PHYSIOLOGY OF THE TEMPORO-MANDIBULAR JOINT, AND THE RELATION BETWEEN JOINT AND TEETH *)

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The anatomy of the Temporo-Mandibular joint has just been demonstrated and described in an excellent way by the last speaker (Dr. Landsmeer) — so referring to what we have just heard, I can directly try to describe the physiological function of the same.

Let me first formulate a few short statements.

If the Temporo-Mandibular joint were a simple hinge joint we, in the dental profession, would have been spared many problems and difficulties.

Unfortunately, however, the Temporo-Mandibular joint is one of the most complicated in the human body.

The anatomy of the joint, its opening and grinding movements have long been familiar to us.

In spite of this, however, the dentist is still often proceeding as if he were dealing with a pure hinge joint.

Although we know that the individual tooth is not driven into the solid jaw bone like a nail in a piece of wood, we are often acting in our daily routine as if it were. We accept it as being a solid unity. On the contrary we all know, that we here meet one of nature's most wonderful arrangements for holding the tooth firmly during its function, and at the same time, for helping it to take up and to tolerate the great variability of forces, released during chewing action. The load can vary between zero and 150 kg, and the direction from zero up to 90° referred to the long axis of the tooth.

These two facts — the joint-mechanism and the attaching mechanism of the tooth in the bone — must all the time be born in mind, when you try to understand the masticating function.

We are mostly concerned with the movement of the condyle in the sagittal plane, especially in prosthetic dentistry, because in the movement from the closed to the open position, the condyle travels from the bottom of the fossa up the eminentia articularis.

It is perhaps hardly surprising therefore that it should be a dentist — the Dane Christiansen 1901 — who was first to draw the practical conclusion from these facts. He then constructed the first articulator in which the inclination of the condyle path was variable, so that it could be adjusted to the individual slope of the eminentia articularis.

*) Paper read for the Nederlandse Vereniging van Tandartsen.

This dentist also was the first to describe a method of measuring this inclination with, what is now known as, an "*intraoral wax record*".

The comparatively great degree of freedom of the condyle in the fossa which enables the condyle to move also in the transverse plane, provides the explanation to the fact that the "centric relation" might not necessarily be the one and only position of the mandible.

On the contrary: the mandible might be guided into a false centric relation through one or more malplaced teeth acting as guiding elements (impediments, cusp guidance, etc.).

This is therefore called the *habitual centric relation* and is the result of the fact that the condyles may be displaced in their fossae.

This carries us directly over to a short description of the laws of articulation.

Those who wish to penetrate the problem more deeply I would refer to my paper: "*the Term Balanced Articulation, its Origin, Development and Present Significance in Moderne Odontology* — (*Dent. Record*, Nov. 1949). In the present context I must confine myself to quoting the following important points from that article:

"Balanced occlusion" of "balanced articulation" was originally confined to a term associated with a certain technical operation in the construction of full dentures. *Occlusion* is the contact between cusps and cusp-planes in the teeth of the upper and lower jaws, when they meet in biting position (static condition). *Articulation*, on the other hand, denotes this contact during the functional movement of mastication (dynamic condition). In both cases we may speak of a normal, traumatic, centric, eccentric, unbalanced or balanced, etc., position or movement.

In speaking to-day about "balanced articulation", the reference is chiefly to the *natural bite*, and the designation is used as a collective term for various forces that will be exerted on jaws, alveolar processes and teeth and their supporting tissues during physiological mastication and swallowing movements; and by *balanced* articulation is meant *such an ideal state of equilibrium during these movements that all teeth will be* as *uniformly stressed as possible*. During the past twenty years, clinical experience as well as experimental research and histological investigations have convinced us that overstrain on an individual tooth or group of teeth, owing to lack of balance in articulation during masticatory movements of the jaws, *may* be a *releasing and precipitating* cause of a latent disease factor, and that, unless this overstrain is corrected, our local methods of treatment will be frustrated, and a relapse will set in.

By a deeper knowledge of the full denture articulation problem, and the transference of this analogy to the natural bite and its function, we have made a major advance. Some authors, it is true, have denied the possibility of transferring an analogy from the laws of denture articulation to the natural bite, on the grounds that such an ideal equilibrium of articulation scarcely occurs in civilised man except in rare instances, and that a bilateral articulatory balance, which is necessary for stabilising a full denture, does not exist in the human bite. Although this view is correct in principle, it is nevertheless an indisputable fact that the

distribution of stress between the individual teeth will be effected best if the laws of articulation, as formulated by H a n a u, are observed as closely as possible. We have here to bring the overbite, the height of the cusps and the compensatory curve into harmony with the individual's condylar path and with the laws of articulation. In so doing we feel that we have created the most favourable conditions for the periodontium, thus helping any weakened attachments of the tooth to withstand the stress associated with mastication in a case of predisposition for periodontal disease. In the light of these laws of articulation it will be easier for us to understand that complete articulatory equilibrium will occur only

1. when the vertical dimension (usually called the height of the bite) is correct;
2. when the incisal overbite and overjet are correct;
3. when the occlusal details of the teeth of one jaw are in full harmony with those of the opposite jaw, both in a position of rest and during masticatory movements; and
4. when the two condyles lie and move symmetrically in their respective fossae.

It will also be readily understood that if, owing to loss of one or more teeth, an irregularity has been created in the occlusal curves, the guidance of the mandible by these occlusal details will not correspond to the guidance directed by the two condylar paths in their joints, and one of the following possibilities will occur.

1. The displaced tooth, or teeth, will act as an impediment to the movement of the jaws — usually called cusp-trauma — with resultant overloading of such teeth due to unilateral stress. If this overload exceeds the margin of safety of the relevant periodontium, or if the latter's resistance is lowered by a factor predisposing to periodontal disease, the result will be a breaking down of the periodontal membrane, and in due course the loss of the teeth involved. If, on the other hand, the stress does not exceed the safety margin of the periodontium, the reparative power of the body will be capable of strengthening the attachments of the relevant teeth — compare what happens in orthodontic treatment.

2. Any existing incongruity between the tendency of the lower jaw to be directed by the temporomandibular joint itself and by individual tooth-impediments may cause disturbances in the articular function, leading to what are usually called "temporomandibular arthroses". In such cases, too, a certain predisposition seems to be necessary if the disease is to develop.

3. The third — and most desirable — possibility is that none of these diseases will occur.

Having regard to the foregoing, as well as the very complicated movements of the mandible due to the complex mechanism of the temporomandibular joint, we are led to another logical corollary: "*The human mouth is not the best articulator*". To clarify this statement I would refer to my work on balanced occlusion, published in *Dental Cosmos*, 1933, in which I pointed out that when a mouth is closing in

"centric occlucion", the lover jaw may be directed into a false position, due to the presence of cusp trauma. I therefore called this position *habitual centric occlusion*, and it is made possible by the resilience of the temporomandibular joints. *True centric relation* can only be acquired when the mandible is in the relaxed rest position; that is to say, hanging loosely in the relaxed muscles. That is why this position has also been called the relaxed centric relation. From there the mandible goes into the correct physiological occlusion only when all occlusal details are in harmony with the laws of articulation; in other words, no cusp trauma must be present.

It must be obvious that it is easier to study the position of the teeth and any irregularities which may occur, such as abrasive surfaces, cusp-trauma, etc., on an exact study-model than in the mouth itself. (At quite an early stage O s t m a n, 1930, also pointed out that it was useful to note for instance the depth of pockets and degree of firmness of the teeth on such models.)

With the aid of these study-models how is one to study articulation and any upsetting of its balance which may occur? Is it possible, by placing these models on each other, and guided by the details of the occlusion surfaces, let them slide on each other, to gain an impression of what is taking place in the mouth? In my opinion only on *very broad lines.* In this assertion, which I justified as far back as 1932, I definitely opposed to other authors in this field. In my works, published later, on the importance of the mandibular joint for articulation balance, I think I have succeeded in offering clinical proof which suggests that this assertion is correct.

Those who represent the other view state that the mandibular joint is of no primary importance for the articulation movements and that these are quided entirely by the details of the occlusion surfaces in the teeth.

None can deny that such guidance of the mandible does take place, but that these movements and the *path* which the condyle simultaneously describes in the mandibular joint should conform, this should be self-evident to anyone who has studied these problems and from his clinical experience been able to *ascertain* that such really is the case.

The logical consequence of this whole reasoning is that the study-models cannot give a correct interpretation of what is taking place in the mouth during the act of articulation, unless they can be mounted in an instrument, (an articulator) in such a relation to each other that any cusp-trauma which may occur is not allowed to misguide the mandible. In other words: *the models must not be mounted in an habitual central occlusal relation but in the relaxed or real central occlusal relation.*

For this reason a study of the articulation, s.c. bite analysis, must in my opinion *be performed with study-models mounted (by means of a face-bow) in an individually adjustable articulator*, in which the path of the condyle can be copied with a necessary degree of accuracy. It is not possible to obtain complete *accuracy* with such an instrument, nor is it desirable because there are bound to be errors in the registering *procedure* carried out on the patient.

I cannot in this connection enter into the purely technical manipulations, and the difficulties involved in transferring the models to the articulator, but I should nevertheless like to state that I am quite convinced that not only is the *intraoral method of registration* not frighteningly difficult to master but also that it gives far superior results compared with the *extraoral method.* I will confine myself here to a brief outline of my procedure:

1. The upper study model is mounted in the articulator by face-bow transfer.
2. A relaxed centric relation record is taken intraorally with soft wax interposed between the two jaws. The patient is instructed to close gently into the soft wax, and is stopped before any occlusal details come into contact with each other.
3. After chilling the wax record, the lower model is mounted in the articulator.
4. Condylar path registration is carried out in the usual way.
5. On removal of the centric wax record and closure of the articulator the occlusal details will guide the two models into habitual centric occlusion; and if cusp impediments exist, the operator will be able to detect the source and also observe a displacement in the condylar mechanism of the articulator. By scraping or grinding those cusps or cusp planes on the models that act as impediments, the occlusal curves and details can then be corrected, thus securing as completely balanced an articulation as possible.

But to return to what happens in the articulator when surveying a case, I have already pointed out that it is possible to detect a major or minor displacement in the condylar mechanism when a cusp impediment directs the lower jaw into habitual (false) centric occlusion. Such a displacement must of course also occur in the T.M. joint. How can this be diagnosed?

Around 1930 this question began to attract increasing attention and resulted in the various X-ray techniques that so far have been evolved. If we could study radiologically the opening movement, observe how long it remains a pure rotatory movement, establish the point at which the condyle begins to move forward and downward along the oblique plane of the articular eminence, and finally determine its ultimate position after maximal opening, then a great step forward woul have been taken. This is what has actually occurred; for to-day we are able to verify radiologically what has previously been mere empirical supposition. With these X-ray checks of the T.M. joint we have completed our array of diagnostic weapons. But what is more, we possess a very valuable differential diagnostic method of establishing in advance whether we are confronted with a genuine *deep-bite* or merely with a *lowered bite* (see *Dental Record*, 1939). The X-ray check not only provides information about the shape and type of joint (such as a deep and narrow fossa, or a shallow and wide one, etc.), it also indicates the location of the condyle in the fossa — whether it is in the rest position and symmetrical in

both joints, whether it is displaced forward or backward, and whether such a displacement is unilateral or bilateral. Such X-ray diagnosis of the T.M. joint — if properly carried out — will afford the best and most reliable evidence of a correct relaxed centric record; in other words, of the correct rest position of the mandible.

Bite Analysis

After this short review of the principles of balanced articulation, which has been essential to explain some of the most valuable expedients in carrying out the planning procedure called bite analysis, I want in conclusion to give a brief description of the practical procedure in such an operation.

A bite analysis should precede, and serve as basis for, not only prosthetic treatment, but also the surgical treatment of periodontal diseases, and indeed even for the orthodontic correction of a bite. Similarly, the purely conservative treatment of a bite must often be based on preliminary examination and planning of this kind. Finally we have the large group of disturbances in the temporomandibular joints — called temporomandibular arthroses — for which bite analysis is often of primary importance.

To be able to carry out a proper bite analysis one requires:

1. A comprehensive case history; 2. a complete radiological examination of *all* teeth; 3. a careful examination of the oral conditions; 4. good and accurate study models of the upper and lower jaws: 5. a survey of the occlusion and articulation, properly carried out by means of these two models, mounted as above in an individually adjustable articulator and designed to detect any cusp interference that may exist during functional movements of the jaws; 6. X-ray investigation of the T.M. joint.

On the basis of these six factors it will then be possible to devise a diagnostic plan for the treatment of the patient in question — a bite analysis in the wider sense of the term.