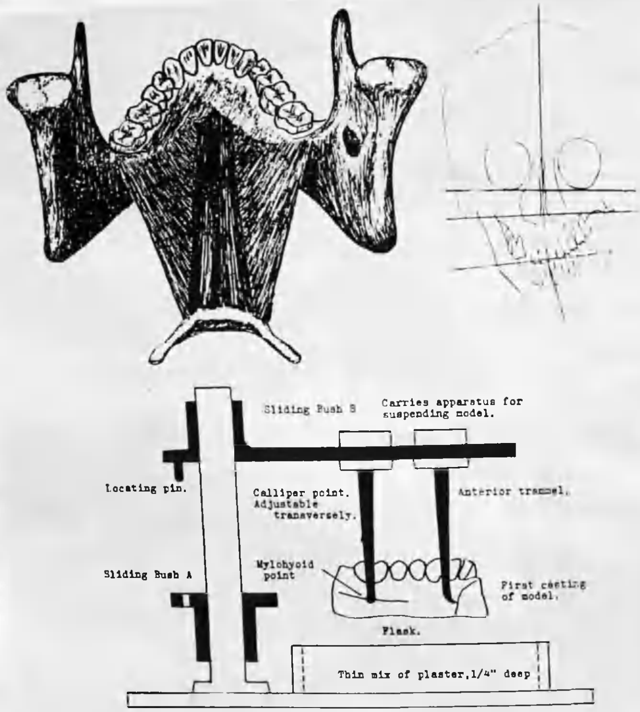


Fig. 95 (top left).—Attachment of mylohyoid muscle to mandible.
Fig. 96 (top right).—Tracing of frontal cephalometric x-ray demonstrating la of parallelism of mandible with line drawn across lower edges of orbits.
Fig. 97 (bottom).—Method of suspending first casting of orthodontic model a of furnishing lower model with a base parallel to mylohyoid line.
(Courtesy of Campbell, J.: D. Rec. 70:204-208, Sept.-Oct., 1950.)

Fig. 22.

From the Dental Year Book. Shows the use of accurately surveyed plaster models of the mouth, for assessing facial asymmetry.
From article by J.Campbell, Dental Record, 70: 204-208, (Sept.Oct.) 1950

the basal bone of the mandible. I published an article in the Dental Record, and in the Dental Year Book, 1951, on this method of recording of facial asymmetry, Fig.22.

The mounting of models in this fashion, while not perfect, is a step in the right direction. The hap-hazard trimming of models should be discouraged; an ungainly lump of plaster for a model-base confuses the eye so that false conclusions are drawn. The following little experiment is instructive; three sets of models are cast from the same impressions, then different plaster bases are added to each. It is possible to carry away three different mental pictures of the occlusion; one of them might convey the image of a pre-normal lower occlusion, another a post-normal and the other neutral occlusion. Models always should be cast in a standardised form.

But a most attractive prospect opens up if the models could be mounted on the anatomical articulator so that the models would lie in exactly the same inter-maxillary relationship as they did when in the mouth in its physiological resting position. Especially would it be desirable if the articulator were capable of closing up along the same path as does the jaw.

STABILIZATION OF MANDIBULAR POSITION.

As fore-mentioned, there is a school of thought which believes that the prime factor in slinging the jaw under the cranium is the balance between the opposing opening and closing muscle groups. The claim is made that the angle between the mandibular and Frankfort planes is constant throughout life, even that it is maintained after complete extractions. As afore-mentioned, this school of thought believes that, in adult life, the inter-maxillary distance is unchangeable and that even in the edentulous state of the inter-maxillary space will continue to be maintained throughout life.

While I do not accept this concept in toto, nonetheless it has a substratum of truth and is of high practical value; therefore, a further explanation is due here. Assuming that the jaw of a subject is lying at rest, there is a space of a few millimetres between the teeth; also in many cases the jaw will lie slightly in front of the position it will ultimately assume when the teeth inter-lock. As the patient closes his teeth, a tooth may strike its occluding counterpart, abruptly changing the pathway of closure. We remember that in the idealised subject the path of closure of the lower

Plate 3.

Plate 4.

Due either to over-eruption of the incisors or under-eruption of the posterior teeth, the incisors meet in such a way as to displace the condyle backward.

incisors is 'forward and upwards', in a smooth, unbroken flow of motion from rest position. But how often we are confronted with a pathway of closure which demonstrates a step, where the lower teeth strike the uppers, to be deflected backwards: if the jaw is diverted in this way surely the condyles are also pushed out of normal position. Plates 3 and 4.

THE POSSIBILITY OF THE STRETCHING OF THE JOINT LIGAMENTS.

Caution must be observed in accepting this conception of mandibular deflection without equivocation; it is an unwarranted assumption that the jaw has been deflected merely because it was seen to jump backwards as cusp-interference was encountered. Indeed, perhaps it was only returning to proper resting position, having been reached out for the purposes of incising off a piece of food. But, such a case will in most cases be an uncomplicated backward displacement which can be confirmed by lamingraphic examination, a pair of pictures being taken in the resting position and another pair in the interlocking position. The photographs of the plastic model, Plates 3 and 4, show a hypothetical example of mandibular deflection by lower incisors striking uppers 'pathomechanically'.

Summing up this point, we have no right to assume that the joint ligaments are stretched merely because a cusp-interference has been detected, although in most cases the assumption is valid. Roentgenography is invaluable on this point.

The cusp-interference to be seen in the plastic models of Plate 3 may be caused by (1) over-eruption of the upper and/or lower incisors, or (2) under-eruption of the posterior teeth.

ASSESSMENT OF REST POSITION.

The determination of rest position is not easy; many methods, radiological and otherwise, have been described, Logan (133), Craddock (134), Thompson (135). Where natural teeth still exist, the method described by Stansbery seems useful. He injects between the lips, into the mouth, some quick-setting plaster from an improvised plaster-gun; the plaster setting between the teeth records rest position.

I have experimented with another method of securing inter-maxillary relationship, which is interesting enough to justify continuation of the work. A stiff wax base-plate is fitted to the lower jaw. If natural teeth are present, the base-plate can be made secure by wire clasps; if edentulous, heavy wires can emerge

Fig. 23.

This illustrates an experimental method for recording rest position. Method presently being tested.

from each corner of the mouth to extend backward to the molar region, and from these wires a broad elastic band passes under the chin holding the base-plate firmly in position. Now, whether edentulous or not, this lower base plate carries outside the lips a small, light metal pot. Then, similarly fixed to the upper jaw is a light metal bar terminating in a small spade which has been so fixed that it lies in the pot without touching it. Fig.23. To register occlusion, all that is needed is to wait until the patient is at rest and then fill the little pot with plaster. When the plaster has set the device is removed from the mouth and the upper and lower models dropped into the base-plates. In this manner rest position is registered.

REGISTRATION OF OCCLUSAL RELATIONSHIPS BY HAND-MADE CHECK-BITE.

I have employed another rather unorthodox method of recording rest position which has been evolved from a technique which Nove (136) uses for the correction of harmful occlusal relationships. Carefully observing the relaxed inter-occlusive distances and angles, I reproduce them in a stiff wax check-bite which is placed into the mouth to see if it fits.

The check-bite has been made by pressing a thin roll of specially hard wax on to the tops of the plaster lower teeth; while it is still fairly soft the upper teeth of the model are pressed into the wax to reproduce the freeway space which had been mentally recorded at the time of the inspection of the mouth. The wax is next trimmed to remove overlaps on to labial or lingual surfaces, because, should any overlaps remain, they might guide the jaw into an influenced relationship (dictating the occlusion, to which I shall later refer).

The technique just described may savour of "guessing the bite", and indeed, the charge may have some validity, but nevertheless, the ease with which the teeth drop into the wax thus 'oriented', strongly suggests that the human eye can be trained to a remarkably precise appraisal of inter-occlusal dimensions. Admittedly, some of the apparent success may be attributed to the resiliency of the temporomandibular joint, and to a less degree, of the pericemental membranes.

No heavy apparatus being hung on the jaw, this method has merit.

TRACING METHODS FOR REGISTERING REST POSITION.

We must think of rest position in three planes of space, the saggital plane, the frontal and the vertical plane.

Another method of registration by tracing, requires two smoked-glass plates; the one in the horizontal plane will record the position of the jaw in antro-posterior and in lateral relationship, and the plate which is set up on the profile will register the position of the jaw in saggital relationship. If the stylus is fixed in this latter method to the lower teeth, not only will the rest position be recorded, but also all the jaw movements in saggital plane.

Where the plate is arranged horizontally, there is a choice of two methods, either the stylus is fixed to the upper teeth, with the plate moving because it is attached to the lower jaw, or the stylus is fixed to the lower teeth with the plate on the upper. If the former method is used, the so-called "Gothic arch" will be scribed on the plate; if the latter, the "sea-gull". Whichever method is employed, the jaw will be in rest position when the stylus lies at the intersection.

Another tracing method is to use recording pens carried out of the mouth from the lower jaw, so as to write their graphs in the region of the condyle; these are mostly used for recording the condylar path, but the method could be adapted to show resting position.

Summarising "bite-analysis" by articulators, these techniques have undoubted merits and are sure to develop. Apart from aiding the diagnostician, the instrument can be passed on to the technician, who will find it indispensable for the construction of the apparatus.

TRACING TECHNIQUES FOR THE STUDY OF MANDIBULAR MOVEMENTS.

A copious literature has been written on the subject of recording mandibular movements by tracing. Probably Bennett's method has never been surpassed. He fixed tiny spots of light at various parts of his jaw, and by using a magnifying lens in a darkened room, the paths of movement of the lights were thrown on to a wall and there recorded by his brother. The small lights were located over the posterior part of his jaw by extending the stout wire which was fixed to his lower teeth.

Other investigators (137), have used light also. For example, the bright head of a pin was inserted between the lower incisors and movement photographed using a slow exposure (138). Luce used this technique as far back as 1889, (139).

The stroboscope, an instrument utilised by the mechanical engineer to "slow down motion" has been used by Kurth (140) to study mandibular movement.

I am experimenting with a tiny source of light carried at the end of the mandibular bar which extends back to the condylar area. The whole apparatus is very light, and as there is no direct contact between upper and lower jaw, jaw movement is entirely uninhibited. Only the spot of light traces over the card which has been banded to the cranium in Frankfort orientation.

While, in a manner, it is not strictly relevant to our main theme, it is interesting to note that Kemp and Ardran (141) have made an excellent cinematic roentgenographic study of the act of swallowing. Their subjects were fed a meal of radiopaque material and screened when swallowing, much useful information being derived from the study. For example, it was interesting to see from the antro-posterior view, how the stream of soft food was divided into two by the root of the tongue, only to join again. One of these workers had a silver clip fixed to his own epiglottis; the movements on the film of this part were fascinating to behold.

STUDIES OF THE ACT OF SWALLOWING.

Rix (142) has made a cinema film (not a roentgenogram) of the act of swallowing. A patient having lost his cheek in a cancer operation, a chance was provided to obtain an "inside view". Gwynne-Evans (143) also has made many excellent cinematic records.

Nove (144) also has made a film of the act of swallowing, showing how it was influenced by "functional" and "non-functional" dentures. His slow-motion study is very impressive.

The function of swallowing is not entirely divorced from our study, as can be seen by the statement that a few of our patients have complained primarily of pain and disorder during swallowing.

SUMMARY OF TRACING METHODS.

It is hard to make an unbiassed appraisal of the real value of tracing methods for diagnosis and for study. The present opinion that I hold, is that some of the enthusiasm for the method will disappear as the diagnostician developes clinical skill. However, during his training years, he definitely should make use of these techniques in order to discipline his observations, but later when he has trained his eye to see that which is to be seen, and his fingers to feel that which can be palpated, he then may discard tracing techniques. The research worker is exempted from this advice; there is much to learn and tracing methods will help.

While I sponsor the value of the "clinical eye", as a measuring instrument superior to any mechanical device, it suffers from the shortcoming that it does not leave a record which can be placed in the files for future reference. This is the consideration which makes me hesitant to advise that tracing methods may be dispensed with.

SUBJECTS FOR THE STUDY OF MANDIBULAR FUNCTION.

Wherever one goes one sees subjects for study; in the tram-car, on the television, at the next dining-table. Look around and you may be lucky in that a perfect subject for study presents himself! His thin face shows clearly the condyles working below the integument; surreptitiously we watch him; he is quite unaware of our observation. The number of 'chews' to each mouthful impresses, together with the speed of the masticating stroke. We promise ourselves that some day we shall watch him and count every chew for the entire meal, and then apply the formulae of Manly (145), and Shiere (146) in order to calculate the approximate energy expended by his masticating muscles!

But we are not interested in foot-pounds, so much as in the action of his mandible. Among the many lessons we have learned from him is confirmation of the theory that the mandible swings in its wider movements on a centre of rotation located near to the lingula.

PALPATION.

As in the case of the eye, the palpating finger-tips need education and experience. The finger-tips are placed over the temporomandibular joint and the patient is requested to open and shut the jaw, the clinician stands in front so that he can also see the action of the jaw.

Many points of diagnostic value can be disclosed, some examples follow:- Do both sides function normally? Is there a side without translatory movement? Does one side lag behind? Is the movement of one side or both sides excessive? Is the condyle inclined to stick up on the crest of the eminence? Is the click soft or hard and loud? Is there crepitus? When does the click take place, at the beginning, the end, or in the course of the opening or closing movement? What is the direction of the opening and closing pathways? Is there any lateral movement of the condyle? Is there any side-dislodgment of the disc? Is the disc loose?

The diagnostician should be on his guard for any artificiality of movement; in fact, the patient should be given a biscuit to eat, so that a natural, or rather, a habitual movement may be induced.

It is claimed by some that the placing of the tips of the little fingers in the external meatii will show up the distal displacement of the condyle with greater certainty. I have discarded this method because every case could be felt as a distal displacement!

Where a cusp-interference exists in the mouth, palpation over the condyles is delicate enough to feel the first contact of the teeth. The amount and direction of condylar shift which takes place after the initial occlusal contact, as the teeth continue to close to their closest inter-locking position, can be felt.

Several authors advise palpating the action of the masticating muscles. For example, it has been said that centric occlusion can be detected as a complete relaxation of the temporal muscle, but because many patients have such weak muscles as to defy palpation, the method seems to have little value.

AUSCULTATION.

Auscultation is a method advocated by some as a method whereby the joint noises may be more accurately

Plate 5.

Each side is here shown fully closed and fully open, the range of movement being limited short of causing pain. It will be seen that there is no traverse of the condyle on one side, whereas the condyle is hyper-mobile on the other. But, this case is deceptive : it would be wrong to conclude that the condyle was bound down by adhesions, because with a special effort, the condyle belatedly jumps forward.

perceived. However, if the noises are so slight that they can only be detected by the stethoscope, then for all practical purposes they can be neglected.

An occasional patient is found who demonstrates functional asymmetry, in that one condyle descends down the slope of the eminence, while the other condyle remains in the original position. By hingeing on the "immobile" condyle while the other moves excessively, the jaw attains a fair opening. This feature is shown in Plate 5.

This figure teaches two lessons. In the first place, it shows functional asymmetry, but it also proves how easily we can be deceived in diagnosis. It would be natural to conclude from inspection of the laminagrams alone, that one condyle was immobilised by adhesions, while the other side was unduly free. But, in actual fact, as proved by palpation of the patient's temporomandibular joints, the so-called immobile condyle merely lagged behind in the timing of the movement. It did not begin to move until the wider stages of opening had been reached, when it suddenly bumped up onto the crest of the eminence.

This case teaches one to rely on palpation just as much as on the laminagram. When one has palpated many temporomandibular joints in action, one

Plate 6 A.

These laminagraphs are from different patients.

Plate 6 B.
This is Plate 2.

This illustrates a wide range of movement.

This patient suffered facial neuralgia.

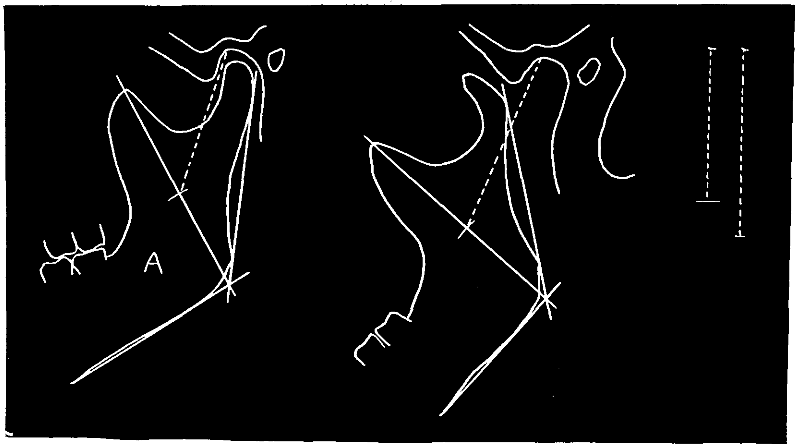
realises that it is not uncommon for a jaw to open on a condylar axis for a considerable opening, then for the condyles suddenly to snap up to the crest of the eminence.

The condyle which suddenly jerks in this fashion is always associated with a steep inclination of the distal slope. The path of condylar travel is not a straight line in these cases; it is steep until it reaches the crest, then it abruptly changes direction when it moves forward.

Plate 6 brings out another point: mention has been made elsewhere in this paper of the ease with which some patients can place their jaws in this pseudo-dislocated position and then return them to rest position without difficulty.

Now, this young man suffered neuralgia: could it be explained by the extreme hyper-mobility of his temporomandibular joints? Could his repeated pseudo-dislocation have stretched ligaments and nerves to their painful point?

We now investigate the possibility of stretching the inferior dental nerve. This nerve emerges from the skull at the foramen ovale, and it enters the mandible at the entrance of the inferior dental canal, therefore,



A.   B.

Fig. 24.

Here we discuss the possibility of pain being caused by the continual stretching of the inferior dental nerve, by the hyper-mobility of the jaw. This nerve emerges from the oval foramen at the base of the skull, and it is held here, to some extent. In like manner, it is held at its point of entry into the mandible. Can hyper-mobility stretch the nerve between these two fixed points?

This theory was tested by measurements taken from laminagrams taken by a precise technique, so that dimensions are comparable. The dotted lines show the amount of stretch between the two fixed points.

to some extent it is anchored at both points. This fact must be taken in conjunction with the physiological principle that nerves enter bones "at their point of least movement", a principle which, incidentally seems to suggest that a nerve was not meant to be stretched.

Now, let us look at Fig.24A and B from this point of view: it can readily be seen that the distance B is longer than the distance A. Have we the right to conclude that the inferior dental nerve was stretched, or on the other hand, did the opening of the jaw merely take up the slack?

Objection might be taken to making measurements from the deepest part of the glenoid fossa in lieu of the foramen ovale, but a piece of wire was inserted into this foramen in a skull, and this was set in a jig with the trans-meatal axis at right-angles to the film. The laminagram which was then taken, showed coincidence between the foramen ovale and the deepest part of the glenoid fossa, so that we felt justified in using this as a suitable point-of-departure for measurement.

Some difficulty was experienced in finding a clearly defined land-mark on the lower jaw near to the point of entry of the nerve: the compact bone at the entrance to the canal cannot always be distinguished. As seen in Fig.24. lines were drawn tangential to the lower as well as to the distal borders of the mandible; then a line was drawn from the point of inter-section of the tangents up to the crest of the coronoid process. A distance was measured up this line to be the same on both laminagraphs, and these points declared as the fixed points for measurement. The difference in the lengths A and B can be appreciated.

It is some diffidence that I advance the hypothesis that the inferior dental nerve, as well as the joint ligaments, may be stretched to the painful point.

The young man whose tracings are here illustrated, was cured within a few weeks of bi-lateral facial pain, by immobilising his jaw during sleep, by a simple head-harness and chin-sling.

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Chapter 15.

OCCLUSAL RELATIONSHIP AND MANDIBULAR DISPLACEMENT.

OCCLUSAL RELATIONSHIP AND MANDIBULAR DISPLACEMENT.

It is fitting to begin this discussion of occlusal relationship with a quotation from Nuttal (147), "From the first time that dental services were rendered down to the present, most patients have been interested in the involved tooth. This attitude requires the dentist to direct his attention to a particular area rather than to a careful observation of the entire mouth". It is very difficult to resist this pressure to restrict one's vision, but the more enlightened members of the dental profession now look upon the mouth as a whole.

A notable step in the right direction was made by Angle, (148) one of the first to classify occlusal relationships. His classification however, had short-comings; merely relating the lower teeth to the upper, it did not make clear the need to take into account that the dental arches might be out of accord with the cranium. As afore-mentioned, the modern orthodontist knows the pit-falls of starting the orthodontic examination after the patient has placed his teeth together. He knows that closure of the teeth often forces the jaw awry.

The last word has not been said on the classification of dento-facial anomalies, and it is evident that many orthodontists are now paying regard to the rest position of the mandible as a suitable relation upon which a classification may be based.

Much valuable work on occlusion and on functional analysis has been done by the periodontists, and the fact that this paper deals mostly with orthodontics and prosthetics does not deprecate their contributions.

FULL DENTURES.

By virtue of necessity, the prosthetists who studied full dentures were early interested in occlusion. From occlusion, the logical next step would be to the temporomandibular joint. But it would appear from a study of the early literature, that their interest stemmed from an urge to make an articulator which would re-produce every conceivable movement of the jaw. With such an instrument, they reasoned that dentures might be made to balance in every excursion of the jaw, and thus provide stability.

It is fairly easy to provide a balanced occlusion if the occlusal surfaces are made perfectly flat - and this point will be discussed shortly - but to balance a full denture with cusps is a different matter. Now, cusps are advantageous; they aid in shredding food, but it is extremely hard to set artificial teeth in wax in such a manner that <u>every</u> plane of <u>every</u> cusp maintains occlusive contact in <u>every</u> excursion of the jaw. Even conceding that this is possible, it is now known that dentures cannot be processed without disturbing the occlusion (149). It is now generally recognised that the procedures of converting a wax "set-up" to a moulded acrylic, are not so exact as originally believed.

The full denture should be designed so that the patient may protrude his jaw without tipping his denture off its seat. The cusps should slide over one another without cusp-interference. A cusp-interference in a full denture, does not have the serious effect on the temporomandibular joint as in natural dentition; a cusp-interference in a full denture will be more inclined to cause pain by upsetting the stability of the lower denture and thus chafing the edentulous ridges.

But to a slight extent, cusp-interference in a full denture may affect the joint. In a case where free lateral excursion had existed in the natural dentition, and where the patient is presented with a new full denture for the first time, and where a cusp-interference now precludes lateral excursion, the patient will soon learn a new way of chewing. He will soon give up his attempts at lateral excursion after he has bruised his ridges, and he will develop an up-and-down masticating stroke.

The prosthetist's concept of an uninhibited mandibular shift from, say, closed protrusive relation back to centric is commendable. Swenson (150) and Gysi (151) illustrate the theoretical contact between the distal surfaces of the upper cusps and their occlusive counter-parts, and claim that these inclines are segments of an imaginary circle which has its centre behind and below the angle of the jaw. They also say that where cusps are shallow, the theoretical rotational centre shifts more and more to a position above the occlusal plane. In this country Chick (152) has written on similar lines.

The opinion is here expressed that many authors have focussed on the saggital aspect of occlusion at the expense of the third dimension. They illustrate their articles with plane figures purporting to be cusps. Now, teeth are solid objects, not flat geometric figures. Masticatory function is three-dimensional, and in action the jaw has merely to shift a little laterally to nullify all the calculations based on measurement of the cusp-

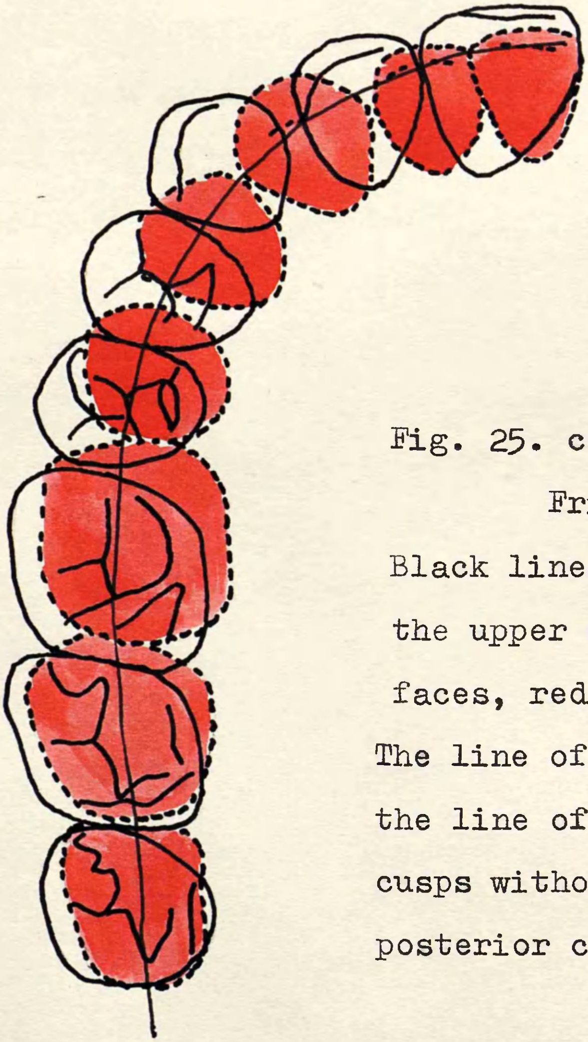

Fig. 25. copied from Friel.

Black lines represent the upper occlusal surfaces, red the lower. The line of sulcii meets the line of lower buccal cusps without much antero-posterior cusp-interference.

inclines of plane-surface drawings.

The student of occlusion must realise that the inter-digitation of the posterior teeth does not inter-lock and restrict movement so much in the antero-posterior dimension as in the lateral. This point may be appreciated if we examine the occlusion of the buccal cusps of the lower teeth, into the central sulcii of the upper. On Fig.25 the middle sulcii are to be seen running in a continuous line, and at a reasonably unvarying flat level, from last upper molar to first premolar; that is, there are no obstructions hereabouts to lock the occlusion; even the sharpest cusp does not enter far into an occlusal sulcus. Therefore, the jaw can retire from closed protrusive relation to centric with less "leap-frogging" of the cusps, than is commonly believed. The student of occlusion can appreciate this point from the drawings of Friel (153) and McCollum (154).

Now, while the return of the jaw from protrusion is only slightly impeded, the swing of the jaw into lateral excursion, and the return from lateral excursion, are much more complicated movements, even in cases where occlusion is normal. These are the movements which apply a horizontal displacing stress

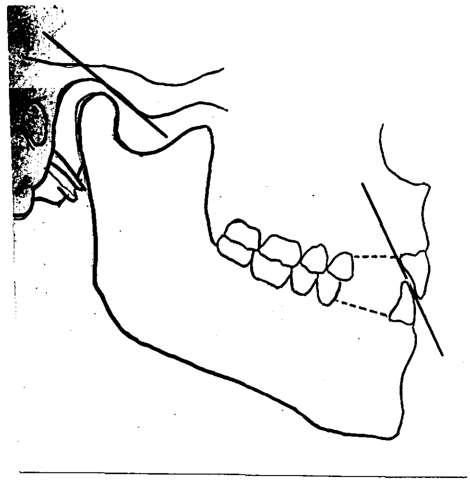

Fig. 26.

Shows a discrepancy between the condylar path and the path which would be taken by the tip of the lower incisor as it feels its way into centric occlusion. As explained in the text, this theory is of little importance in a case where the lower incisors swing into centric with an axial pivot on the condyles, which is, in fact, the final movement of physiological closure.

But, as a general principle, a close incisal over-lap is desirable neither in the natural teeth, nor in a denture.

to the denture, and produce "denture sores", especially on the lowers.

DYNAMIC OCCLUSION.

The last decade has seen many notable contributions on "dynamic occlusion", in contra-distinction to "static occlusion", of which Schuyler's is selected as an example, (155). Apart from the tenderness of the edentulous ridge, modern opinion holds that the features most likely to apply bruising force to the ridges, are, in order of importance, long overlap of the incisors, high cusps and steep condylar path. By the time the patient requires dentures, there is little that we can do to change the condylar path, but the wise dentist will not be coerced by his patient to set up the incisors with a steep incisor-guidance; that is to say, a line drawn from the tip of the upper to the tip of the lower incisor, theoretically should have a less steep incline than the condylar path, Fig.26.

A long, close incisor over-lap will put an end to the horizontal protrusion of the jaw; there is no great loss if the patient no longer can protrude per se, but he is handicapped when he tries to bite off a piece of food, which, after all, is tantamount to protruding. It is well to remind ourselves that the jaw does not operate in the fashion of the proverbial "barn-door-hinge", and that it is liable in certain excursions to strike a premature cusp-interference, if the incisor over-lap is long and close, or if the cusps of the posterior teeth are long and badly arranged.

I hold unorthodox ideas concerning the correlation between the inclination of incisal guidance and the inclination of the condylar path. Again, in this instance, very convincing geometric figures can be drawn showing how the jaw will "home" into centric if the angles of incisal guidance and condylar path, are identical, and further, how the movement will be impeded should the inclines be out of accord. But, the proponents of these theories assume that the condyle glides upwards and backwards, during the final physiological closing movments. Undoubtedly, this is exactly how many condyles travel, when the natural incisors have a long, close impeding over-lap; but this is a patho-mechanical movement, not physiological. As aforementioned, in normal mastication the pathway of the lower incisors in the final closure of the jaw from rest position, ought to be forward and upward. That is to say, the condyle hinges throughout this movement, it does not at this stage, travel along the condylar pathway.

This is not intended to demean the research workers who draw geometric figures of occlusion; merely do I suggest that some popular theories are untenable. However, one should be cautious in deprecating theories which receive general approbation; in many cases the condyle closes along a pathway which is a replica of the glide of the lower incisors up the lingual of the upper; but on the other hand, a long, close over-lap of incisors does not always constitute an interference which displaces the condyles. It is quite within the bounds of probability that a hinge-axis from rest position to full closure, can function in the presence of a long over-lap.

DESIGN OF OCCLUSAL SURFACES OF ARTIFICIAL TEETH.

A long line of research workers have applied themselves to the problems of design of the biting surfaces of artificial teeth, particularly the posterior teeth. The objectives of the modern tooth-designer would seem to be the provision of artificial teeth which could be set up by capable hands to give the maximum shredding power, with the minimal side-thrust. This concept would be incomplete without the so-called anatomical articulator.

In theory, the cusped denture will function more efficiently as a food-mill, but will only act without traumatic thrust on the edentulous ridges, and with maximum efficiency, in a conjunction of contingencies almost verging on the miraculous. That is to say, to give balance, the incisal guidance pathway, both condylar pathways, and every surface of the occluding cusps would have to be "just right", to such an extent as to be quite fortuitious. The designers of the artificial posterior teeth, therefore, are turning away from cusps with long slopes and steep angles.

The modern concept of the three-dimensional chewing with shallow-cusped teeth with angles between cusps of about 150 degrees, has much to commend it: when properly handled, the working side, the incisors, and a point in the contra-lateral molar region can be arranged so that they all balance as the teeth meet through the bolus. The reader who is interested in balance in articulation has an extensive bibliography to study, out of which the following can be recommended, (156), (157), (158). Sear's theory of the sub-occlusal segment on the lower teeth, which is designed to push the lower denture to the lingual, that is, to the side of the lower ridge best able to with-stand thrust, is interesting.

FLAT-CUSPED TEETH. SO-CALLED "INVERTED CUSP" TEETH.

Only flat cuspless teeth with a minimum of occlusal contact, and free escape-ways, should be used in a patient who has under-gone mandibular re-positioning. Throughout this thesis, it has been repeatedly emphasised that the antro-posterior component of re-adjustment is just as important as the "bite-raising". In that case, everything should be done to ensure that the occlusal relationship shall not be impeded in (1) selecting its best position in the antro-posterior plane, which often happens spontaneously when the vertical dimension is restored, and (2) permitting the mandible to retrude into its natural position at the end of a treatment for the relief of pain, during which the condyles were temporarily held in a forward position. It will be seen that cusped teeth would not satisfy these requirements, to a great or less degree, they would interlock and restrain self-adjustment.

Cuspless teeth are easy to set up and are suitable in almost every respect. The surfaces ought to show features which are sharp enough to shear up food. Hardy overcomes the smoothness of plastic posterior teeth, by inserting small loose coils of stainless steel ribbon into the plastic when it is about to be moulded, (159). The sharp edge rises a little higher than the surrounding

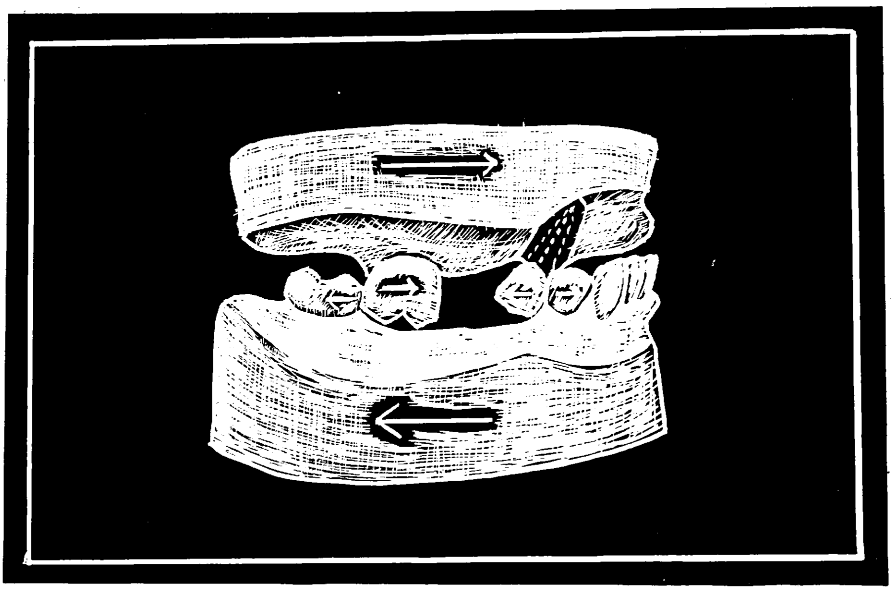

Fig. 27.

These plaster models demonstrate cusp-interference. The extruded upper molar slides along the mesial surface of the lower molar, in such a manner as to drive the lower tooth back and the upper forward. A secondary effect can be observed in that the upper premolar becomes tilted distally.

plastic.

If the posterior teeth must be porcelain, and in passing, much can be said in its favour, then sharp-edged depressions on the occlusal surfaces will catch the food while it is being sheared. We have seen posterior porcelain teeth which were too smoothly rounded to perform in this manner. But, when setting up, care should be taken to ensure that all the flat tops are in continuous occlusal line, with no semblance of a ledge to obstruct freedom of excursion.

NATURAL TEETH AND DISPLACEMENT OF THE MANDIBLE.

It is easier to understand cusp-interference in the natural dentition. Whatever mouth one cares to examine, cusp-interference is almost sure to be present, in great or in small degree. It results, in most cases, from premature extractions. Adjacent teeth drift into the gap and opposing teeth extrude into it, and thus is created an interference, the inclined planes of one tooth sliding over the inclined planes of the other, in such a way as to direct the jaw out of true relationship, Fig.27.

Here is a short list of the commoner inferferences.

(1) The extruded posterior tooth, as described.

(2) The incisor cross-bite.

(3) Upper lateral incisor inside lower.

(4) Upper premolar entirely to the buccal of the lower premolar.

(5) In the deciduous dentition, interference between canines. A deciduous molar about to be shed.

(6) Angle's Class II, div 2.

(7) The postural pre-normal mandible.

These are the more gross examples; many others can be recognised. Every case must be examined from first principles; in fact, it is probably unwise to attempt to classify cases.

Angle's Class II, div 2 is the classic example of an occlusion which may displace the mandible; here the incisal edges of the lower teeth strike the lingual surfaces of the uppers and glide up until the movement is stopped on the posterior teeth. Beginning with the first contact, the front part of the jaw will shift in the same direction as the lingual surfaces of the upper teeth are sloped. On the other hand, the posterior part of the mandible will shift according to the slope of the condylar pathway: intermediate parts of the mandible will shift as influenced by both.

It should be borne in mind that the mandible has two joints which, up to a point, can operate independently. Whatever the shift of infra-dentale, in a case of Class II, div 2, it is unlikely that it will take the true physiological pathway from rest position to full closure, that is forwards and upwards.

REST POSITION OF THE CONDYLES.

The term 'rest position' has wider implications than dental relationships; the condyle must also be considered. As afore-mentioned, the condyle ought to rest firmly, but ready to slide forwards, half-way up the slope of the distal surface of the articular eminence. Now, here is an important point: even though the jaw has obviously been displaced, the condyles have not been displaced if they rest half-way up the slope and closer to it than to distal part of the glenoid fossa. In other words, displacement of infra-dentale is not synonymous with condylar displacement. The mal-contact between lower and upper incisors may simply have been a very unimpressive procedure of returning the condyles to their correct resting position. Perhaps the condyles have been brought forward to bite off food.

We discuss this point as it applies to:-

(1) Angle's Class II, div 2,

(2) " Class II, div 1.

(1) In the former case, we must be cautious in

concluding that the condyle has been pushed back. True it may be that both upper and lower incisors are tilted lingually, and true it may be that the lower incisors glide back as they seek centric, but this does not signify that the condyles have been pushed back beyond the physiological position. The child, perhaps, has suffered her dental anomaly for so long that it becomes "part of her"; that is to say, growing up with it, the growth-activity has modified the mechanism of the joint to suit the new occlusion. Compromise though it be, it is now the best thing for the patient: therefore, an ill-considered attempt to "correct" this occlusion with over-lays, inlays, or crowns is doomed to failure. Even though the "bite" is obviously wrong, the condyles may be in correct position.

Should normal closure or excursion of the jaw be restricted by interference, the condylar action will soon alter to accommodate.

(2) The effect on the temporomandibular joint of the Class II, div 1 anomaly is different. Here the incisors do not over-lap so much nor so closely, therefore, protrusion is less restricted.

In this orthodontic condition, there is a tendency to an excessive horizontal forward translation

Plate 2, (repeated)

Shows an apparent dislocation, from which the patient can return to rest position with ease. A casual inspection of the laminagram in the absence of the patient might lead to the wrong conclusion that the jaw was dislocated. Many such cases have been observed.

of the condyle in the act of opening. Cases have been seen where the lower incisors were set so remotely from the uppers, that the jaw had to be protruded over half-an-inch to incise food. This excessive protrusion must pull the condyles right out of their fossae. Indeed, palpation has proved that the condyles have mounted the articular eminences when the incisors were placed in the biting position. Laminagrams of these cases confirm the remarkable extent of condylar shift; unless one knew differently, the pictures would lead one to believe that the condition was that of dislocation, but the jaw never sticks; the jaw can be retracted with the same ease as it was protruded. Plate 2 shows a case. This type of case is common and has been recognised as early as in an eight year old patient.

These experiences offer an explanation of the hyper-mobile temporomandibular joint occasionally to be seen in an adult. In passing, it may be noted that where a great horizontal space exists between the upper and lower incisors, the child will often bite off food with his premolars, not with his incisors.

Summing up this point, it may be said that roentgenology provides the only method for determining the rest position of the condyle at the moment when the jaw has arrived at habitual centric. In other words, the teeth may appear to be in centric occlusion, but the condyle may or may not be at its proper rest position; only roentgenology can give a positive answer. The Gothic arch technique, valuable though it may be, shows the most retruded position of the jaw, but does not concern itself with the position of the condyles: the technique cannot discriminate between a displaced distal position of the jaw and the distal position of true centric.

FORWARD DISPLACEMENT OF THE MANDIBLE.

The directions of jaw displacement are infinitely variable. Forward displacement of the jaw is frequently encountered, especially in the orthodontic field. Commonly, a child is brought to the orthodontist for consultation: one's eye is struck by his facial expression, reminiscent of the bull-dog. The closed vertical dimension is complicated by a mandibular protrusion. Close examination shows that the child can almost place his teeth edge to edge, but the edges of the lower incisors lie just slightly to the labial of the uppers. His posterior teeth being shorter than the front teeth, he can only exercise the human desire to chew with the back teeth at the price of increasing the protrusion: this is known as the "bite of convenience". The results of this displacement may be quite severe; they may vary from the up and down masticating stroke induced by the occlusal lock, to a forward displacement of the condyles accompanied by pain.

We have treated a few adults with mandibular protrusion and pain: in some cases the protrusion was acquired, in the others it was reckoned to be genetically endowed. The beginnings of the condition may be as simple as the prolonged retention of the deciduous centrals, behind which the permanent centrals erupt, being deviated from their proper eruption pathway, and so their edges may be caught behind the lower incisors. Years may pass without the condition worsening; the lowers remain just a little in front of the uppers. Then comes the day when the posterior teeth must be extracted; the molars no longer remain to hold the jaws apart, and the whole weight of mastication falls on the incisors. The vertical height of the face shortens and the lower incisors slide up the <u>labial</u> face of the uppers, protruding the jaw.

These cases where the jaw has shifted its posture to a closed and pre-normal position, hold a special interest. They seemingly contradict the common opinion that temporomandibular pain is caused by the pressure of a distally deflected condyle upon the auriculo-temporal nerve. In the example quoted, the condyle is <u>mesially</u> displaced!

However, whatever explanation of the pain-mechanism one favours, the fact remains that instances have arisen where pain started with the forward and upward shift of the front part of the jaw, precipitated by the extraction of the posterior teeth. Furthermore, in these cases the pain was relieved by replacing the lost molar support.

THE LATERAL DISPLACEMENT OF THE CONDYLE. IS IT POSSIBLE?

It is theoretically possible to displace the jaw in every plane of space; not necessarily in the cardinal points of the compass, but in every conceivable direction. Further, the jaw has two joints, so that it may slew and tilt and vary diversely from normal.

I feel that lateral displacement of the condyles has received insufficient attention. At first sight, the internal displacement of the condyle would appear impossible, but examination of a skull will show that a little latitude is permissible. This point has been discussed from another aspect, in the part of the paper which deals with ancient skulls.

VERTICAL DISPLACEMENT OF THE CONDYLE.

When vertical displacement of the jaw is mentioned, one's thoughts turn to dislocation of the jaw, and indeed, this subject will be briefly dealt with, in later pages. But the insiduous upward displacement of the jaw is our biggest problem: that is to say, over-closure of the vertical dimension.

As afore-mentioned, claims have been made that the mandible rests at a constant distance from the maxilla, even after the loss of the natural teeth. While there is a grain of truth in this contention, it does not fill all the requirements. In final analysis, the rest position depends on muscle balance between antagonistic muscle groups, and who would deny that muscles can be trained to new behaviour patterns. Among the many dentists who have written on this subject are Rogers (160), Ballard (161), McCollum (162), and Brodie (163).

It should be remembered that muscles can be conditioned for better or for worse; in the latter respect they soon fall into the new ways of a deteriorated occlusal relationship, and make "the best of a bad job". This process of accommodation will be easier in a child than in an adult; in fact, in an adult they may cause pain in their reluctance to stretch and otherwise learn new ways of function. But, while the process of re-education of a muscle may be slower in an adult than in a child, the capacity never ceases.

The ability of the masticating muscles to contend with a degenerating occlusion is easy, compared with their rehabilitation. General opinion seems to be agreed that the conditioning to a successful behaviour pattern, requires resolution of an unusual order on the part of a child and his parents; and as to the adult, once the muscles have been conditioned to wrong behaviour patterns, they show a strong tendency to hold on to their wrong habits. An example of this is ready to hand in the case of the speech-therapist who tries to cure a lisp in a child, and then in an adult.

Therefore, to the clinician who would try to relieve pain in the temporomandibular joint which has been diagnosed as due to mal-function of the masticating apparatus, twin problems are presented, (1) the physical restoration of the parts, and (2) the restoration of a proper manner of usage. The problem is still further complicated by the doubt as to what should be restored; should restoration be merely regarded as replacing artificial teeth in the recent position of the natural teeth, that is to say, shall we restore the individual as he was recently, or on the other hand, shall we go better and restore him to that which he ought to be?

Sloane states:- "Kinesiology has established the fact that muscle-groups can be re-trained. It has been proved conclusively that corrective exercises for the purposes of inducing postural changes must result in an increased tonus in one set of muscles and in a shortening of the muscles themselves. Muscles held in a shortened position, and in use in that shortened position, will shorten and accommodate themselves to the new length with the establishment of normal tone. The antagonistic muscles will become proportionately stretched and accommodate themselves to their new length and tone. The joint affected will have a new rest position", (164).

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Chapter 16.

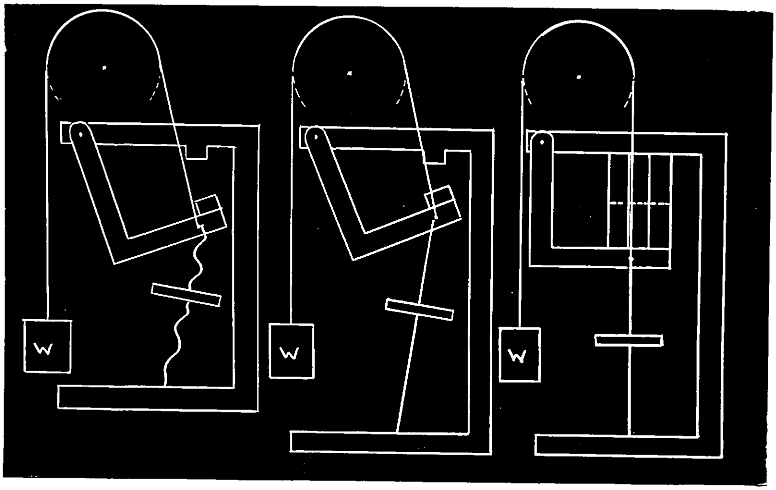
DENTURES.

THE PROBLEM OF THE OLD FULL DENTURE.

Most dentists have encountered the old lady who has successfully worn the same full denture for forty years, and the experienced dentist will often "shy-off" from the "privilege" of making a better one. The facial expression of the old lady has altered, as recourse to old photographs will prove. Because of alveolar resorption, the dentures have sunk in, especially the lower, and a great space is left between the occlusal surfaces; this is known as the "free-way" space. Now, what has happened to the rest position? Admittedly there is much truth in the theory of constancy of position, but I submit that in many cases, the jaw has closed up slightly to the cranium, the reason being that the patient has habitually been overclosing with every chew. In other words, the rest position changes with old age, although only slightly.

CHANGE IN TONUS OF THE NECK MUSCLES.

I hold the opinion that the constancy of the jaw position depends on the constancy of tonus in the complicated muscle system of the entire head and neck, and this in turn depends on posture and on many other matters. For example, if the patient continually bends the neck forward, there is slackening of the linked



C B A

Fig. 28.

By the use of pulleys and springs, the balance of forces upon the mandible and the hyoid bone is illustrated. (A) Here we see the lower teeth being pulled against the upper by the weight running over the pulley: the latter system represents the masticating muscles. An elastic cord from the mandible to the hyoid bone, and from there to the sternum, is so delicately balanced so as to hold the teeth lightly together. (B) With the loss of dental support, the "masticating muscles" close up the jaw, until the elastic tension increases so much that the system is again in balance. (C) If the height of the column is shortened, the weaker elastic permits the closure of the jaw. Short, powerful springs on the same chain as long, less powerful, remain at rest only so long as the system is not shortened, but when the length of the chain is shortened, it is not the short spring which yields.

chain of muscles in front of the cervical vertebrae. Theoretically, this slackening of the chain should permit the more powerful units in the chain to dominate, and so the masticating muscles move the jaw up until the muscles below the mandible exercise the balance of forces on the jaw.Fig.(28).

I wonder how the tonus of the neck muscles, and hence the rest position of the mandible, is affected by the shortening of the cervical vertebrae, due to the thinning of the inter-vertebral discs which is concommitant with old age.

HANDLING OF THE PATIENT WITH A VERY OLD DENTURE.

What is to be done with the old lady who has worn the same full denture for forty years? As I see it, her case falls into two categories, (1) she is suffering temporomandibular pain, or (2) she does not suffer.

If suffering temporomandibular pain, then she must be treated in the manner shortly to be described, that is, by re-positioning the jaw.

On the other hand, if she is free from temporomandibular pain, the problem is merely a matter of replacing a denture, although a difficult case admittedly. Great care should be taken to make the denture no taller than it ought to be; most failures can be traced to this source. Her old muscles must not be stretched because this would drive the dentures into the edentulous ridges.

Where a large free-way space has existed for many years, the patient has found it too easy to place food into the mouth with less stretching of the jaw muscles than she used in her youth; therefore if her dentures are built up too high, the food will strike her teeth unless she opens to an extent to which she is unaccustomed, thus stretching her muscles and perhaps causing pain.

Therefore, a careful assessment should be made of the free-way space, and the denture built up to fill the space, except for 3mm. That is to say, we accept the slightly over-closed rest position as the best compromise for her present condylar relation, and make no attempt to improve on a trouble-free situation.

PERSISTENT OVER-CLOSURE.

For the moment, we concern ourselves with the effects of persistent over-closure, upon the temporomandibular joint.

Every experienced dentist knows of the confusion which over-takes many patients when occlusion is about to be registered. The loss of all his teeth has deprived the patient of the proprioceptive sensibilities which had abounded in his pericemental membranes, therefore, in a sense, he has forgotten how to place his jaws together. This is one reason why the dental profession is so keen to have the patient wear a denture continuously from the day of the extractions. After a few edentulous weeks, the sense of the old occlusion has gone; only the muscles and condylar paths, for what they are worth, remain to guide the jaws together. No wonder the jaw blunders around, to delude the dentist in the try-in of the denture; the dentist may be trapped into completing the denture to the "wrong bite". Unfortunately, the fault may only be disclosed after weeks of wear. The explanation seems to be that the restoration of inter-occlusal support induces a self-correction of the wrong antro-posterior relationships. Indeed, this may well be the essential principle of our own method of mechano-therapy; that is to say, by the restoration of the vertical dimension, the re-positioning of the jaw to the correct antro-posterior relationships takes care of itself.

"WRONG BITES".

I hold the rather unorthodox point of view, that many "correct bites" are, in a sense, "wrong bites", in that the dentures merely perpetuate a bad mandibular posture which the patient may have acquired. In addition, frequently the "bite" is not quite correct, but the patient gets used to it by adapting himself. It is good that mankind is so cheerfully adaptable to changing conditions of life; in the case of the denture, perhaps it is true to say that at the end, he is little the worse. This must not be taken as condoning carelessness: on the contrary, I submit that the registration of occlusion has depths as yet unplumbed.

I hesitate to predict the future of full denture prosthetics, but techniques may evolve whereby laminagraphy of the condyles may be regularly used, in order to ensure that rest position has been truly registered.

Chapter 17.

PHYSIOLOGICAL EXCURSIONS OF THE JAW.

THE MONOBLOC.

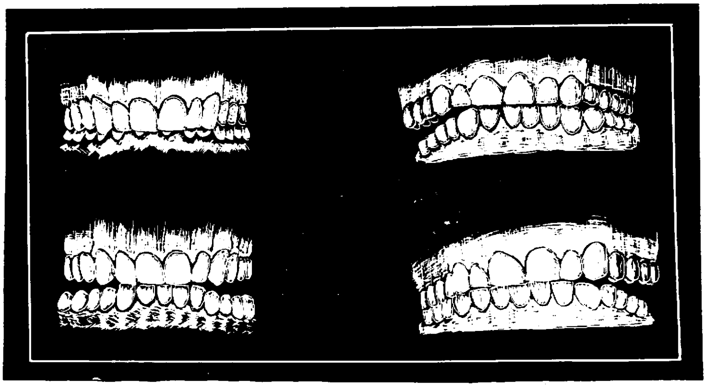


Fig. 29.

Upper left :- a common centric occlusion.

Lower left :- shows the occlusive gap which appears when the incisors are placed edge to edge: this gap may be caused by incisor over-lap, or alternatively, by the descent of the condyles.

Upper right :- shows the gap which appears when the jaw is swung into left lateral excursion.

Lower right :- shows the gap which appears when the jaw is swung into right lateral excursion.

OCCLUSAL RELATIONSHIPS IN PHYSIOLOGICAL EXCURSIONS OF THE JAW.

It is necessary to present some practical examples of changes wrought in occlusal relationships by <u>normal</u> mandibular excursions. For this purpose, a series of hypothetical subjects will be selected to illustrate the points. The first that we envisage is an adolescent with 28 sound teeth in good occlusion; his condylar relations are normal. He is asked to place his front teeth edge to edge, and we peer into the posterior part of his mouth to see how the occlusion has been altered. We observe that a considerable inter-occlusal gap has appeared. The extent of this gap depends on two things, (1) the vertical height down which the condyle has descended, and (2) the relative difference between the anterior and posterior teeth, Fig.29. Where the incisors are over-erupted, an inter-occlusal gap will obviously open, the greater opening where the discrepancy between anterior and posterior levels is large. But, on the other hand, where the anterior and posterior teeth are on the same level, that is, where there is no over-lap of incisors, an inter-occlusal gap will still open up, provided that the slope of the distal surface of the articular eminence is more steeply inclined than the occlusal plane.

NATURAL DENTITION: THE BENNETT MOVEMENT.

To illustrate this next point, we take the same hypothetical patient. Again he is requested to place his incisors edge to edge, but this time the mid-line of his lower teeth must be shifted to one side, say, to the right. This shift presents the so-called Bennett movement in the natural dentition. We inspect the posterior occlusion when the jaw is so positioned. It will be seen that the cusps of the lower teeth have swung over and forwards on this working side until they are just below the upper cusps, and that the inter-occlusal space has increased moreso contra-laterally. To produce this change in vertical height, two factors are at work, (1) the opening of space as the incisors come edge to edge, and (2) the greater descent of the contra-lateral condyle down the slope of the eminence, than the descent of the ipsi-lateral condyle. In fact, some observors say that the ipsi-lateral condyle actually does not descend, but instead retracts.

The significance of the observation is profound.

THE CORRECTION OF ASYMMETRY IN A CHILD.

Now we put the fore-going principle to practical application; another patient is envisaged; he is 12 years

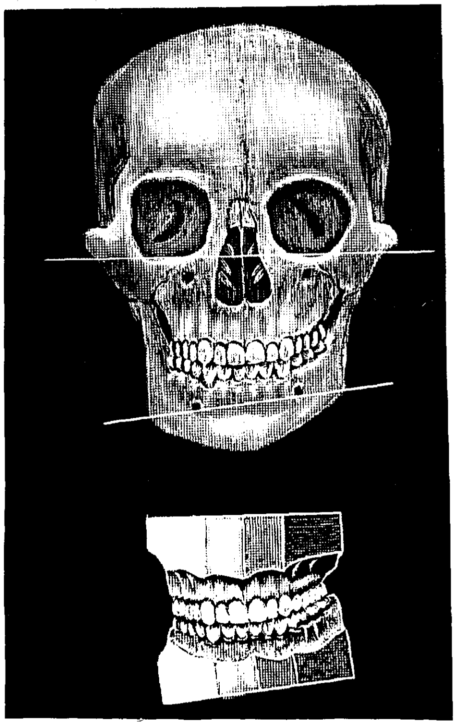


Fig. 30

The upper figure shows lack of parallelism between a line connecting the orbital points, and a line inter-connecting the mylo-hyoid ridges, which I have designated the Nove line. If the base of the upper model represents the Frankfort plane, and if the base of the lower model represents the Nove line, then skeletal asymmetry can readily be recognised. The lower model illustrates models oriented in such manner.

old, all the teeth for his age are present. They are in good occlusion, but his fault is that he has not developed an equal amount of alveolar bone on both sides, upper and lower. That is to say, if we examined him from frontal view-point, imaginary lines between his orbital points and the lower edges of his mandible would not be parallel; a point of survey which has already been described, Fig.30.

What can we do to rectify this asymmetry? If only the patient were made of clay, we would know what to do! We would elongate the bone framework of the face on the short side by setting the upper and lower jaws further apart. This would be done by extruding the posterior teeth further out of their sockets, until a balanced occlusion is evolved. But unfortunately it is not so easy on the actual patient, but the same principle applies; the teeth are shifted orthodontically until the inter-Orbital line and the Nove-line are parallel, that is, if ever this objective can be reached.

Referring to the temporomandibular joint of this hypothetical patient, it is unlikely that it will show any significant roentgenographic changes; the condylar relationships will probably appear normal, because of the compensating adaption of the growing bone, that is, the temporomandibular joint compromised to suit the asymmetry. But, in a child, where bone-growth has not yet been exhausted, the initiation of orthodontic treatment may reverse the process, from one that is getting progressively worse, to one that is getting progressively better.

Further details of the therapy will be given later.

THE CORRECTION OF ASYMMETRY IN AN ADULT.

An imbalance of structure similar to that just described, can often be recognised in an adult. Here the situation is much more serious and the chance to correct is handicapped by the inability to harness a bone-growth which is now arrested. The bone-growth centre on the condylar head is said to be responsible for forming most of the mandible, but while it continues activity longer than any other growth-centre in the body, it cannot go on indefinitely.

Our next hypothetical patient is aged forty; he complains of severe pain on the left side of his face, and roentgenographic examination shows a distally displaced condyle on this side. Intra-oral inspection shows extraction of three lower molars so that he has lost molar support to the condyle on the side in question; this suggests that the condyle is carrying a masticating load beyond its tolerance.

The clinician has no other choice than to construct a prosthesis, either a temporary intra-oral splint, or a denture. The build-up may be done in one stage or by several progressive additions to the vertical height, until ultimately pain is relieved. It would be desirable, but in most cases would be hopelessly idealistic, to parallel the inter-Orbital line and the Nove-line.

ASYMMETRY OF FACE CAUSED BY UNDER-DEVELOPMENT OF ALVEOLAR RIDGE ON ONE SIDE.

One of the sad sights presented to the practising dentist, is the very young child with hopelessly decayed first permanent molars; the dentist cannot save them and yet he is aware of the consequences of extraction. It is not within the scope of this paper to trace out the inevitable sequelae; but to build up the next point of our postulate. We imagine a young child who has lost the first permanent molars on one side of the mouth, together with the deciduous molars while the other side remains intact. As I conceive it, the consequence, in the course of a few years, will be a comparative shortness of the ascending ramus; we may take it that the child's condyle will not develop so actively on the side without teeth.

This opinion is in line with the experiments of Baker, (165), who, as already explained, ground off the occlusal surfaces from the molar teeth of experimental animals, on one side of the mouth, and this caused asymmetrical development of the mandible, as well as the skull.

Returning to the child, and assuming that the ascending ramus is shorter on one side than on the other, we wonder what will happen to the permanent teeth yet to erupt? It is not illogical to argue that these teeth will erupt less than their counter-parts on the other side of the mouth, before eruption is arrested by their coming into occlusion. In other words, the teeth on this side are "crushed back into their sockets". One has searched in the mouth and on models of the mouth, for clinical evidence of this "crush-up", and while it is believed that bulged bone at the alveolar edge is symptomatic, nevertheless, the evidence is too inconclusive. While deprecating the intra-oral evidence of asymmetry, I would stress the importance of the recognition of asymmetry by the use of models prepared to demonstrate the Eye - ear plane and the mandibular plane; this was explained in the chapter which dealt with survey. Dental Record (166), and Year Book, (167).

CORRECTION OF ASYMMETRY BY THERAPY.

As already indicated, the growing child is treated by stimulating alveolar bone-growth on the side with the "crush-up". Some orthodontists favour fixed appliances, banding the teeth and elongating them with inter-maxillary elastics. A device which is sometimes successful is the monobloc. This night-worn appliance is constructed from a "wax orientation", which was made as already described, but in this instance, the wax is built up outside the mouth, so that one condyle is pulled further out of the glenoid fossa than the other.(168) The hope is that the side under traction will catch up in the continuing development of the mandible, and the "crush-up" will be eliminated. In other words, we attempt to correct uni-lateral over-closure, by increasing the height of the ascending ramus, as well as the alveolar bone.

CORRECTION OF BI-LATERAL OVERCLOSURE.

Now, the principle which has been elaborated in these previous paragraphs is that uni-lateral structural and functional imbalance can be corrected, at least partially, either by orthodontic or prosthetic measures.

But we should err, should we apply our corrective methods only to uni-lateral overclosure: they are equally applicable to bi-lateral overclosure. If the patient is very young, we first determine what has shifted the mandible, then in what direction and how far it has shifted. The orthodontic treatment should be designed to bring the entire jaw and its attachments into a position more in accord with Nature's intentions.

The adult is treated in similar fashion; the cause is diagnosed and appropriate prosthetic treatment begun. In the case of an adult where the jaw has been consistently displaced, the diagnostician would expect to see, on the laminagrams, each condyle out of its true position, in (1) the widest comfortable opening, (2) the greatest comfortable closure, whether edentulous or otherwise.

Again, the therapy by prosthesis should have the ultimate intention of restoring the jaw to Nature's best compromise position, but sometimes a long-term point of view must be the policy; a gradual build-up is not likely to disturb the patient, whereas a "one-stage build-up" may be intolerable.

THE PRACTICAL REHABILITATION OF THE JAW BY MONOBLOC.

Before studying the monobloc, other methods of repositioning the mandible may be briefly mentioned.

Apart from the orthodontic fixed appliances, cap-splints may be fixed to the teeth, either anterior or posterior. The splints may be metal castings or acrylic mouldings, and may be used in conjunction with head-harness and chin-sling. Orthodontic molar-bands with a short chain between, may limit the opening of the jaw.

Inclined planes, either fixed to the upper jaw, or removable, may be used to glide the lower incisors forward, (169), (170). The Schwarz plate might push an interfering tooth out of the way, thus allowing displaced muscles to return the unimpeded jaw to normal position.

But a device which appeals to many is the monobloc. Here is a removable appliance which during the sleep, anchors the lower jaw in a relation to the upper as determined by the clinician. The acrylic is trimmed with a rotary file either to hold the teeth, or to allow further eruption. For example, over-erupted anterior teeth may be held while further eruption of the posteriors is encouraged. Space limits a full discussion of the monobloc, (171), (172), (173).

The opinion is here expressed that this appliance is not so simple as was formerly thought, and that the differing response of patients, is not yet fully understood. Probably we have much to learn on how muscular function bears on the prognosis.

But the feature of the monobloc which is so attractive, is the ability to position the jaw (so long as the appliance is worn), as the clinician dictates.

He may have, for example, diagnosed that the jaw is slewed horizontally, backwards to the left and forwards on the right; the monobloc can be built to give correction. The mid-lines would be made to coincide, the lower left teeth would be advanced and the lower right retracted by the calculated amounts, and the condyles influenced to grow so as to balance the jaw and teeth in their new position. Such an instance would be limited to correction in the horizontal plane; in similar manner, the jaw can be tilted by the appliance, in any pre-determined way. That is, to quote one example, the left inter-occlusal space may be opened up to stimulate further eruption, while restraining the right teeth. The condyle on one side may be pulled down the distal slope of the eminence, in the hope that the ascending ramus on this side may elongate, while holding the other, thus securing the ultimate aim of balancing not only the intra-oral occlusion, but balancing the complete masticating face. It is a hope which will be seldom realised, but nevertheless it ought to be our objective. Even though we influence events a little, we may have reversed the trend towards re-habilitation, and stayed the day of the inevitable break-down of the masticating apparatus.

PRACTICAL TECHNIQUE OF THE MONOBLOC.

To get the best out of the monobloc, the technique must be taught at the chair-side and at the bench; to this there is no effective substitute. Consequently I shall only point out a few principles. As an example we shall take a 12 year old patient, who has a mandibular shift to the right, and his Orbital line - Nove line angle closes to the right. We have ascertained that we have not been deceived in diagnosis, by the mid-lines having been deviated by teeth shifted or inclined; this is a genuine case where the mandible is out of truth. It is back and up, on the right side.

Examination of the lamingrams do not show osteoporosis or any other structural bone-defect. Palpation shows only a slightly excessive translation of the left condyle in the act of opening, whereas the right side shows some restriction of movement. This is confirmed by inspection of the four laminagrams which have been taken; that is, right and left, each side showing the fullest comfortable opening, as well as the closed position: a wider range of traverse of the condyle can be seen on one side.

The intention, therefore, is:- (1), because the mid-lines of the teeth are on the mid-lines of the jaws, we intend to place the upper and lower mid-lines coincident, (2) we intend to move the right condyle more horizontally forward than the left, (3) we intend to bring the Nove line parallel to the orbital line by moulding the monobloc so that when it is worn, the right condyle is pulled down more than the left. If these intentions are to be implemented, we cannot trust the patient to give the correct registration of occlusion. That is to say, if the wax were placed between the teeth and the patient requested to impress it, she would imprint it in the manner of her recent custom. This is not what is wanted: the clinician must "dictate" the new occlusion.

THE MONOBLOC. ORIENTATION OF THE JAWS IN WAX.

The object of orientation is to make use of the upper and lower models to imprint marks of the teeth in the wax, in such a way, that when this wax "orientation" is placed into the mouth, the teeth freely drop into their impresses, in the corrected position of the jaw. Naturally, this is not invariably an easy technique, but with experience and with a back-ground of accurate perception, it is remarkable how exact the method can be.

When preparing to orient in this manner, I first spend a few minutes in mentally registering the new occlusion. I place the jaws, in imagination, into the corrected position, and then I try to measure the distance and inclination of each teeth from its occluding fellow. Then allowance must be made for the amount of tilt to be given the jaw in the new position, and a further allowance for the fact that the technician could not produce an appliance where the natural teeth could be placed edge to edge. So in this latter respect, a minimal 4 mm. is allowed for plastic between the incisal edges and this dimension is added all around. When all these measurements have been mentally noted, the models are taken and the wax imprinted with tooth-marks. It is trimmed up so that the natural teeth can be seen without obscuring wax over-laps, and then it is checked in the mouth. The wax should be neat and no wider than the occlusal surfaces; if it is too large it may influence the position of the jaw too strongly. There is a difference between a wax orientation which allows the teeth naturally to drop into it, and an orientation which forces the jaw into a wrong position. We must dictate the "bite" persuasively, not forcibly.

In the case of a young patient, where a slight

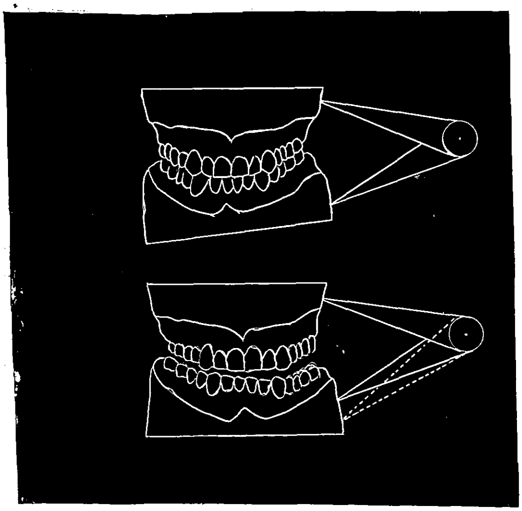


Fig. 31.

Divider marks are made when spanning from upper to lower model, firstly as the models sit in centric occlusion. Then, in a case of structural asymmetry, where it has been decided to "jack-up" the occlusion on one side, the increased opening of the dividers will give information as to the precise dimensions of the correction of asymmetry.

resilience is normal in the temporomandibular joint, it may be expedient to make a wax orientation which pulls the condyles down rather more than the incisors; that is to say, in this case we are not accepting the theorem that the jaw opens exclusively on a condylar hinge-axis.

I have tried other methods of orientation for the monobloc, and have found them wanting. Only this method permits "jacking-up" the occlusal registration. The other methods whereby the patient has the final word in indenting the wax, fall short. In the method of choice, the wax is thoroughly chilled under the cold-water tap, before the last check-up in the mouth.

The models are now fixed to the wax, and articulated backwards on a plain-line articulator. I spent some time in trying out anatomical articulators for this purpose, but they offered no advantage, rather the reverse; an articulator made to my own design was likewise useless. Before articulating, the models should be marked with pencil in the habitual centric, and divider marks made to span the sides of the models, from upper to lower at the rear. Then after articulating, that is, after re-positioning the jaw with the wax, the distance between the divider marks may be measured, to ascertain if we have opened up the "bite" unilaterally in accordance with our calculations. Fig.31.

Next, the wax monobloc is fashioned on the articulated models making sure that it fits everywhere, especially lingually at the embrasures.

This wax monobloc is now re-produced in plastic with the greatest accuracy, and from then the procedure has already detailed.

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Chapter 18.

FLAT-TOPPED SPLINTS.

FLAT-TOPPED ACRYLIC SPLINTS.
OVER-LAYING NATURAL TEETH.

The upper and lower natural teeth may be over-laid with flat-topped removable appliances, which should be worn only during sleep. In a remote way, these splints resemble a monobloc which has been sawn into upper and lower halves. Contrary-wise, a monobloc may be made by fixing together with "quick-set" plastic, the upper and lower flat-tops.

But the over-lays cover the occlusal surfaces, whereas the monobloc is generally cut away where the posterior teeth are to erupt.

The monobloc or the over-lays may be selected according to conditions. The monobloc can relieve pain by resting the jaw, but also allows for a change in jaw and dental relationship during treatment. On the other hand, the over-lay will not permit tooth eruption or any other change in dental relationship. Both types could change condylar relations, in fact, if the patient is still young enough to have some remaining condylar bone-growth activity, the relationship may alter permanently, not merely during the hours when the appliance is worn. But in an adult where teeth cannot be effectively moved nor bone re-moulded, it is often possible to achieve the same effects by opening up the inter-occlusal space with either dentures or temporary splints.

There is another advantage in over-lays for adults: the repositioning of the mandible may be done in stages. That is to say, the over-lays may be initially fitted to the mouth with the minimum of "bite-raising", and then built up with plastic after the patient has got used to wearing them.

This method is particularly indicated when the intention is to "jack-up" more on one side than the other.

The question may be asked, "Why over-lay both upper and lower teeth?" The answer is that if one splint were worn, it would soon become scored with the sharp tips of the opposing cusps, and the little dents might be sufficient to restrict the free slide of the jaw to a better position.

In order to learn how the jaw relations are changing in treatment, the following method is used. The acrylic is marked with a thin fissure-bur so that the upper mid-line coincides with the lower mark, and similar marks are made at each side at the molar region. If, at the end of a few weeks, the marks no longer coincide, the direction and extent of shift can be seen.

For the same reason, the labial and buccal surfaces are finished where possible with the upper flush with the lower.

Occasionally I have exerted positive traction on the jaw by the use of orthodontic elastic bands. The splints are finished, then tiny holes are drilled at appropriate points, and small pieces of stainless steel wire are warmed, imbedded, and turned up at the ends to form hooks; the elastic bands are fitted by the patient after the insertion of the over-lays.

Use has been made of guiding-planes fixed to the buccal, but these were discarded as clumsy and restrictive. I have also encouraged the desired shift of the mandible by carving inclined planes on the flat tops, the slope being arranged to guide the jaw in the indicated direction.

FLAT-TOPPED SPLINTS IN EDENTULOUS MOUTHS.

Judging from the literature, most clinicians who try to relieve temporomandibular pain by "bite-raising", do so by new dentures.

There are sound reasons for not supplying the patient with a denture initially. In the first place, the patient must be impressed that she is an ill person, who must be cured by a treatment, not by the supply of a new denture: if patients got to think that a new denture could cure a pain, they might next think that a new hat would be equally beneficial!

The method of mechano-therapy used to re-position the condyles, entails that the vertical dimension be slightly over-extended; the patient does not mind this in a splint, especially if night-worn only, but the patient would have every right to object to wearing a denture of the same vertical height. The co-operation of the patient must be secured for this treatment of bite-rehabilitation which often takes months, and co-operation would be extremely doubtful if supplied with a denture which made her look like a horse!

After a few months wearing a high temporary splint, the patient is content to wear a full denture of a vertical height which she would have resented if supplied at the beginning of treatment.

Then, one of the most important assets of the temporary splints, is the smooth flat top, which permits the horizontal re-adjustment of muscle and skeletal structure. With a denture, an occlusal lock is likely to be present, and so to maintain a faulty occlusal relationship.

Then again, the temporary splint permits of addition to the appropriate surface, or reduction from a surface.

Another reason for preferring the splint to the denture, is that the splint is only worn intermittently. Consequently, it is more easily tolerated by tender edentulous ridges. It should be remembered that the vertical height has been built up to over-fill the inter-occlusal space, therefore, the masticating muscles are slightly stretched, and consequently will tend to drive the appliance down into the tissues. It would be intolerable if worn the whole round of the clock.

There is another reason for preferring the splint to the full denture. In a case where the edentulous ridges are adjudged to be unusually tender, it would likely precipitate denture-sores were the splints fully built up in the first stage. It is better practice to make splints short of free-way space; such will not be impressed into the gums by the over-stretched muscles; they will at least prevent over-closure, and be of some benefit. When they have been worn for a few weeks and have become comfortable, the occlusal surfaces may be built up to the pre-determined level.

THE REASON FOR OPENING UP THE FREE-WAY SPACE.

It is probably true to say that my most unorthodox approach to the treatment of temporomandibular pain is the height of my intra-oral splints. Here is the reason:- In a case where the laminagrams have proved that the condyles are outwith the physiological pathways, it is useless to make a splint which perpetuates this displacement; we must try to shift the condyle back to the optimal rest position. That is to say, the condyle must be placed so that it rests half-way up the distal slope of the eminentia articularis. Now, if we were able to assess the rest position of the mandible with perfect accuracy, and if the intra-oral space was filled-in slightly short of rest position then, as I see it, no influence has been brought on the condyles to shift. True, the appliance will prevent further over-closure, but it does not restore the condyle to a better position; that is to say, condylar relations are accepted as they are, and no attempt is made to improve them.

Now, when does the condyle begin to shift in the act of opening the jaw? This is individual to the patient, and can only be accurately determined by laminagraphy, but it is surprising to what extent many patients open their jaws without the condyles stirring from condylar hinge-axis; a half-inch separation of the incisors before the condyles start forward is common.

I do not suggest that the "bite" should be opened in every case until the laminagram proves that the condyle has shifted; other factors must be considered and a mid-course selected. It should be remembered that we are not entirely dependent on the opening movement for re-placing the condyle in optimal relation with the distal slope; the protrusion of the jaw has the same effect.

To sum up this point:- my objective is to assess the rest position of the jaw, then to build up splints to eliminate the free-way space, and then to increase the vertical height by an additional 2 mm. but such splints are for intermittent wear only.

MAKING USE OF ANTRO-POSTERIOR CORRECTION OF THE CONDYLES.

In a case where opening of the vertical dimension has failed to induce the forward re-positioning of the condyle, horizontal influences may be brought to bear on the intra-oral splints. This is comparatively easily done in patients with some of their natural teeth remaining. A practical case is quoted. Flat-topped splints which were supplied to a patient with some natural teeth did not ease her pain within three months. At the end of this time, examination showed that the splints did not have the usual effect, in that the jaw had not advanced with the "bite-raising": in most cases, an advance of a few millimetres can be detected. The reason for her tardy response may have been that her jaw opened exclusively on a condylar hinge-axis, thus the increased height of occlusion had not induced the condyles to shift forward.

The plan of her mechano-therapy was changed: "quick-set" plastic was placed between the splints which were now anchored together in a slightly more protrusive relation. As a consequence, her pain has eased.

THE EDENTULOUS CASE. THE "ROCKING CHAIR" OCCLUSION.

When dealing with the anatomy of the temporo-mandibular joint, reference was made to the type of patient who could open his jaw keeping his occlusal planes parallel. Or at will, he could open on the usual condylar hinge-axis. In the former case, he pulled his condyles down the articular eminences while raising the chin. I have sometimes tried to copy this feature in mechano-therapy by grinding-in the occlusion of the flat surfaces so that the thrust of mastication is taken on the distal ends of the splints, and a gap of 2 mm. is left at the front. I have never knowingly done this in a full denture case, although Sears advocates it, (174), but I have used the method often in cases where some of the natural teeth remain. Where a gap has been thus left at the front, it is generally eliminated in a few weeks, suggesting that the condyles have descended rather than that the splints have sunk in, which they could not do in cases where molar teeth remain.

MAKING SPLINTS WHERE NATURAL TEETH REMAIN.

The alginate and hydro-colloidal impression materials have been a great boon to the dentist. Although I take final impressions in plaster in edentulous cases, alginate is all that is required where natural teeth exist. Undercuts are usually to be found, but they are eliminated by the use of the clasp-surveyor, and then by duplicating the model.

Much of the difficulty of gauging rest position disappears when natural teeth still remain; I assess the vertical height of the splints as that which will barely cover the occlusal surfaces, provided that no extruded teeth lift themselves above the occlusal plane; should they do so they must be extracted. To those who make partial dentures, this advice to cover the occlusal surfaces must make startling reading. The technique is in keeping with the previously stated policy of opening up the vertical dimension 2 mm. beyond rest position.

Great care must be taken with the surgery and laboratory procedures to ensure the best fit of the splints. Being tooth-borne, and in contact with the occlusal surfaces and incisal edges, any misfit will have serious consequences.

If expense were no object, these flat-tops would be cast in metal, which would make for strength and minimal "bite-raising", but while we prefer metal, nonetheless acrylic has not been too unsatisfactory. To keep the height down to the bare minimum, the following technique is practised. To the lower model is added a thin sheet of acrylic previously made by flasking a metal occlusal templet, which on removal from the flask, leaves a space to be filled with acrylic. The thin acrylic templet is trimmed buccally and lingually, and laid on the occlusal surfaces, then waxed-down and all is completed in acrylic; thus the lower splint has a flat top which raises the "bite" to the minimum, and also is ready at the second visit, at which the upper wax bite-block records the occlusion against the acrylic while the jaw is in slight protrusion.

EDENTULOUS SPLINTS.

Flat-topped edentulous splints are constructed with the same precision as should be applied to the full denture. My technique consists in first impressions in alginate, second in plaster on special trays. Registration of occlusion is thorough, and the acrylic blocks are built out to buccal and labial contour with as much care as in making a denture, the reason being that the lips and tongue must not be restricted from "picking up" their natural position. In addition, the muscles around the mouth must be placed in their position of greatest harmony, so that the neuro-muscular reflexes are in accord.

The dentist who is experienced in full dentures has not long taken up "flat-tops", before he is struck with the low susceptibility to "denture-sores": perhaps the reason is the absence of horizontal thrust against the ridges, because the flat top represents the minimum of cusp-interference. On the other hand, the full denture with long cusps or close incisal overlap, is notorious for bruising the sensitive lower ridge, especially when resorption of alveolar bone has progressed below the mylo-hyoid ridge, which may often be as sharp as a knife!

THE UNSIGHTLINESS OF ACRYLIC SPLINTS.

Hitherto, patients have been asked to confine the wearing of the intra-oral splints to the privacy of their own bed-rooms, but experience has shown that many obtain such comfort from them, that they insist on keeping them in position the whole round of the clock. When this little problem is met, we overcome it by carving the blocks into the shape of teeth. This is possible only if the blocks have been built out to proper contour, and where the block at the incisal part has been shaped to incisor width, pre-molar part to pre-molar width, and molar part to molar width. In anticipation of carving the blocks into tooth shape, the plastic is made of a suitable tooth colour upto the length of the average tooth, thereafter gum-pink. An hour's work by the technician can convert an unsightly block into a fairly personable denture.

THE TONGUE.

Whether or not the intra-oral splints are carved into teeth, they should be shaped labially and lingually to the same outlines as a denture, so that the tongue has ample space. I have been struck during my orthodontic experience by the constriction of the tongue by mal-posed teeth, so often to be seen in children, as evidenced by the impediments in their speech. It is not unreasonable to say that in these cases, the tongue is thrust back into the throat by the narrow dental arches, by the lingually inclined teeth and the closure of the inter-occlusal space. It will be seen, therefore, that in the edentulous patient, an opportunity may be seized to open up space in the hope that the tongue may come forward, perhaps in doing so, improving the lumen of the air-way.

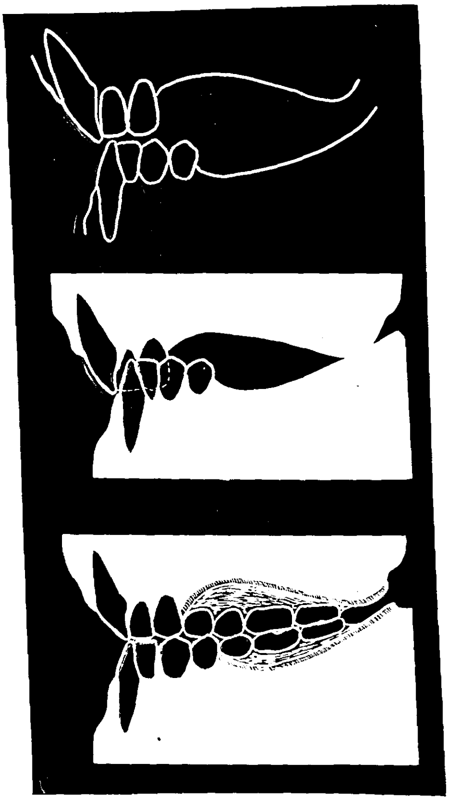
Where natural teeth remain, there is less scope for opening up tongue space, nevertheless the point should not be over-looked.

SPEECH THERAPY.

It is inexpedient in this paper to dwell even on such an important matter as speech therapy, but it is obvious that if a muscle-group like the tongue has been forced to take up a false position, despite the genetic intention, then not only should we aim at removing the cause by orthodontic or prosthetic techniques, but every measure should be adopted to re-position the muscle-group. The advantages of speech-therapy and other exercises is incontestable.

REGISTRATION OF OCCLUSION.

A stage has now been reached when we can discuss



A.

B.

C.

Fig. 32

The diagrams represent the patient in three different positions of occlusion.

(A) Rest position.

(B) Closure until the natural teeth meet, the "bite" commonly used by the dental profession, for the construction of partial dentures.

(C) The vertical height of the face restored (at least partially), by the use of correct partial dentures.

the present methods of the dental profession, in the registration of occlusion in preparation for a partial denture. For purposes of illustration, we take the instance of Fig.32. The first glimpse of this patient showed the characteristic "concertinaed" masticating face. She had six incisors and one pre-molar in each jaw. Both incisor-groups were grossly retro-inclined: there were no posterior teeth to support the jaw. Not only was the vertical dimension badly closed, but the jaw was distally deflected at every chew, by the lower incisors gliding up the lingual surfaces of the retro-inclined uppers. The effect on the condylar relation can be imagined.

Heavy attrition on the incisal edges signified that the patient was substituting the incisors for molars for shredding food, which is another factor that overloads the temporomandibular joint; the incisor contact forming a lever-fulcrum, against which the masticating muscles can rotate the condyles.

This patient was wearing at her first visit, a tiny upper, and equally tiny partial lower denture, neither of which ventured backwards beyond the second premolar. We now come to the point of the story; <u>how should the dentist have registered the occlusion</u>?

Let me first describe how he had registered it. Presumably, he had asked the patient to close the jaw until the remaining natural teeth met, and had "taken the bite" in this posture. His technician next realised that the closure of space at the rear would put the edentulous ridges so close together, that there was no room for artificial teeth, so they were left off. As a consequence the patient had suffered facial pain for five years.

I tackled the project in another manner. I reasoned that her jaw was displaced upwards towards the maxilla (closure of the "bite") and backwards by the incisor contact. I further reasoned that the patient had to some extent "grown up with the genetic arch relationship", and therefore until she had lost her posterior teeth she would have a reasonable compromise in the temporomandibular joint; that is to say, until the back teeth were extracted, the condyle was not out of place. But when she consulted, both jaws and condyles were being strained.

Now, I did not have the confidence to supply this patient with dentures straight-away; intra-oral splints were first used to re-position the jaw. I registered the occlusion differently from the dentist.

Wax bite-blocks were built up in this instance, to continue the occlusal planes backward on the level of the incisors, and finished in acrylic to a "rocking-chair" occlusion. Now, this placed the lower incisors considerably lingual to the uppers, at which level the patient could not initially protrude the lower incisors to touch the uppers. However, in the course of a few weeks she could do so, partly, as I see it, because of subconscious forward thrust of the chin, and partly because of the restoration of the physiological level of occlusion. Within a few weeks her facial pain had gone, and soon she was uncomfortable if asked to put her jaws together in retruded relationship. As aforementioned, given the opportunity, muscles which have been recently displaced as a consequence of mandibular displacement, will tend to self-correct.

Partial dentures have been built for this patient. Because of the extreme lingual inclination of the incisor-groups, the saddles had to be connected by castings which, here and there, had to cross the occlusal surfaces, so as to avoid the under-cuts on the lingual. Experience of cases such as the foregoing, leads me to suggest that the profession will need to revise its definition of centric.

REGISTRATION OF OCCLUSION IN PARTIAL DENTURES.

It will be seen that if these newer techniques of occlusal registration become widely adopted, the tooth-borne over-lay cast denture will become common, and our thoughts fly to the socio-economic implications. It would appear that we must legislate for the future, when each member of the population must provide for two or three expensive partial dentures in the course of his life-time. Alternatively his parents must ensure that he avoids dental caries altogether.

As one who has for years held the above un-orthodox theories of occlusal registration, it was a great comfort to read that such an authority as Fish, held the same opinions, (175)

HAVING ALTERED THE ANTRO-POSTERIOR RELATIONSHIP, CAN IT BE HELD?

Among the principles which can be learned from such cases as the foregoing, it appears that the antro-posterior relationship can be changed, or perhaps 'restored' is a better word. The question now is, can this re-adjustment be held? The opinion is expressed that there will be little tendency to relapse, provided the jaw has been induced back into its true position; and when the phrase "true position" is used, due account has been taken of the "position of best compromise", which has been described in previous pages.

However, in the present stage of our thoughts on these newer concepts, and in view of the extreme technical difficulties involved, it lies with us, in these experimental years, to feel our way very cautiously. That is to say, there are two difficulties here, (1) the vertical dimension and (2) the new antro-posterior relationship, and they are integrated. The concept of the restoration of vertical height has been studied by the dental profession for years; the change in antro-posterior relationships is new. Therefore, I seriously suggest that if the clinician changes the jaw thus, he should provide that it may continue to alter its relationships without encountering encumbrance. In practical terms, this means that if we have induced the jaw to come forward for the relief of temporomandibular pain, then the shape of the denture should not interfere with the jaw continuing to pick up its best posture. I feel, therefore, that in the present state of our knowledge, a clinician must be very confident indeed, to make his cast metal over-lays inter-lock with the cusps of the opposing jaw. I usually try to arrange a free-sliding occlusion. It is often difficult to do so, but "inverted cusps" rather than tall ones are preferred. Sometimes a bit of judicious tooth-grinding helps.

TOOTH GRINDING.

British dental practice seems to give less opportunity than Continental or American, for controlled tooth-grinding for the release of occlusal locks. This would only seem feasible where the amount of tooth-substance to be removed by grinding is small enough to justify the procedure: the cusp-locks which we usually see are so gross that the interfering teeth would need to be reduced to a damaging extent.

However, the clinician should have the knowledge of the skilled periodontist, in respect of tooth grinding. He should know how to clear lateral and protrusive excursion without closing the "bite".

If a tooth is so extruded, or otherwise so far out of alignment, that it needs a great deal of grinding so as not to get in the way of the splint or denture, then it had better be extracted.

(174) Sears, V.H. Experiments in occlusion. J.Pros.Dent. 2 : 22. 1952.

(175) Fish, E.W. A new principle in denture design. Brit.Dent.J. (March 18th) 1952.

(175) Fish, E.W. A new principle in denture design. Brit.Dent.J. (March 18th) 1952.

Chapter 19.

OVER-LAYS AND DENTURES.

PREVENTION.

CHANGES IN ARCH RELATIONSHIPS AS THE RESULT OF WEARING SPLINTS.

After a few weeks of wearing intra-oral splints, it is not uncommon to see a slight drift forward of the mandible; this occasioned no surprise. But I was frankly astonished when first I encountered cases where space opened up between the upper and lower "flat-tops". This was first attributed to the sinking-in of the splints, although this was hard to credit in cases where the teeth had been extracted for years, and where the occlusion of the splints had been ground in with articulating paper. But when the same opening of inter-occlusal space occurred in patients with nearly all their own natural teeth, I could not concede that these teeth had been driven into the bone, especially as the depressing force would be neutralised just as soon as occlusal contact was lost.

It is presumed that the space is due to a change in the condylar position; that once the condyle had been induced to come down or forward, the corrective movement had continued of its own accord. But another explanation is offered. It is generally believed that when the vertical height of dentures is altered, the antro-posterior relationship will sometimes alter too. Therefore, I suggest that, <u>as the mandible comes forward</u>, the condyle may descend a steep eminence, and thus inter-occlusal space is created.

The fore-going observation was forced upon our notice by patients who for a time had made favourable progress but who had relapsed.

In many instances, the gap amounted to 2 - 3 mm. Plastic was added to make up for the lost molar support, and in most cases the pain was again relieved.

I hope when more precise methods are available, to investigate this point further.

The pit-falls of splint or denture construction are many and various; take for example, the registration of occlusion in an edentulous case. The clinician inserts the wax-bite-blocks, and after they are trimmed down to size, the patient touches them together. Ideally, the contact should press upper and lower bite-block onto the gums with equal pressure at every part of the ridges, but we suspect that in many cases the wax block is not pressed sufficiently on one side, in fact, it lifts away from the ridge. Now, suppose flat-tops had been finished in this fashion, the clinician would press each home and then ask the patient to place them together: this he might apparently be able to do, but only by the splints drooping on one side while the other side is over-loaded. This pressure of a denture into a resilient ridge has been studied by Hanau (176).

Now, I want to assure the reader of this paper, that Hanau's "resilient and like effect", could not possibly be the explanation of the strange opening of inter-occlusal space which is presently being described, because no patient is dismissed until we are certain that pressure is equally hard on both sides; this is ascertained by the bi-lateral use of feeler-gauges, as well as by articulating paper.

DEVICES FOR EQUALISING INTER-OCCLUSAL PRESSURE.

As more knowledge on this point is brought to light, devices may be introduced whereby inter-occlusal pressure may be equallised. I have inserted spring-loaded contrivances - actually cabinet-makers' ball-catches - at the distal ends of the plastic splints. Only the ball is proud of the surface; when under load it is flush with the surface. More experience with these techniques is necessary.

TRANSFERRING FROM THE SPLINTS TO THE DENTURE.

To transfer a patient from wearing a splint to wearing a denture, can sometimes be very awkward. Generally speaking, no great difficulty arises in calming the patients' concern as to her appearance. In the ordinary routine of denture construction it is often difficult to convince a patient to wear a new denture of proper height, because of the relative conspicuousness of the teeth; we find that after a spell of wearing a "bite-raising splint", that the patients willingly consent to wear dentures which at an earlier stage, they would have resented.

Acrylic flat-tops are generally so comfortable, perhaps as has been said before, because of the absence of occlusive thrust on the sides of the ridges, that the transfer to the full denture may not match up to expectations: as soon as cusps appear on a denture, so begin denture-sores. In addition, the splint probably has not been used for chewing. This is a saying, "enter bolus, exit balance".

THE PROBLEM OF THE SPLINT WORN BY NIGHT AND THE DENTURE BY DAY.

Many patients have been seen with full dentures which were so lacking in vertical height that any benefit derived from the night-worn splints would be off-set through the day, by masticating with the old dentures. That is to say, the period of greatest strain on the temporo-mandibular joint, is when muscular force is applied to an over-closed masticating apparatus, the joint will not be

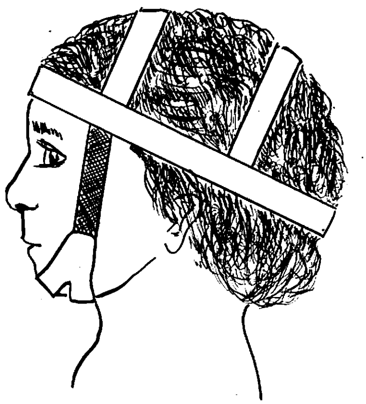


Fig. 33.

A simple head-harness with chin-sling.

strained during the times when the jaw rests quitely in its muscle sling.

In cases where it is apposite, a temporary denture is supplied for day-time wear, this denture being a compromise in height between the old denture and the splints.

THE HEAD-HARNESS WITH CHIN SLING.

The basic principle of our treatment could be stated as, "rest of the condyle in its optimal position". The splints should be designed so that when they are worn, the jaw rests in the position of the lightest contact between the splints; that is to say the occlusion is not opened much beyond the true rest position, yet the jaw cannot be closed any more. Now, this posture of the jaw should protect the joint from over-closure, but gives no assurance that the joint may not be strained by excessive opening.

While hypermobility of the jaw is secondary in importance to over-closure as a pain-causative condition, nonetheless, it may also strain the temporo-mandibular joint. Therefore, we cannot omit reference to a simple device which prevents excessive opening; hence the head-harness and chin-sling, Fig.33. The apparatus is simple, and is generally made by the patient. Two precautions must be observed, (1) the elastic which lifts the chin should not pull the chin back, (2) the elastic force must be mild.

We have made the head-harness from poly-vinyl-chloride ribbon, which can be fabricated very easily; it welds when a hot table-knife is dragged out from between two parts being pressed together.

The head-harness with chin-sling keeps the jaw from sagging away from the support of the splints, especially when snoring. It is remarkable how the jaw may sag in sleep, and this is not confined to the elderly. When the jaw gapes, it may be forced by the pillow to one side, thus straining the joint tissues.

This device also helps the patient over the initial awkwardness, by causing the patient to waken up should she try to remove the splints in her sleep, a trick which many develop during the first weeks.

THE CHIN-SLING WORN WITHOUT SPLINTS.

Where we are certain that the pain has been caused by pseudo-dislocation (hyper-mobility), there is no need for the splints. These cases may be treated by immobilisation only. It would be highly desirable if we could put the patient to bed and wire his upper natural teeth to the lowers for a few weeks, during which he could be fed slops through gaps between his natural teeth. But we do the next best thing and immobilise him at night-time only, by his head-harness and chin-sling. Actually, the cases where one can use this contrivance without the intra-oral splints are few and far between, the combination being best of all.

THE COMPLETION OF TREATMENT.

The reader will have gathered that in the present state of our knowledge, even though a patient may tell a typical case-history and may have every sign of temporomandibular disorder, it would be very rash to promise to cure a pain. It would be quite unjustified, therefore, to set about rehabilitating her occlusion with crowns and bridges, until firstly, we knew the exact height to which to build them, and, secondly, until we knew that this procedure was certain to relieve her pain. For these reasons, temporary splints must be utilised.

By cutting away part of the splint at the site of each crown, inlay or bridge, the level established by the splint is maintained.

We prefer to replace the temporary plastic splint with a metal over-lay, this also being removable.

My present view, tentative it must be admitted, is that a surprising number of patients do not require either fixed restorations or metal overlays to follow splint therapy. Once patients have been relieved of pain by a night-worn appliance, they seem less liable to a return of pain even though the mandibular deflection remains. In other words, in most cases the wearing of the appliance by night renders any other form of treatment unnecessary.

Some patients have been able to dispense with appliances altogether, without return of pain. This is remarkable, and the solution is difficult to find. It may be that the repositioning of the jaw by night has rested the joint and broken up the pattern of pain.

On the other hand, perhaps the painful ligaments have somehow become strengthened during the rest, so that when appliances are abandoned, the existing pain-cauastive factors which originally gave rise to the pain, are now better resisted.

If this speculation can be definitely established, it is of economic importance; it means that if we can cure by temporary bite-rehabilitation, there is no need to follow up with expensive restorations. It would be no great handicap if the patient were required to wear a night-worn appliance to the end of her days; few object.

PREVENTIVE ORTHODONTICS.

It would be impossible to treat temporo-mandibular neuralgia, without becoming obsessed with the preventive outlook; the greatest step to prevention is the avoidance of extraction, or the preservation of the natural teeth. But the mere preservation is not enough; the teeth must be in ideal occlusion, and as has been implied in previous pages, we are unsure of what comprises ideal occlusion.

The genetic endowment of the patient is an all-important factor; there seems to be an "intelligence" in the bone cells, which will mature the mandible without the stimulus of environment, at least part of the way to its full development. But the mandible with an unusually obtuse gonial angle is cropping up in the human race with increasing frequency, and it is hard to believe that this gross deviation should be activated by genetic mutation alone: I cannot see how atavistic theories can supply the answer. It is outwith the scope of this paper to discuss neo-Lamarkian theories on the inheritance of acquired characteristics, but the human mandible might furnish the proponents of these theories with some apt arguments. The subject is dismissed with the comment that the orthodontist can do nothing to retrieve basal bone once it has become distorted.

DIET.

While bowing to the generally-held opinion that the obtuse gonial angle is genetic and irretrievable, one cannot but remember that similar opinions were held three generations age, concerning rickets. The student of pain in the temporomandibular joint, is perforce a student of bone-growth, and he must interest himself in the quality as well as the quantity of the Nation's food, with particular reference to the bone-forming ingredients and to their optimal metabolism. The study of the cooking, preparation and storage of food is relevant. The physical make-up of food is also not without importance: if fibrous it needs vigorous chewing and the consequent muscular activity will impel more blood through the growing part.

(1(176) Hanau, R.L. Resilient and like effect. Chicago Dent. Soc.Bulletin. (Jan.7) 1932. 16-23.

Chapter 20.

SOME SPECULATIONS AS TO PAIN-CAUSATION.

BI-LATERAL HYPERMOBILITY OF THE CONDYLES.

As a result of persistent over-closure, a patient may develop such a loosening of the joint ligaments that the condyle develops an excessive forward range as well as backward: the condyle may come right out of the glenoid fossa, perhaps to the front of the crest of the eminence. The first time that the condyle jumps to the front of the eminence, may cause the patient alarm, and may require the services of a surgeon and perhaps an anaesthetist, but usually the jaw can be returned to rest position by the patient's own efforts. When it happens the second time, there is less pain and alarm; each succeeding incident is easier, until the patient can throw the jaw into this position without being aware of it.

It has been my observation that the patients who take badly to dislocation, are those with steeply inclined distal slopes to the eminence. I have reported a case (177) where the jaw remained dislocated for nine months.

A very small minority dislocate their jaws and remain dislocated for minutes. Probably this follows on a spasming of the lateral pterygoid muscle. Indeed, neuro-muscle synergia has a bearing on dislocation; it may be a simple matter of timing, as to which muscle relaxes first; if the lateral pterygoid muscle were to relax first, the others would be able to pull the jaw back to rest position.

Several surgical operations have been devised to obviate persistent dislocation; bone implants have been inserted into the zygomatic arch to raise the height of the articular tubercle (178). Flaps of temporal fascia have been stitched to the masseter muscle or to the capsule to restrict movement. One operation deliberately reduces the height of the eminence to facilitate the return of the condyle.

Ricketts, (179) draws a distinction between the horizontally dislocated condyle, and the vertically dislocated, according to how it lies in front of the crest; undoubtedly, the vertical dislocation ought to be more difficult to reduce.

THE GAG IN GENERAL ANAESTHESIA.

It is well-known in general dental surgery, that the opening of the mouth of the anaesthetised patient by a gag, will often dislocate the jaw; indeed, the anaesthetist routinely ensures, at the termination of the operation, that the patient is not dismissed with the jaw dislocated. Two points here emerge, (1) predisposition, and (2) how the gag is used.

(1) Predisposition:- It is my opinion that in most cases where the condyles comes out too readily, we will find that the patient is the usual "slack-muscled, stretched-ligament", type of patient. Probably, there has been a long pre-existing state of over-closure of the jaw, with loss of molar support. In other words, the jaw has been for years gradually conditioned to be readily dislocated, a point of view, which ought to be more fully understood by witnesses involved in law-suits against dentists who have been charged with dislocating jaws.

(2) Nevertheless, every precaution should be taken to avoid dislocation; but this is not the occasion to discuss this subject. But it is relevant to be interested in the action of the gag. I believe that the gag forces the jaw open in a manner which is quite foreign to the natural opening, that is, if it is inserted between the upper and lower molars. Theoretically, if it were inserted between the incisors - which is absurd - the mouth would open with a natural movement, but as I conceive it, forcible opening of inter-molar space must endanger the ligaments, if not the muscles.

When our research was first set up, I anticipated that inquiry into case-histories would produce evidence that a prime factor in the production of temporomandibular pain, would be general anaesthesia just prior to the onset of the pain, with the obvious implication of dislocation by gag. But, astonishing to relate, only two cases out of over two-hundred and fifty, could be related to this cause, and even these not convincingly.

One of these cases was a man who suffered pain for three months in the distribution of both temporal muscles after a general anaesthetic for tooth-extraction. The dentist on being questioned made it clear that there had been no dislocation, although, force had been used. The pain was relieved spontaneously: I was just about to supply the patient with splints, when the pain ceased, which was fortunate for our records, because if splints had been inserted, a cure would have been credited to them. His pain, therefore, was attributed to traumatism of the muscles and indirectly of the temporomandibular joint. It should be noted that the pain was experienced in the origin of the temporal muscles; was this simply a pain of traumatised muscles, and not a referred pain?

GLASSOPHARYNGEAL NEURALGIA.

The passage of the pain impulse cannot be arrogated to the Vth nerve exclusively; facial pain may also involve the IIIrd, VIIth, IXth, the vagus and the autonomic nervous system. The posterior cervical nerve roots may also influence pain on the face. But the pain-conducting mechanism of the Vth nerve is that which is most frequently evoked. However, among the 250 patients whom we have treated by mechano-therapy during the last two years, one seemed to be suffering from glosso-pharyngeal neuralgia.

When the patient initially consulted, she was the victim of an intermittent, flashing, searing pain on the right tonsil and soft palate, radiating into the ear and neck. She was wearing a well-made denture supplied about three months previously, to replace an older full denture; the onset of the pain coincided with the insertion of the new denture. The vertical height appeared to be correct. The pain disappeared when the upper denture was removed. The only fault discernible in the denture was that it was post-dammed rather extensibly behind the right tuberosity. About $\frac{1}{8}$" was removed from the backward extension, and the trigger-spot painted with "surface anaesthetic" each day for a week. The pain disappeared and has not returned in two years.

POSSIBILITY OF A DENTURE PRESSING ON THE SHARP HAMULAR PROCESS.

While I am satisfied that the pain in the patient just mentioned, was a IXth nerve neuralgia, nonetheless, there is less satisfaction in accepting that the slight pressure of a denture on the epidermal tissues, could cause such agony.

Another alternative hypothesis is offered. Could it be possible that the denture pressed the soft tissues up against the hamular process? Examination of museum skulls has shown that the hamular process is often very sharp and quite close to the site of the post-dam. This is a point which could bear closer examination.

TINNITUS AND DEAFNESS.

Whether bite-rehabilitation can help tinnitus and deafness, is still being argued. Several contributions to the controversy, are set out in Schweitzer's text-book (180). One gathers from the study that the oto-laryngologists are by no means clear as to what causes tinnitus; and doubt still exists concerning the help derived from re-positioning the jaw. I can only place on record that several patients have been treated and that they claim that their low-note tinnitus has improved.

Sometimes the tinnitus is associated with pain. It gives one a "yard-stick" to measure pain, to be told by a patient that the ringing in the ears is much more annoying than the pain; but, of course, there are pains and pains!

As to deafness, several have reported improvement, although no audiometer tests have been done. However, some reliance can be placed on stories told by patients such as the following. This patient could not hear her radio when sitting in her favourite chair at a certain accustomed distance from the set. After treatment, the radio could be heard.

TRISMUS FOLLOWING INFERIOR DENTAL BLOCK ANAESTHESIA.

In 1926, I was a personal victim of trismus following an attempt to anaesthetise the inferior dental nerve by the block technique: the case was reported in the Dental Record, circa 1935. A full case-report is not justified in this paper, but it can be said that my incisors could not be separated more than ¼" for six weeks. The condition was painless, but when an attempt was made to open more widely, pain was felt in the temporomandibular joint.

I reasoned that the temporomandibular joint was only secondarily involved, and that the disorder was primarily in the medial pterygoid muscle (internal pterygoid), which had spasmed, perhaps reflexly, due to the passage of a hypodermic needle through its tendon; perhaps the muscle spasmed because of a haemotoma caused by the needle.

The experience probably initiated my interest in the temporomandibular joint, and did much to implant in my mind the impression, which remains to this day, that the joint may become tender because of pressure from a tense muscle.

During the course of my professional career, patients have been referred to me, who were suffering trismus. Sometimes this was due to extension of an inflammation from an impacted wisdom tooth, sometimes the spasm of the muscle was reflex from the impaction; sometimes the trismus came from a badly administered inferior dental block.

Most patients who suffer trismus do not develop temporomandibular joint symptoms, and those who do, sometimes suffer pain, and others a "clicking jaw". Probably the trismus changed the muscular pattern of mastication in these latter patients, with consequential stretching of the ligaments and uncapping of the cartilage from the head of the condyle.

The diagnostician cannot afford to overlook trismus.

Where a trismus has supervened from an inferior dental block, it has been my experience that the average case will last about six weeks, at the end of which time the remission will begin. In making this observation, it is presumed that the instruments which gave rise to the condition have been sterile.

I am unaware of any therapy which is genuinely useful, but fortunately most cases resolve of their own accord. Diathermy may be tried.

Although this type of trismus is painless unless stretched, patients have been encountered who demanded from their doctors that the jaw be stretched, and I know of a case where this was done under general anaesthesia, with great aggravation of the condition: if the temporomandibular joint has not been traumatised before this assault, it will be after. One can imagine that the tight muscle, or tendon, will not yield even using curare, but that the manipulation will lever the condyle upwards and backwards.

A UNIQUE CASE OF TRISMUS OF LONG DURATION.

I have been privileged to undertake the treatment of a patient whose trismus lasted 18 months after an inferior dental block. I was puzzled how to handle the case, but while cogitating, I proceeded with the preparation of cavities which had been neglected during this time. The mesial surface of the upper left premolar was badly carious, and had been aching for months. Now, remarkable to relate, as soon as the root-treatment was complete, the trismus completely resolved.

The explanation could not be found in neurosis, because the patient was a calm and self-reliant woman; but the fact remains that within a few days, the incisors which could not be parted more than $\frac{3}{8}$", opened more than 1".

I hazard the opinion that the trismus initially was a spasm of the medial pterygoid muscle, caused by the severe stimulation of the stretch-reflex nerve-endings in tendon of the muscle. Thereafter, the spasm was sustained by a "throw-back" reverberatory reflex, abetted by spatial summation from the pulpitis; there was a "beaten track" of afferent and motor impulse which was broken up by the pulp-removal.

The point of this case-history is that the afferent arc which may give rise to pain or motor activity, may be subliminal, and consequently may not be interpreted either as pain nor spasm, but when there is superimposed an additional impulse, the threshold may be crossed.

In practical terms, this means that, for example, a temporomandibular joint may be irritated only sufficiently for a sub-threshold stimulus, but when another impulse is added, then the pain may become subjectively perceptible. In other words, we should not over-look the possibility of multi-causation.

WHEN IS MANIPULATION OF A JAW JUSTIFIED?

It says much for the medical and dental professions that only one case has come within our orbit, where a jaw was subjected to manipulation under anaesthesia, for a non-dislocated locking. If the jaw locks in the classic position of dislocation, manipulation is indicated, but not when the jaw locks with the teeth only slightly apart. In the latter case, probably a meniscus has got out of position, and this calls for gentle persuasion, not for force applied to the jaw. The patient can usually correct the lock, but the clinician may be called to push a distally displaced disc back into place.

The patient referred to in the previous paragraphs received a severe set-back by being manipulated under general anaesthesia for a dislocation, whereas the lock was apparently a slipped cartilage. In other words, a joint already traumatised by over-closure, was further traumatised by forceful manipulation.

THE THREE JAW LOCKS.

Apart from tetanus and strychnine poisoning, there are three modes of locking the jaw:-

(1) Dislocation, where the condyle has stuck in front of the crest of the eminentia articularis.

(2) The lock of the slipped cartilage, where the condyle has got stuck either in front, behind or at the side of a displaced meniscus.

(3) The lock where the condyle is only secondarily involved; due to a spasming or trismus, the condyle is held fast in its closed position, although a little movement is possible by hingeing on the under-side of the meniscus, and still greater opening by swinging the jaw to the affected side.

EHLERS- DANLOS SYNDROME.

This paper would be incomplete without reference to the syndrome of Ehlers - Danlos, (181), (182), a familial condition which has not been explained.

I was initially attracted to study it because of its strange effect on the ligaments, but as I went deeper into the subject, the idea formed that the patients who suffer from this complaint, as well as our patients who are victims of facial neuralgia, share many common symptoms. But let us begin with a quotation from Johnson and Falls, (183).

"The paucity of the literature on the Ehlers - Danlos syndrome in all fields except pediatrics and dermatology would make one believe that the condition has been arrogated by members of these groups. It seems, however, that the syndrome should have been recognised and emphasised by others. For instance, the orthopedist should have been recording the joint symptoms; the surgeon, the friability of the skin; the roentgenologist, the roentgenologic findings; the pathologist, the tissue changes; the internist, the echymoses and hemorrhages, and the geneticists, the familial characteristics. The syndrome ...... is characterized by (1) hyperlaxity and hyper-extensibility of the joints, (2) hyperelasticity and hyperlaxity of the skin, and (3) friability and fragility of the skin and blood vessels".

Apart from its temporomandibular interest to the dentist, the condition might account for the profuse bleeding which occasionally occurs after a simple tooth extraction, Aardenne (184). But, of course, most cases of unusual bleedings are leukaemic in origin, whereas blood-clotting time is normal in Ehlers - Danlos syndrome.

Returning to the syndrome, the suggestion has been made that the "rubber-jointed and elastic-skinned man" of the circus has been recruited out of the Ehlers - Danlos class, although this is hard to credit on account of the bruising which results when the skin of a genuine subject is roughly handled: as to the joints, the subject may demonstrate his double-jointedness, but at the price of pain, at least to begin with until he has stretched his joint ligaments so much that dislocation can take place painlessly.

In these cases, the disturbance of the leg joints is usually noticed in early childhood, because of much dislocation of the knee and ankle joints; walking and running having to be done with caution. The shoulder joints may be so slack that both dislocation and replacement may be done with equal facility. Dislocation of the shoulder may even follow the putting on of a coat. Such a slackness of ligaments strikes a familiar chord to the temporomandibular specialist.

The hands of the Ehlers - Danlos syndrome patient show a characteristic ability to flex the thumb either backward or forward until it touches the wrist; the flat of the foot may touch the lumbar region; fingers placed round the back may touch the ears. The hyperlaxity of the joint ligaments may allow the shoulders to be touched together in a manner similar to cleido-cranial dysostosis, (185).

Indeed, the similarity of these two syndromes is so close as to suggest that they have a common origin. A further argument could be advanced that not only are Ehlers - Danlos syndrome and cleido-cranial dysostosis linked, but also ectodermal dysplasia, (186), fragilitas ossium (187), cretinism (188), and hyper-telerism of the eyes. Aitchison (189) has reported this occular hypertelerism as being associated with cleido-cranial dysostosis, and the widely spaced eyes, together with the broad-bridged nose, is also to be seen in cretinism, and in Ehlers - Danlos syndrome. Friability of the skin is to be found in Ehlers - Danlos syndrome, ecto-dermal dysplasia, cretinism and in fragilitas ossium.

Epicanthic folds have been frequently noted in Ehlers - Danlos syndrome and in cretinism. Partial anadontia and hypoplastic teeth have been reported in Ehlers - Danlos syndrome, cleido-cranial dysostosis, ectodermal dysplasia, and in cretinism. Blue sclera have been noted in fragilitas ossium and in Ehlers - Danlos syndrome.

Is it possible that these apparent distinct entities have a common origin? Can they be the familial expressions of genetic hormonal disturbance, the clinical manifestations of which differ from individual to individual?

BLUE SCLEROTICS.

It is with some hesitation that I append this following clinical observation, but among the neuralgic patients whom we have treated, a number have had blue sclerotics. The intensity of the blue is much less than that which I have seen in patients who suffer fragilitas ossium; it would be proper to describe it as a muddy greyish-blue, which is, of course, common enough in less intense shades, in normal subjects.

It is difficult to give figures of this phenomenon because of the variation in shades, and especially as I only commenced looking out for it during the last year; nevertheless, a fair number of neuralgic patients have been found with more than normal blue in their sclera. It has been said that the sclera are blue because the collagen of the sclera is thin. Does this signify systemic collagenous aberration, particularly manifest in the temporomandibular joint?

SLACK LIGAMENTS OF SYSTEMIC OR GENETIC ORIGIN.

The pathologists who have studied Ehlers - Danlos syndrome, while unable to explain either the transmission of the condition or its hormonal causation, have nonetheless been able to show tissue changes in the joint-ligaments, usually of a generalised nature. The specialist in the temporomandibular joint will immediately react to this report, by recalling cases within his experience, where the patient has been able to dislocate the jaw with such facility that he no longer notices it.

What makes the joint ligaments systemically weak? Is it due to some inherent difference from normal in the structure or constituents of the ligaments? Or could the pathologic changes, which are doubtlessly present, be accounted for as tissue changes, as the result of strain which have been thrown upon the ligaments by weak muscles, that is to say, the muscles are not sufficiently powerful to protect the joint ligaments.

A practical illustration may convey the lesson: the stresses of mastication ought to be borne largely on the lateral pterygoid muscles, as explained in another part of this paper. If these muscles are weak, the stress will fall unduly on the temporomandibular and capsular ligaments, and to a less degree, upon the sphenomandibular and stylomandibular ligaments.

Most of the patients who suffer facial pain suspected to be temporomandibular in origin, are slack-muscled women, and female muscle is said to be weaker than male, having less decussation of the fibres. Is it a reasonable conclusion that this inherent sex difference accounts for the disproportion in numbers? I look forward in hope that electromyography will explain the role of the muscles in the protection of joint ligaments.

OCCLUSAL LOCKS.

The reader will have gathered that our mechanotherapy consists of, among other things, unlocking the occlusion, not perhaps, to the extent of allowing three-dimensional chewing, but certainly to remove any factor which displaces the jaw. There is one particular occlusal lock which is inclined to be over-looked, because it does not force itself upon the gaze of the observer. I refer to the mouth which is narrow across between the upper canines and first premolars: each chew glides the lower teeth backwards. Perhaps the muscle behaviour pattern is such that these muscles have an instinct to carry the jaw forward, but are prevented from so doing by this defect in occlusion.

In the course of my orthodontic experience, I have been astonished at the number of cases where the mandible has come forward, as seen in the change in molar relationship, by no other treatment than expanding the inter-canine distance.

We cannot afford to forget this point in diagnosis.

CLICKS IN THE TEMPOROMANDIBULAR JOINT.

Patients have consulted for no reason other than the social embarrassment of a "clicking jaw"; sometimes the noise is so loud as to be heard distinctly all over a room. But, on the other hand, patients have been met who were blissfully unaware of joint noises.

The click may be hard or soft, in which case the term is a misnomer. The soft "click" is that which is produced by a tardily moving condyle suddenly jumping up onto the crest of the eminence, and when it jumps back again the noise is softer still.

A really thorough-going creiptus in the temporomandibular joint is one of the most blood-curdling noises I have heard: probably the cause is the grating of osteo-arthritic bone upon bone.

But the common click is believed to be a loose cartilage snapping about in the joint; indeed we have seen a projection appear above the condyle, quite evidently seen through the integument, which when pressed with the finger-tip snapped back into place.

By asking the patient to perform natural opening and closing movements while palpating the joints, the clinician can determine when the click takes place, whether in opening or closing, whether at the beginning, middle or end of these acts. I try, without much success, I confess, to feel the cartilage smapping into position as it clicks, with the intention of deciding how it jumps as it makes the noise.

A great controversy exists as to what makes the click, and what makes the jaw lock in the semi-closed position which is characteristic of the slipped

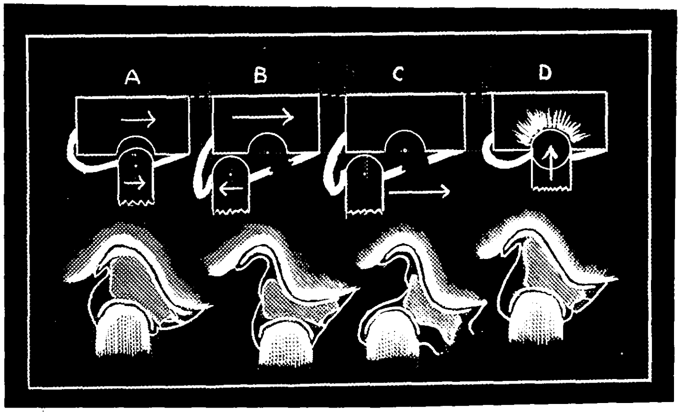


Fig.34.

A possible explanation of the click. The upper row of diagrams shows (A) condyle and meniscus travelling in unison, the disc being held down securely by the undamaged fibres of the capsular ligament. (B) shows that the anterior fibres no longer hold the disc down effectively, because they are torn or stretched, so that disc and condyle do not always travel in unison : in this example we imagine that the groups of fibres of the lateral pterygoid muscle have pulled the disc in front of the condylar head. This rides up on to the distal rim of the cartilage. (C) represents the condyle starting forward, to slip back into its bed (D) with the characteristic click.

Alternatively, the meniscus may travel back to its proper physiological end-point, but the condyle may travel back still further by over-closure, so causing the click.

cartilage. Some observers believe the click to be made by the condyle bumping over either the front or back edge of the meniscus, whereas others say that the click is caused by the disc itself lagging behind the condyle in either its opening or closing movements, and snapping belatedly into position. Fig.34.

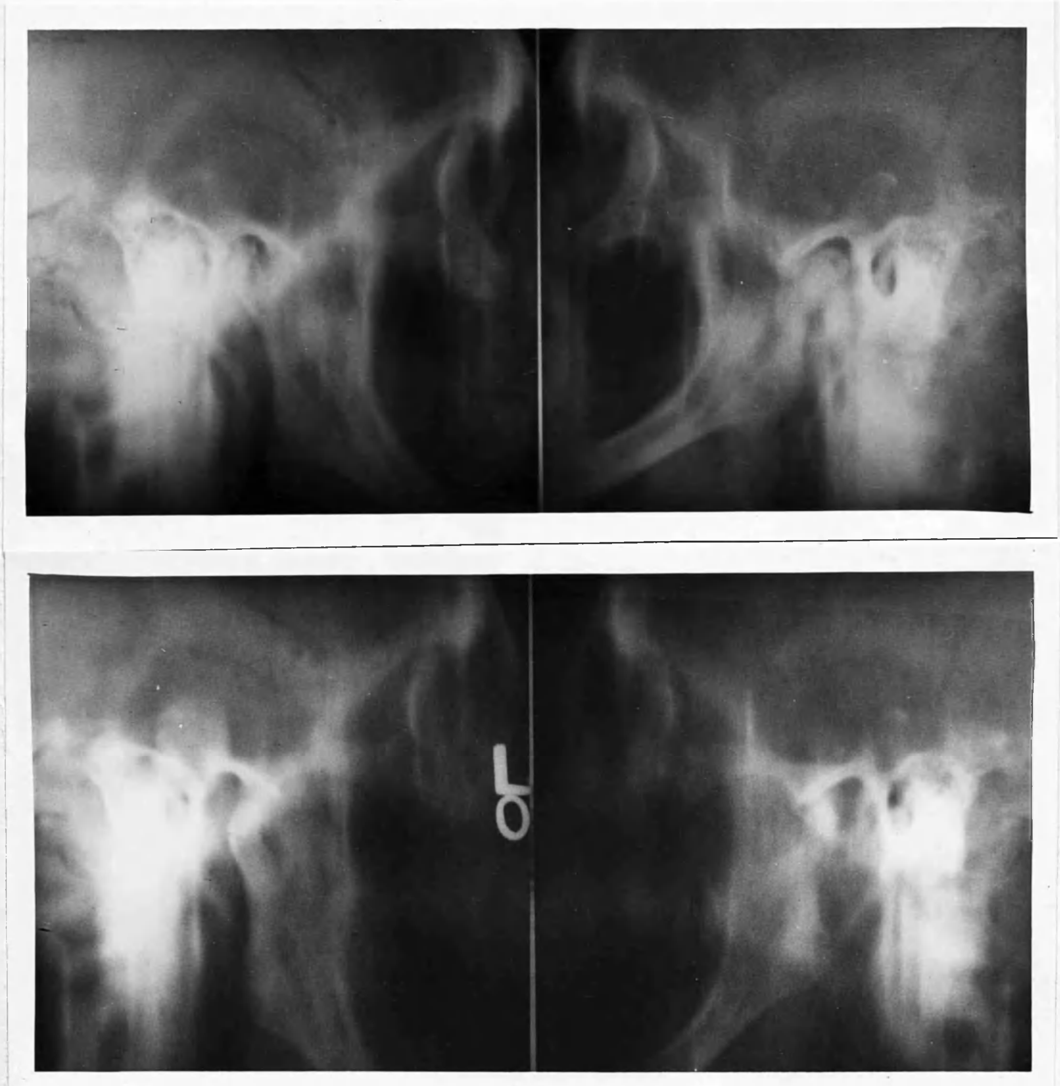
My own opinion is that the common click is caused by the disc, having been loosened by persistent over-closure, remaining forward, while the condyle rises forward onto the thick distal rim of the cartilage; then as the condyle moves forward, for it to slip off the high portion into the hollow of the under-side of the meniscus. Two observations substantiate this view, (1) the histology of the joint, and (2) the silencing of the click by over-lays.

(1) In an earlier page I made out a case for the greater security of the capping meniscus on the condyle during its forward passage, compared to its backward. The histology shows the taut and horizontal fibres which make up the anterior part of the capsular ligament, and helps also in holding down the disc. On the contrary, the distal fibres are puckered and slack, so that the meniscus is more inclined to be left in front, as well as being more inclined to trip

over.

(2) Now assuming that the meniscus has remained a little in front of its correct position because of the tension of the lateral pterygoid, that is to say, the slack distal fibres of the capsule did not drag the disc back simultaneously with the condyle, then the condyle will ride up on to the thick distal rim, the click being heard when it starts forward again. Now, here is an important point, <u>this could not happen if the condyle was prevented from going back so far as to ride up onto the distal rim</u>. Let us put this reasoning to test: let us place wax over-lays into the mouth of the next clicking patient. This I have done, and it has been a successful test in a proportion of patients. A patient may have a consistent and loud click; on inserting the splints and being told to do her worst, to her delight the click cannot be produced until the splints are removed. When I first discovered this little phenomenon I thought that, at long last here was the criterion for assessing the correct vertical height of the wax: that is, wax should be added until the click stops. But unfortunately, not every patient responds in the anticipated manner. However, we persist in the technique, and it frequently

Plate 7.



These laminagraphs show asymmetry of structure. Please note different shapes of condyles, how one slopes forward and the other backward, the differing heights of the ascending ramii, and the differing inclinations of the distal slopes of the eminences.

operates; when it does the patient is impressed.

OSTEO-ARTHRITIS, A CASE OF STRUCTURAL ASYMMETRY.

The need to economise in space in this paper has rendered it necessary to omit any reference to arthritic lesions of the temporomandibular joint, but the point has been well covered in such text-books as Schweitzer's. The opinion is expressed that while the temporomandibular joint shows remarkable immunity to arthritic lesions, there is no justification for assuming that it is exempt.

The set of joint laminagraphs which are shown in Plate 7 demonstrates our most gross case of an arthritic joint. A comparison should be made of the lengths of the opposing ascending ramii, of the inclination of the slopes of the distal surfaces of the eminences, and it should be noted that the condyle has an abnormal backward bend on the affected side. It should be clear that when these pictures were taken, there was no possible fore-shortening of the lengths of the ramii; the patient was accurately set with the transmeatal axis at right-angles to the film. It is hard to say if this is actually a case of arthritis, or a case of arrested development of the ramus; I am inclined to diagnose it as rarefying osteoitis, because the antro-posterior roentgenograph shows that the affected condyle has lost a great deal of its lateral width.

This case should be studied in contra-distinction with the case of functional asymmetry, mentioned on an earlier page. One case is functional asymmetry, while the other is structural asymmetry.

The whole subject of rheumatism is in the melting-pot, and an enormous amount of medical research is under way. We look forward in hope that their discoveries may help those who suffer temporomandibular pain. It is hoped that some day we may try the effect of cortisone on some selected patients.

It is hard to believe that the relief of rheumatic pain which sometimes follows an administration of cortisone, can be due to any action on the bone; it must be on muscle or tendon. In that case, we would be interested to see the effect of the drug on the tense, agitated type of patient who is always chewing her condyles up into the glenoid fossa. This thesis has repeatedly referred to the role of the muscles in pain-causation; cortisone may add to our knowledge of neuro-muscular physiology, especially if the experiment is controlled by electro-myography.

INJECTION INTO THE TEMPOROMANDIBULAR JOINT.

A bibliography exists on injection into the joint; Schultz's studies (190), probably being representative. My opinions are unformed on the use of sclerosing solution, probably because I have not used it. But not all investigators are in favour of it.

Conceivably, sclerosing solution may be useful where the intention is to fibrose a joint so as to cut down hyper-mobility, but it would seem to be contra-indicated in the case of a painful temporomandibular joint, where the movement is already limited.

Greater justification exists for the injection of local anaesthetics, partly for aiding diagnosis and partly for the relief of pain. The technique is the same as described by Schultz, except that novocain is used instead of sclerosing solution. Strange to say, when it is successful, the anaesthesia lasts much longer than the expected two hours. I have known of it last a fortnight. It usually lasts longer the first time than on any succeeding occasion.

In one case, a permanent relief of pain was derived from a novocain injection, after several years of suffering. I do not attribute any magical charms to the novocain in this case; probably the irritation of the passage of the hypodermic needle into the capsule caused fibrosis, and so a pathological hypermobility was converted into a much more comfortable immobility.

It is likely that the inflammations of the temporomandibular joint are mostly of the traumatic order rather than of the septic; this may explain absence of the more gross bony excresences.

The research worker is handicapped by the paucity of post-mortem material, and the difficulty of relating it to known clinical case-histories.

OSTEO-ARTHRITIS. OSTEO-POROSIS.

We have at least a thousand temporomandibular laminagrams in our files, and each has been searched for evidence of osteo-porosis, but it must be admitted that few clear-cut cases have been seen. Of course, the slightly fuzzy outlines of the compact bone as seen in the laminagrams, may obscure a break in the surface of the bone, but nevertheless, an obvious break would be expected in osteo-porosis.

One should be cautious about so-called osteoporosis as seen on roentgenograms; a more careful analysis will often prove them to be normal anatomical features. For example, the neck of the condyle, at the front and just below the head, will often show in layer roentgenography, a distinct rarefaction. But recourse to museum skulls will show the bone to be naturally hollow hereabouts.

THE PERFORATED TYMPANIC PLATE.

A feature which can usually be recognised in the laminagram, is the petro-tympanic fissure, sometimes it is narrow, sometimes wide and sometimes so wide as to suggest that the tympanic plate is perforated.

The possibility of perforation has been hotly argued and the reader is referred to Sicher's and Schweitzers' contributions. But I have before me, a skull where the tympanic plate is amissing on both sides, but then Sicher would say that these defects owe their existence to an arrest in the development of the tympanic bone. The tympanic ring changes in the newborn into the tympanic plate, and the foramen thus formed gradually narrows, and Sicher states that it persists in 19 per cent of all persons.

A controversy has also raged as to whether the post-glenoid tubercle can invariably limit the backward displacement of the condyle. However, the

Plate 8.

A.

B.

Unfortunately, despite several attempts, we were unable to obtain a clear picture of this patient. This explains why a positive print direct from the film is used. Please note in (A) the amount of joint-space between the condylar head and the distal slope of the eminence, and the appearance as if the tympanic plate were perforated. This may be a perforation, or alternatively the condyle may lie in super-imposition over the tympanic plate. But, how ever one may regard it, the fact remains that the condyle is in retro-position.

(B) shows the change in relation after treatment. The pictures were taken under identical conditions. The tympanic plate seems to have thickened.

reader is referred to Plate 8 which quite unmistakenly shows a case of a perforated tympanic plate. Unfortunately, try as we might, a clear picture could not be obtained of this patient; probably some unusual radiopacity lay over this temporomandibular joint. But the figure is clear enough to show that the condyle projects through the tympanic plate.

This patient aged 72, had all his teeth extracted during the First World War, and since then had only worn an upper denture. For the five years before consulting, he had suffered facial neuralgia, characterised by a constant back-ground pain with occasional flashes which resembled tic douloureux. He suffered dullness of hearing and tinnitus on the affected side. Bite-raising splints soon cured pain and tinnitus, and helped his deafness.

The figures on Plate 8 were selected to show the closest approximation of his jaws, before treatment, and again after several months of splint-wearing. On each occasion, the patient was asked to close his edentulous jaws as much as he comfortably could; the laminagrams of the jaw relations are therefore, comparable. It will be seen that after treatment, he could not place his condyles as far back as before. What caused this improvement is hard to say; I personally believe that the stretched or torn ligaments have shortened and have become strengthened. There has been no recurrence of pain in two years.

VERTIGO.

A fair number of the patients whom we have treated have complained of vertigo. Again, this has been a subject of controversy, which we shall avoid in this paper. The fact remains that many patients complain of disturbance of balance; a few actually fall. Sometimes the gait is ataxic, and as previously mentioned, the disorder may exist in the central nervous system, but it is possible that there may be local disturbance of the semi-circular canals by pressure of the condyle on the ear, although the mechanism is not clear. The reader should refer to Meniere's Disease (191), and Petit Mal (192).

A link is suspected with migraine because often the giddiness is associated with violent vomiting and photo-phenomena. The practitioners of the last generation who designated atypical neuralgia "migrainous neuralgia", had arguments to justify their opinions.

TEMPOROMANDIBULAR PAIN IN A CASE OF ACROMEGALY.

This case is briefly detailed as it brings out a point of principle.

In October, 1950, an edentulous patient of 55 was referred to us suffering from a left-side facial pain of 10 years duration. His appearance showed the classic symptoms of acromegaly. His hands and feet were large, his face demonstrated the text-book characteristics; the skin was chlorotic; the tongue was thick and the speech slow but the intellect was unimpaired. His mouth was edentulous, and the facial bone showed the over-growth which is characteristic of the condition.

The disease had been diagnosed shortly after its inception, and deep X-ray therapy had been administered. About this time facial pain developed, but had been attributed to the X-ray acting on the nerves in some unknown fashion.

The pain was constant, exacerbated by occasional flashes, and concentrated on the temporo-mandibular joint, but was also felt on the temporal area and at the inside of the lower edge of the mandible.

The pathological over-growth of the mandible had opened up a free-way space of over an inch. Therefore, each time he chewed he must have grossly over-closed.

However, there is an interesting speculation as to the cause of his pain. Could it be that the overgrowth of the mandible out-paced the growth of the muscles attached to the jaw? Did the ascending ramus grow quicker than the muscles and ligaments, thus causing the condyle to be driven up and backwards. I was delighted and frankly surprised when the pain disappeared never to return, immediately on the insertion of the splints.

This case confirmed the previously-held opinion that the temporomandibular joint may become painful, not necessarily because of temporomandibular disorder, but because of pressure on the joint transmitted by a shortened muscle. It should be noted that pain was felt at the insertion of the medial pterygoid muscle; that is, at a point which was stressed when the jaw was opened.

THE HYPERTENSIVE PATIENT.

Nobody could treat temporomandibular pain for long without becoming impressed by the systemic and mental aspects of his study: indubitably there is a type of patient who is prone to pain as a whole, and to facial pain in particular.

Mention has been made of the soft, effeminate type of girl whose slack muscles cannot fully protect her joints from over-strain. But there is another class of sufferer, the anxious, worried and tense subject, who does not know how to relax. Sometimes she has abnormal blood-pressure, sometimes high but sometimes low, a point which again hints that there is a tie-up with migraine and other manifestations of vaso-motor upset; indeed, the pain impulse might be conveyed by the autonomic system. This type of patient is continually working her jaws, and muscular strain is evident to the practised eye. She is especially liable to make temporomandibular trouble for herself if her chewing deflects the condyle by means of a contact between the sloping inclined planes of extruded teeth.

Much good would come if this type of patient could be taught to relax, but it is no mean task to eradicate the tension of years. One strongly-willed woman relieved herself of facial pain by disciplining herself to stop grinding her teeth together, and to hold them gently apart. Soft-rubber splints may help.

In this respect, a lesson was learned from one of my failures. A middle-aged man suffered so obviously, writhing in agony with tears streaming from his eyes, that at the end of a few weeks fruitless treatment, I sought the aid of the neuro-surgeons, expecting that root-resection would be his lot. Later, I was surprised to hear that operation was not considered necessary, and that the patient was cured by teaching him to relax. The reader is referred to "Progressive Muscle Relaxation", by Jacobson.

EMOTION.

When one sets off to treat facial neuralgia, one is inclined to discount all the tales one hears of emotion precipitating a bout of pain, but the facts speak for themselves; the same story is heard so often, although in different forms. It is a common experience to have cured a patient of pain, for example, for six months, and then to have a sudden recurrence of pain brought on by some emotional crisis. A quarrel is a common precipitating factor, witnessing an accident is another; entertaining guests is fairly common especially when the patient is high-strung and house-proud. The prolonged nursing of an invalid is commonly to be found in the case-history.

The student of facial pain, is inclined to dismiss the emotional side of his study, and relegate it to the psychologist, rather than to the physiologist, but I hazard the guess that the future will see emotion explained in terms of physiological reactions. Founding my belief on the phenomena of blushing, pallor, fainting and other manifestations of excitement, I feel that emotion is exhibited through a trophic-control mechanism, and that an investigation is over-due on the association of facial pain with skin temperature changes.

DRAUGHTS ON THE FACE. ARTERITIS.

Another "old-wife's tale", which experience has taught me to believe, is the cold draught of wind on the face, as an exciting cause of pain. The story has been told so often with such convincing proof, that it would be fallacy to disregard it. May we take it that cold wind on the face induces an early stage of ischaemic paralysis?

Further evidence of the link between pain and the nerves which ramify on the arterial cortex, is seen in the operation of lumbar sympathectomy, and the operation for denuding the carotid plexus of its cortex for the relief of facial neuralgia.

One patient has been met, who some years previously had about an inch of artery cut out from the temporal region so as to ease a pain in this area. The pain was cured for a time, but recurred. We treated him by re-positioning his mandible: after a slow start his pain disappeared and to the best of our knowledge has not returned.

Summarising this subject of emotion, it can be said that it is one brick in the edifice of pain. The abstract quality of emotion, which is a response to environment, becomes physiological as it operates through the body mechanisms; in psychalgia it probably works through the autonomic system, although emotion may materialise itself by the clenching of the jaw muscles, thus causing direct over-strain of the joint.

ISCHAEMIA AND PAIN.

Lewis (193) describes a physiological experiment which may have its application to our study. If the arteries to the arm are blocked while the arm muscles lie at rest, the sensation goes quietly dead, apart from the usual "pins and needles". But if the patient keeps clenching his fist as the circulation is cut off, the muscles of the arm become increasingly painful until the pain is intolerable. Could this have a bearing on our study? Could retro-position of the condyle embarrass the blood-supply to the tensor tympani, the stapedius and other ear muscles, by cutting off the anterior tympanic artery? This is improbable, but even if it is possible, then other three arteries contribute branches to the middle ear.

Could over-worked, restless masticating muscles become painful in the deficiency of blood-supply?

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Chapter 21.

CONCLUSIONS.

PSYCHALGIA.

When we initiated our research, we welcomed the opportunity to treat any case of facial pain which could not be otherwise diagnosed. It is now realised that cases were taken in hand which were far beyond our capacity. I had, in these early days been inclined to doubt the occurrence of psychic pain, believing that no patient would claim that she suffered pain unless there was some organic reality. But a few patients have been seen whose talk and behaviour was so irrational, as to engender the belief that they almost seemed to "enjoy" their pain, and would shirk an offer to try for relief. Some patients seem to seek refuge from an irksome environment by chronic invalidism, and facial pain is as good an excuse as any. Perhaps it would be a more exact statement of this point, to say that some of the minor aches to which the human flesh is heir, are magnified out of all due proportion. A more resolute person would push the trivia into the back-ground. The seeds of this behaviour are often sown in marital discontent. Perhaps the job is uncongenial, perhaps the patient is over-worked, perhaps she has not enough work to use up her energies. The domestic atmosphere is probably the most potent of all incipient causes.

These cases should be treated - if at all - in association with a psychologist: Dr.Gaylor has rendered valuable aid in this and in many other respects. He showed us that the facial pain of which one young lady complained, was relatively unimportant to her compared to a "bee in her bonnet" concerning foul breath. Despite the fact that her mouth was exceptionally clean, since her adolescent days she had shunned all company, and incidentally had stifled her biological urges.

Then there was another lady who claimed that her husband was poisoning her: I wonder how genuine was her case.

But the reader cannot be left with the impression that psychalgic patients are common, in fact they are few and far between.

RESPONSE TO TREATMENT.

As experience is gathered the clinician becomes more discerning as to the types of patient who will benefit from mechano-therapy; obviously psychalgias will only be improved by the hopes which may be raised. Now, we have looked upon our work as a research. We have taken an objective and detached attitude to our work, and credit is repudiated unless the cure of the pain can be accounted to mechano-therapy only. Therefore, no confusion of over-lapping treatments was allowed. During the first four years, apart from mechano-therapy, advice was given only on protecting the face from draughts, how to apply warmth to the face, and relaxation. Of course, the doctor's sedatives were permitted. This routine was determined so as to permit a valid assessment of mechano-therapy. This is not to suggest that the treatment in our clinic will continue on these lines. For example, we now inject sometimes into the joint; we hope to make use of diathermy.

It soon became apparent that a pattern was evolving with regard to the type of patient who might be expected to react well to mechano-therapy, but the opinion is here expressed that, no matter how experienced the clinician is, he will on occasion, err in his prognosis. Obviously patients with early but definite temporomandibular joint symptoms will respond better than those with no positive joint symptoms, but who have facial pain. Surprisingly, some of these latter have been helped, and several cured.

Another factor in calculating the chances of success is the site of the pain and its remote reference.

If the pain is in the near vicinity of the joint, the hopes are high, all else being equal. If the pain is in the origin or insertion of masticating muscles the chances are still good.

But the prognosis is less favourable if the pain is referred: especially if the pain is referred to a site remote from the joint, the omens are not auspicious. But I have often been surprised by the remoteness of the reference. I have relieved a pain which lasted for a generation, in a patient's chest, by extracting a buried lower premolar; there has been no recurrence in at least fifteen years. By bite-rehabilitation we have cured two cases of left-arm pain which simulated angina.

Temple Fay (194) has reported four cases of patients suffering from gall-bladder disease, whose facial pain disappeared after the gall-bladder operation. One wonders how many of these cases are unobserved and un-reported. Patients normally do not report these matters to the dentist.

Summing up this point, the closer to the joint is the pain, the higher the expectations, especially if clicking, and locking and tenderness, are definite, although but recently developed symptoms. Next in the list, are areas where strained muscles may be found. Then come the referred pains; here the prospects are not so good, but they are reasonable if the pain is close to the joint. Where there is no continuity of the painful area with the joint, the chance of success is poor; if the pain is bi-lateral it is worse.

IIIrd division pain, I suspect to be not IIIrd division pain at all, because it usually does not pass further forward than the mental foramen. I incline to the belief, therefore, that this type of pain is really felt at the insertion of the masseter, the medial pterygoid and the mylo-hyoid muscles. If the pain had been genuinely IIIrd division, it surely would run to the mid-line, and in that case is not likely to be associated with the temporomandibular joint.

IInd division pain is still within the hopeful category but the hopes are not high. Ist division pain is very uncommon in association with the temporomandibular joint, and probably no benefit will follow treatment by the dentist.

The reader will have gathered that I am inclined to view facial pain originating in the temporomandibular joint as the orthopaedist would see it; but, of course, I do not exclude the possibility of referred

Plate 9.

This patient was 16½ years old when he presented for treatment. An incisor lock deflected the jaw forward and to the left. He suffers facial neuralgia, and the jaw frequently locks on the left side with the incisors slightly apart.

pain.

A CASE IN PRACTICE WHICH SUMMARISES THE CONCEPT.

As this paper approaches its end, it is seemly that the case of a certain boy be described, as it sums up several diverse aspects of the temporomandibular joint. He was brought to me about three months ago for advice as to his bleeding gums; a cross-bite in the incisors had loosened the lowers. His age was 16½ years. Obviously he was in need of orthodontic treatment, the upper left central and lateral were inside the lowers in centric. The teeth were all present, and the dental arches were well-shaped with the exception of the region of the upper left central and lateral; these teeth being lingual to the catenary (195) of the arch. The lower left central and lateral were to the labial of the arch. With these exceptions, the arches were properly related to each other. But, although most of the teeth might have been capable of normal occlusive inter-digitation, these two groups of offenders glided the jaw into protrusive relation as the jaws approached one another. That is to say, if the upper offenders had been only two millimetres forward and the lowers the same amount back, occlusion would have been perfect, Plate 9. As it was, the mandible was deflected forward from a harmonious rest position to an ugly centric. The speech was also affected. The boy was a neurotic finger-nail biter; the question arises, did his fingers find their way into his mouth because subconsciously he realised that his mouth was out of harmony. Perhaps it is stretching the concept too far to suggest that his natural excitibility was heightened by the neuro-muscular disturbance of his occlusion.

Close inspection of his mandibular function showed the jaw deflected not only forward and upwards, but also to the left. Now, here is the point of the story: as I pointed out the features just described to the dentist who brought the patient for consultation, I remarked in the presence of the young patient, that this was a situation which was likely to lead to temporomandibular joint disturbance. The patient interrupted to say that already trouble had started; for two or three years he had experienced locking on the left side and neuralgia, which he had not mentioned to us as he did not think that it concerned the dentist. Now it is strange that he only felt the neuralgia when spectating an exciting foot-ball match on a cold day! It will be seen that in this single case, several of the themes of this thesis have been integrated, orthodontics, periodontics, emotion, draughts on the face, aesthetics, speech, locking and pain.

He is being treated orthodontically. A removable upper appliance has been supplied, the plan being to move the upper central and lateral over the lower incisors; this should remove the cause of the mandibular displacement, and cure his pain.

Once again, I ask what is the mechanism of pain-causation? Did the cold on his face provoke the pain, or did the excitement? Did he clench his jaws and press upon a tender joint, or did the cold and excitement drive the blood out of his muscles and cause the pain of an over-worked muscle with a diminished blood-supply?

The reader may be astonished at the youth of this patient who had already experienced temporo-mandibular disorder, but another even younger patient has been seen. This eleven year old girl, with a caries-free mouth, but with a grossly protrusive mandible, has noticed that pain commences on the right side of the face when cold winds blow on her.

These and other similar cases make one wonder how wide are the ramifications of occlusal and joint disorder.

PROPORTIONS OF FEMALE TO MALES.

As analysis of our records show that the numbers of female to male patients, are as 10 to 1; this seems to be in accord with the findings of other observers. The explanation for this disproportion may be found in the softer female muscle, with its less decussation. I discount adolescence as a contributory factor, but am certain that the change of life brings latent temporomandibular pain to the subjective perceptions.

FACIAL NEURALGIA AND THE PRIVATE PRACTITIONER.

I am firmly convinced that the private practitioner should not take in hand the treatment of tic douloureux, or atypical facial neuralgia, or even a case which has been definitely diagnosed as a true temporomandibular joint neuralgia. His experience of such cases is bound to be limited, and apart from this, many of these patients have strange phobias, and sometimes are at the limit of their fore-bearance. The hospital clinician can take these cases in hand, having apparatus, experience, resources at call, and a certain amount of authority. The private practitioner may find himself saddled with "an old man of the seas" on his metaphorical shoulders, of whom he cannot get rid having once started treatment. It is much wiser to refer the patient.

On the other hand, the private practitioner has a duty to make himself acquaint with the consequences of dental neglect; the best method of impressing him, so that he may convince his patients, is to have him see the abject plight of some of my patients.

While it is true that only a small proportion of a population will suffer a temporomandibular disorder, and fewer still will suffer pain from that disorder, nonetheless it is a risk that must not be chanced. The public should be made aware that there are simple although rather tiresome methods available, whereby dental caries may be in some measure avoided. By that I mean, reduction of the sugar in the diet, cleaning the teeth after every meal, longer intervals between the meals of children, and optimal fluoridation of water supplies. By these simple methods much suffering could be avoided, but human nature being so frail as it is, we are not likely to see any improvement: rather we may expect more trouble.

The public is not well-informed on the difficulties of the later years of denture-wearing, and many of the dental profession do not seem to have appreciated this point either. Full dentures, and partial dentures even moreso, are not the simple and certain successes that the public believe; satisfaction is problematical. But many failures could be turned into successes by more precise techniques and by better design.

CO-OPERATION OF THE PATIENT.

Not only is the co-operation of the patient needed but some resolution also; some of our patients have abandoned treatment too early, probably because the success was not immediate.

In a few cases success is immediate and pain relieved straight-away, but the usual success comes slowly over months. During this period, the patient must not be allowed to become pessimistic when pain recurs. The clinician will come to have in his mind's eye, the typical pattern of cure: it is slow with a relapse now and again. As time goes on the painful periods space out, and the spasms less severe, but it is during these relapses that the patient's courage must be sustained.

KEEPING A CHART OF PAIN.

In general, it is inadvisable to ask a patient to keep a chart of pain; it might make him too introspective and promote psychalgia, but in a few selected cases this has been done. A few pages of squared paper are given to the patient with instructions to mark off each day into four centimetre sections, forenoon, afternoon, evening, night. Then from the base line, we can count up one to four cms. according to the severity of the pain. At the end of each day a line is drawn according to the pain-experience. One patient changed the line from blue ink to red when he inserted the splints.

His case is interesting. During the fortnight required for making his splints, the pattern of pain as seen on his chart was normally erratic. The splints were inserted, but as soon as they were in his mouth, I had an instinct that they were too high, however, off he went, to report 10 days later. The chart now was most illuminating; it showed that shortly after each insertion of his splints the pain came on, and it disappeared when he removed them. There was no other course than to cut down the height: 3 mm. was taken off the lower. The next visit showed the pattern which was hoped for. Thereafter, the chart showed diminishing severity and increased spacing between attacks.

THE TYPES WHO MAY BENEFIT.

In a previous page, advice was given that success is more likely if the objective symptoms pinpoint the temporomandibular joint, and if the pain is in close proximity. But on the other hand, we have been pleasantly surprised at the reactions of patients to treatment who had neither radiological nor objective symptoms, but who had pain. But the numbers of this class are so few, that it is problematical if this side of the research should be continued. While the occasional cure occurs, it is off-set by the dashed hopes of the failures. The only solution of this point lies in greater exactness of diagnosis. We feel need to be able to distinguish between the true tic douloureux, which cannot benefit from bite-rehabilitation, and the neuralgia caused by a temporomandibular joint disorder. Probably there is a type which belongs to both classes, the patient whose joint has been disordered for years and who now has come to suffer a superimposed tic douloureux.

Only during the last generation has the temporomandibular joint been studied as a pain-producing part, and the difficulties of the study have been out-standing; therefore, any present conclusions must still be speculative.

But one may venture the opinion that if the facial pain is exclusively flashing and of extreme severity, the diagnosis is tic douloureux and it is a waste of time to try bite-rehabilitation. But if the pain is of any other nature and if objective joint symptoms are decisive, then there is justification for embarking on treatment. After all, mechano-therapy can do no harm, even though it may do no good; it is not irreversible like an operation at which a part is cut away.

NERVE RESECTION.

It is more than a generation ago since I saw my first nerve-resection case; there was not only complete Vth nerve anaesthesia, but also motor-root paralysis and eye symptoms. In those old days, the mortality on the operating table was 25%. But, nowadays the neuro-surgeon can differentiate in the nerves to be cut, mortality is negligible, and altogether the improvement in surgical technique has conferred a great boon on suffering humanity. But, the neuro-surgeon would not embark upon such an operation until he had exhausted every other possibility. Therefore, it lies with the dental research worker to examine every case of facial pain in order to steer the patient away from the operating table if possible. We have had to deal with three patients who have under-gone nerve-resection with no benefit; two of these patients had the nerve cut twice. Under our treatment, two of them were considerably improved.

It is on that note that this thesis finishes. We realise the immensity of the task before us: pain is one of the most complicated of studies, and it becomes doubly complicated when we attempt to relate it to deficiencies of structure and mal-function of the parts. But we have been encouraged to continue in the research, by a considerable number of successes; some which were partial successes and other complete.

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RESULTS : ASSESSMENT OF TREATMENT.

33 patients had either no pain or merely slight pain, but had sufficient temporomandibular disorder such as locking, to make them seek treatment.

235 patients had various degrees of pain in several parts of the head and neck, which could be accredited to temporomandibular mal-function.

Many other patients were examined whose facial pains were thought to be caused by dental causes, such as pulp-stones, hyper-cementoses, obscure dental caries, impactions or ill-fitting dentures. These, as well as pains reckoned to originate in the sinuses are not included in our lists.

Pain had been endured for various periods, amounting in one case to 32 years; 10 years was common. This endurance was not neglect; they had sought advice. The age of the youngest patient was 10 years, and the oldest was approximately 90.

In making this report, 35 of the more recently treated cases have been omitted, because improvement cannot be accurately assessed until a reasonable period has passed. The following figures apply to the first 200 cases. All statistics are reduced to per-centage.

STATISTICS.

Males	18	9%
Females	182	91%
Edentulous	90	45%
Pain on Right side	67	33%
Bi-lateral pain	52	26%
Mainly one complaint :-		
Joint snap with neither lock nor pain	33	16%
Lock or stiffness but without click	12	6%
Lock or stiffness together with click	33	17%
Tinnitus only	20	10%
Pain :-		
Gnawing pain only	105	52%
Flashing pain only	14	7%
Flashing and gnawing together	68	34%
Burning pain	12	6%

In condyle	116	58%
Temporal area	70	35%
2nd. Div. area	67	33%
Mandible	64	32%
Gums	36	18%
Tongue	11	5%
Throat	6	3%
Tonsils	3	1%

Suspected disseminated sclerosis, confirmed in a few cases	11 ...	5%

Patients not taken in hand; patients referred for operation, others too ill.	24 ...	12%
Patients who broke off before 2 months, mostly before treatment commenced. They were nearly all at work, young and in no great distress	27 ...	13%

Results.

"5 star" cures	89 ...	44%
4 stars	10 ...	5%
3 stars	19 ...	9%
2 stars	15	7%
1 star	5	2%
Total who received benefit	138 ...	67%
Received no benefit	12	6%

Every patient who had only stiffness or locks improved at least slightly. Nearly all clicking joints showed some improvement. Tinnitus is difficult to treat and assess, but some improved; an accurate check on this point is now being kept.