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SEMINARS

These papers, similiar to the Lectures to State Branches, are included in the Journal *to avail others outside the State of origin of the material being presented to the particular teaching department.* It has been segregated from the 'Lectures to State Branches' section because of its theoretical nature. The material is selected on the grounds that it is suitable background information for current clinical trends.

Keys and lines of occlusion

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INTRODUCTION

The 'Keys to occlusion' are the central principles upon which are based the positions of the teeth when the jaws are brought together.

Occlusion has been taught from several different viewpoints, which at one time or another, have included the various branches of dentistry. The anatomical view was the interdigitation of maxillary and mandibular teeth. In prosthetics we were taught to provide balanced occlusions where working, and non-working sides were simultaneously in contact. Periodontists insist on equalising forces to reduce occlusal trauma, and crown and bridge specialists required us to examine centric relation and anterior guidance as well as the intercuspations when dealing with occlusion.

Angle (1907) said that 'occlusion is the basis of the science of orthodontia'.

In recent years we have all pursued with more interest, a better knowledge of occlusion which not only involves a static analysis of tooth to tooth relationships but also the functional aspects of occlusion. But with this continued pursuit of knowledge of what represents normal occlusion and its temporomandibular joint (T.M.J.) relationships, controversy still continues. Therefore as stated by Ricketts (1969) occlusion has become a medium which brings together all the branches of dentistry.

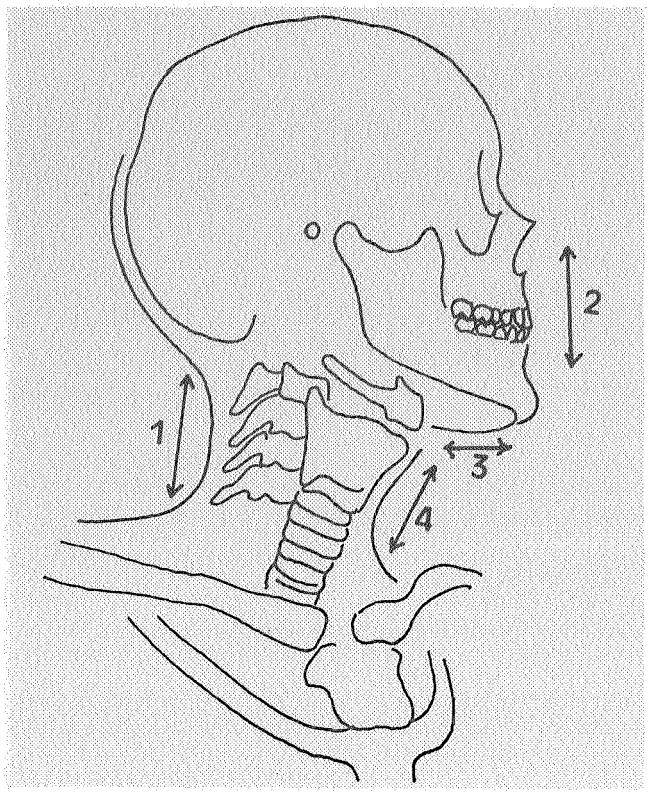

Figure 1. The Kinetic chain of muscles
1. Posterior cervical muscles
2. Muscles of mastication
3. Tongue and supra-hyoid muscles
4. Infra-hyoid and prevertebral muscles

In 1887 Angle proposed his most famous key to occlusion as a guide to orthodontic diagnosis and treatment. It was based on the relationship of the upper first permanent molar to the lower first permanent molar. Since then this basic premise has been extended and built upon by many authors. Andrews (1972) proposed his six keys to occlusion which gave a well delineated prescription for an ideal intercuspation of the teeth. However, these descriptions define *only a static relationship* and tend to ignore functional positions.

Williamson (1976) Aubrey (1978) Ricketts (1979) and Roth (1981) have all expanded the area of knowledge in occlusion to include the neuromusculature and bony structures of the T.M.J. as being equally fundamental in our assessment of occlusion and in establishing treatment objectives.

So, in its total concept, occlusion includes the jaws in centric relation, the nature of the moving paths, the functional strokes during mastication and the performance of the dentition as a stabilising medium to the entire kinetic chain which encircles the head *(Figure 1)* as well as the individual relationships of the teeth on an interarch and intra-arch basis.

In order to examine the keys to the occlusion, it is relevant to examine, in brief, the development of the occlusion. Once the occlusion is established, the elements of both the static and the functional aspects must be examined in order to determine the ultimate treatment objectives in dealing with those occlusions which do not fall into our established range of 'normal'.

DEVELOPMENT OF THE OCCLUSION

The concept of the normal occlusion is generally based on the relationships of the teeth in the completed adult dentition.

However, the development of the adult dentition plays a significant role in the formation of either an occlusion which fits well within the normal range, or one which is abnormal and hence deficient in one or more key factors (Burstone, 1964).

The three primary aspects in the development of the adult occlusion include:-
1. full and complete development of the individual elements of the dentition, i.e. each individual tooth
2. craniofacial growth and development
3. neuromuscular maturation (Moyers 1969).

Predental occlusion

The predental occlusion or jaw relationship cannot adequately be assessed when discussing the key to its development. This is due to:-
(a) a lack of development of ligaments and articulation associated with the T.M.J.
(b) immaturity of neuromuscular control mechanisms of musculature around the jaws
(c) lack of teeth and associated innervation which may be a necessary part in the development of the occlusion.

Primary occlusion

Moyers (1969) states that there is little relationship between primary tooth development and skeletal maturation. Most primary arches are ovoid and show less variability than the permanent arches.

The neuromuscular regulation of jaw relationships is very important in the development of the primary occlusion.

Contact between the two incisors initiates the first step in the occlusal reflex learning. The erupting teeth are guided to their ultimate occlusal relationship by the functioning muscle matrix of tongue, lips and buccal wall. Less variability in the occlusal relationship occurs in the primary dentition than the secondary because of the early development of the musculature and skeletal support. So the keys to primary occlusion are more uniform and predictable.

Transitional dentition

This is the commencement of the stage of individual variabilities. There are four factors which determine the position of each adult tooth as it erupts into its occlusal position within the arch:-

(a) position of the tooth germ which is genetically determined

(b) during intra-alveolar eruption there is a strong tendency towards mesial drift and leeway space loss (Graber, 1972).

(c) after occlusal contact of secondary teeth a more complicated and integrated system of forces determines tooth position, e.g. masticatory muscles; eruption forces; alveolar growth, anterior component of force.

Therefore, little variability is to be found in the predental and primary occlusions. The transitional, however, brings in the first permanent molars and from here the keys to occlusion begin to act on each individual part.

CRITERIA OF OPTIMUM OCCLUSION

Angle (1907) stated that it can be seen with teeth in normal occlusion, 'each dental arch describes a graceful curve and that the teeth in these arches are so arranged as to be in greatest harmony with their fellows in the same arch, as well as with those in the opposite arch'.

He then goes on to say that:-

'the sizes, forms, interdigitating surfaces, and positions of the teeth in the arches are such as to give to one another, singly and collectively, the greatest possible support in all directions'.

This was followed by his now classic concept that the key to the occlusion was the relationship of the upper and lower first permanent molars.

This has, in many respects, stood the test of time. However, clinical observations in subsequent years revealed that, even after orthodontic treatment, obvious inadequacies persisted in many occlusions, despite acceptable molar relationships as described by Angle. These inadequacies led to re-examination of the normal occlusion.

The results of this re-examination was the description of further essential elements which describe a normal occlusion and these elements were of:-

1. a static nature - as observed on dental casts or intraorally
2. a functional nature - as observed during movement of casts on fully adjustable articulators, or intraorally using many different types of monitors such as electronic mandibular movement recording techniques and sophisticated radiographic examination (McNeill et al,1980).

Static keys to occlusion

In an attempt to collect further information on what was a normal occlusion Andrews (1972) studied casts of 120 non-orthodontic patients which exhibited aesthetically pleasing, regular teeth. Six characteristic constants were observed and he referred to these constants as the 'Six keys to normal occlusion'.

Andrews' six keys to normal occlusion can be summarised as:-

Key 1: Class 1 molar relationship
Key 2: Correct crown angulation (mesio-distal tip)
Key 3: Correct crown inclination (labio-lingual torque)
Key 4: Correct tooth rotations
Key 5: Tight contacts
Key 6: Minumum Curve of Spee

Andrews found that Angle's molar cusp-groove was valid. However, there were other qualities of importance. When viewed buccally there was an angulation (mesiodistal tip) and also an inclination (labio-lingual roll). There were no rotations and no spaces and the occlusal plane fell into a limited range of curvature.

Andrews then compared the ideals found in his 'normal' casts with 1,150 orthodontically treated cases. He found that his six 'keys' were present in completely treated models, but lack of just one of these six led to a defect and incomplete or inadequate end result.

FUNCTIONAL KEYS TO OCCLUSION

Beyron (1969) states that optimum occlusion should ensure a stable neuromuscular functional pattern of the masticatory system without undue strain or injury to any of its structure. It should be self-perpetuating, i.e. inevitable changes in occlusion, with function and age should entail a favourable occlusal development.

Ingervall (1976) states that our aim in orthodontics should be, to have the teeth positioned in such a way, that the occlusion will be in harmony with the outer frame of the individual. The outer frame being the pattern of movement of the mandible. This in turn is determined, not only by the morphology of the dentition but also by the anatomy of the TMJ's and the activity of the masticatory muscles.

McHorris (1979) states that not enough emphasis has been placed on the anterior teeth and their role in optimal occlusal function. He also feels that the anterior teeth are a key to preserving good occlusions. This view is supported by Ricketts (1979) Williamson (1981) and Roth (1981). McHorris (1979) states that the most ideal form of occlusion is the cusp-fossa, tooth to tooth arrangement because: -

1. forces are directed over the long axis of the tooth
2. there is greater stability of the entire arch and less tendency toward tooth movement
3. there is less chance of food impaction between the embrasures.

In bringing all these views together, the plane of occlusion, the labio- lingual position of the teeth and the overjet and overbite, are all factors which must co-exist and be organised with mandibular movements if they are to survive and fulfil their intended function requirements (Ingervall, 1976).

Roth (1981) in an extensive series of articles (written in four parts) has been able to assess the many different views on the various elements of functional occlusion and has listed those which he feels are significant *'determinants of occlusion'*.

1. Stable centric relation of mandible with maximum intercuspation of the teeth at this position. This allows the forces of occlusion to be directed down the long axis of the posterior teeth. All the centric stops should hit equally and simultaneously on both left and right sides. The anterior teeth should have an extremely light contact between the anterior teeth, i.e. 0.0005" clearance which is equivalent to two strips of Mylar tape giving some resistance when pulled between anterior teeth.

Stuart (1964) claimed there were three principles of centric. The first was that all teeth contact at the same time on opening and closing when the joint axis is placed normally in its most posterior position.

The second principle was that on the way to contact, 'the teeth should strike nothing, i.e. no cusps deflect the mandible and no cusps guide the path of closure.'

The third principle was, at contact in centric jaw relation, any lateral or forward movement of the jaw requires immediate opening. Such centric occlusion occurs at the most closed position of the jaw. This closure is at an uppermost, rearmost, midmost condyle position. Williamson (1981) agrees and adds that both before, during and after orthodontic treatment the most important requirements for avoiding functional disturbances are:-

(a) in the intercuspal position and retruded contact position the mandible should be situated in the same sagittal plane. The distance between the two positions being< 1mm.

(b) bilateral and stable contact in the intercuspal position

(c) even bilateral gliding movements along shallow paths of movement with:-

(i) multiple contacts on the working side.

(ii) contact of front teeth in protrusive.

(iii) no balancing interferences.

This last statement leads on to *Roth's second determinant* of occlusion.

2. Harmonious glide path of anterior teeth. These teeth should work against one another to separate or disclude the posterior segments as soon as the mandible moves out of centric closure. There should be sufficient overbite and overjet at the maxillary incisor tips to allow for a gentle glide path. This factor of functional occlusion is supported by numerous authors such as Stuart (1964) Chiappone (1975) Guichet (1977) McHorris (1979) and McNeil et al (1980).

The *third determinant* of occlusion is:

3. The canines should provide the main gliding inclines for lateral excursions and the six mandibular anterior teeth and mandibular first bicuspids should articulate with the maxillary six anteriors so that the protrusive load is spread over fourteen teeth. In this way, a mutually protective occlusal scheme is established where the anterior teeth protect the posterior teeth from lateral stress during movement. The posterior teeth then protect the anterior teeth from lateral stress during closure in centric relation occlusion.

In this occlusal scheme the mandible can execute its total range or envelope of motion without interferences between the buccal teeth. Williamson (1981) stated that it is canine protected occlusion that is most often see in the naturally occurring young adult dentition today.

Chiappone (1975) discusses the benefits of mutually protected or canine protected occlusion. He also observed that TMJ articulation is a very important factor in the finishing of orthodontic treatment. He says that it has been observed that *lateral tongue thrusts exist in patients with occlusal interferences*. The patient reflexly places the tongue between the teeth in an attempt to eliminate the constant irritation. Removal of the occlusal interferences led to a disappearance of the tongue thrust. This has also been suggested by Guichet (1977).

The *fourth determinant* of occlusion is:

4. That the teeth direct and maintain the centricity of the condyles in their fossae in closure. The teeth do not prevent the mandible from entering or leaving any possible position that the joints will allow.

Another key to functional occlusion has been described by many authors, beginning with Tweed in 1941.

Lower anterior teeth

Angle realised that the axial positioning of each tooth is critical but it was Tweed in 1941 who first gave the lower incisor axial inclination the individual attention it now enjoys. Cephalometric analyses have allowed closer investigation of the lower incisor but its importance is still controversial.

Berger (1959) suggested that considerable emphasis had been placed on the six year old molar as the 'key to occlusion' but says that the lower incisors have usurped this key position in diagnosis and treatment planning. He then suggested three factors associated with its importance.

1. It is the first to erupt and may therefore be the first sign of an incipient malocclusion.

2. These teeth are difficult to treat and tend to relapse easily.

3. Crowding of the lower anterior is very frequently observed.

Another consideration regarding the position of the lower incisor is its relationship to the centres about which all mandibular movement occurs - *the condyles*.

Stuart (1964) points out that the best position for the lower anterior teeth to resist the mechanical forces distributed to them would be at right angles (90 degrees) to a radial from the opening and closing axis. Mechanically, many work implements share the same advantage, e.g. hammer, pick, hoe (McHorris 1979).

Ricketts (1979) in writing about his Keystone Triad, stated the position of the lower incisor in relation to the A-pogonion plane, seems to be a most useful reference point, in evaluating the position of the lower teeth relative to the basal bone.

Anterior coupling was observed in optimal occlusions by McHorris (1979). He describes a close approximation of upper and lower anterior teeth when the posterior teeth were closed and like Roth found that 0.0005" space was present.

He summed up his observations by saying that in the optimal functional occlusion -

1. The anteriors are in very close approximation but do not touch when molars are in occlusion.

2. The lower anteriors engage the lingual incline of the opposing upper anteriors immediately with mandibular movement.

3. The lingual discluding surface of the upper anteriors seems to reflect the anatomical angle or discluding pathway of the mandibular condyles. The ideal anterior disclosure angle is greater than or equal to 5 degrees more than the condylar disclosure angle *(Figure 2)*.

The discluding lingual angle is not always the concavity but most often is the mesial and distal marginal ridges.

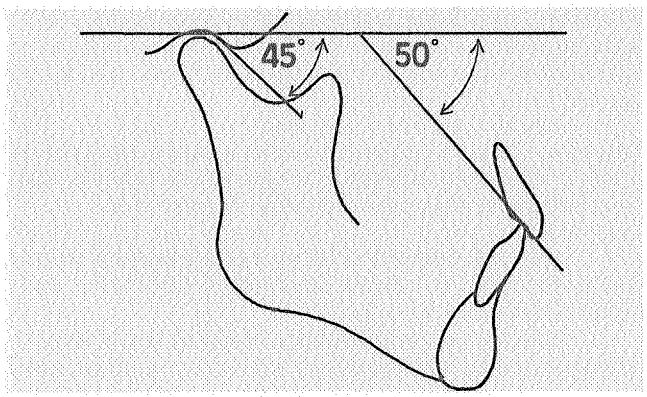

Figure 2. The ideal angle of disclusion in protrusive is thought to be 5 degrees greater than the condylar disclusive angle.

Line of occlusion

Another of Angle's observations was that 'the lower arch is the form over which the upper is moulded'.

Ricketts (1978) in interpreting Angle's writings says that 'by the biologic process of the earlier, unhindered eruption of the lower teeth followed by the action of the inclined planes, under the influence of muscle, the normal occlusion develops'.

Ricketts interprets Angle's line of occlusion to be one passing through the occluding surfaces and not through the contact points of the individual teeth *(Figure 3)*. He says that the line of occlusion through the buccal centric stops gives the position that the teeth must occupy to be in stability and harmony with each other and with all the anatomical structures. When the teeth are in their correct position on the line of occlusion maximum occlusal contact occurs giving an occlusal table having between 21 - 24 contacts on each side (not including the third molar). (*Figure 3*)

Roth (1981) has also stated quite emphatically that *the lower arch must be corrected in detail* to attain an overall satisfactory result. 'It is of the utmost importance that the lower arch be finished and in correct position to act as a template to receive the upper teeth'.

Second premolar as another factor in the occlusal relationships.

In 1969 Ricketts published an article in which he states that

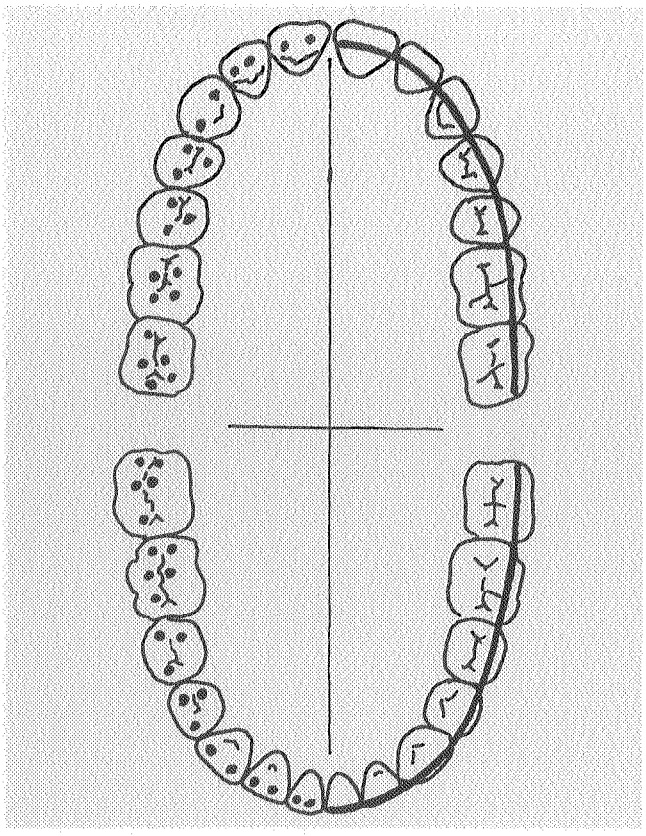

Figure 3. On the left side is Ricketts' occlusogram of the normal pattern of occlusal stops; on the right side is Ricketts' interpretation of Angle's line of occlusion.

the 'key to a well developed occlusion, or to a properly treated malocclusion is the contact position of the upper second premolar'. (*Figure 4*).

His contention is that, if the second premolar is to have a normal contact relation with the mesial incline of the lower first molar, there must be a normal relationship and position of both the upper and lower first molars.

This condition is guided by the first molar occlusion and produces an interlocking of the upper premolars into the corresponding interspaces of the lower premolars. Ricketts states that this relationship produces the most efficient, most self-cleansing and most self-preserving relationship in accordance with Nature's plan.

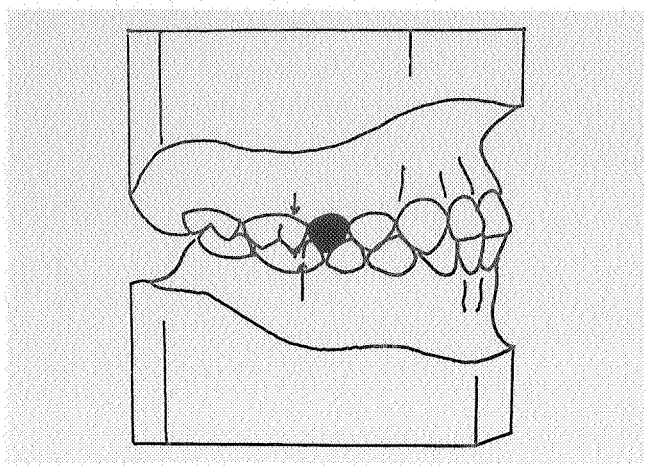

Figure 4. Ricketts' Key to Occlusion: The second premolar in its correct position. When this tooth is correctly positioned, it causes the tip of the mesiobuccal cusp of the upper first molar to be slightly *distal* to the buccal groove of the lower first molar. This is contrary to common concepts.

Inadequacies in occlusal harmony

Orthodontic treatment goals as described by Roth include some very important objectives:-

1. Optimum facial and profile aesthetics that are acceptable to the individual social environment.
2. Optimum dental aesthetics.
3. Optimum functional occlusion and oral health.
4. Stability of the treatment results.

When anyone of these aspects is inadequate or missing then problems can arise. It is therefore important that both static and functional aspects must be carefully assessed before, during and after therapy.

Williamson cites a case of TMJ dysfunction. A patient had what could be considered a good orthodontic result from the traditional static study model analysis but who developed pain and dysfunction. There was optimum dental aesthetics but a lack of optimum function. Ramfjord (1971) says there is an area in which the subtleties of minor deflections from the line of occlusion may cause dysfunction in patients with low tolerance.

Roth (1973) emphasised the importance of second molar deflections in causing TMJ dysfunction and pain. He points to the need for a critical understanding of functional movements by the orthodontist and continued observation throughout treatment. He says that the *majority of potential occlusal problems can be corrected by archwire adjustments or banding of additional teeth such as the second molars.* If functional goals are well understood then tests and continued clinical checks can be performed to ensure that the established ideals and keys to good occlusion are achieved and maintained with first band placement and archwire techniques, rather than equilibration after treatment.

CONCLUSION

When looking at the keys to occlusion, the dental occlusion could be defined as the static, closed, contacting position of the upper to the lower teeth as described by Angle. Since his concept, however, exhaustive attempts have been made to understand the occlusal morphology of teeth as they relate to mandibular movement.

Much of the earlier studies related to the posterior teeth with little emphasis on the anterior teeth. The anterior teeth have an obvious role in aesthetics, speech and incising of foods. However their parafunctional role in providing protection of posterior teeth during mandibular movements and protection of the TMJ and neuromusculature system is equally as important (McHorris 1979).

Centric relation is another factor of primary importance in any occlusal concept. The greatest single error we can make in reconstruction of mouths either with fixed prosthesis or with orthodontic therapy is failure to treat to centric relation (McHorris 1979).

The teeth must be in harmony with condylar movements. When the teeth are subservient to the condyles in static, as well as moving relations, a harmonious occlusion will exist.

The teeth should also be organised in a good relation to each other. Andrews 'Six Keys to Occlusion' delineate these relationships well. Such arrangements require the least amount of neuromuscular adaptation and minimise strain and wear. The occlusal table, the line of occlusion and the relationship of the incisors to the condyles are also significant. In summary, the single goal agreed to by all concepts and theories of occlusion is the preservation, in good health, of the whole masticatory system for the life span of the individual. This includes minimum deterioration of hard and soft tissues, good function and pleasing aesthetics (Schweitzer 1969).

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