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Full occlusal protection – theory and practice of occlusal therapy

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Abstract

In this review the full occlusal protection theory is proposed and its clinical practice demonstrated for varying Angle's malocclusions.

The concept of developing restorative anatomical shapes or bio-designing occlusal schemes of crowns to compensate for poor intra-arch tooth positioning is proposed and demonstrated.

Clinical parameters for full occlusal protection in occlusal therapy are presented.

Key words: Centric platform stop, horizonto-lateral forces, vertico-lateral movement, canine rise ridge, bio-designed occlusal schemes.

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Introduction

The theory and practice of occlusal protection have been proposed by many authors.[1-9] However, the concept of full occlusal protection over a variety of clinical entities has not been thoroughly enunciated.

Many occlusal theories have been postulated[10-15] and the presence of many patients with non-Class I Angle's posterior occlusal schemes, with a poor anterior guidance mechanism due to malpositioned anterior teeth, highlights the need to adopt restorative techniques to provide occlusal protective mechanisms.[16]

This paper details the full occlusal protection theory and the practice of occlusal therapy that delivers a full range of occlusal protection for differing jaw and tooth relationships.

Full occlusal protection theory

Occlusal protection is defined as where the tooth arrangement and contact of opposing teeth directs orofacial forces to protect the teeth, muscles of mastication and temporomandibular joints (TMJ).

Full occlusal protection is defined as an occlusal scheme where occlusal protection is afforded during a clinically significant range of mandibular movements for differing skeletal types. In excursive mandibular movements, this corresponds to a condylar path distance between 4-6mm from centric relation. The specific bioengineering designs that allow full occlusal protection to occur are elaborated for the major occlusal schemes.

Occlusion can be subdivided into three major occlusal schemes: hinge, lateral and protrusive.

The aim of full occlusal protection is to create tooth guiding contacts that prevent unilateral mandibular movements in hinge occlusion and protrusion and restrict excessive angling of the mandible in lateral excursions. The result of these limitations is the mandible moves only in a zone of comfort and safety and is encouraged not to search for the ligamentous extremes of the joints, preventing unnecessary stretching and loosening of the joints. In turn, an environment is created which keeps the discs in a stable position during function and limited parafunctional activities. The TMJ discs are thus protected and disc displacement less likely to occur.

Hinge occlusion

An ideal hinge occlusion occurs when reproducible hinging of the TMJs correlates with bilateral simultaneous contact of the teeth in centric relation. A fully protective hinge occlusion is developed by examining the tooth contacts on the posterior and canine teeth and incisors.

On the posterior teeth, supporting cusps should have a spheroidal cusp tip. A spheroidal cusp tip is neither sharp nor blunt but has the form of a rounded tipped cone with seven blended geometrical shapes (Fig 1). This is aided by deepening buccal and palatal grooves of adjacent supporting cusps of molars and buccal fossae of lower premolars (Fig 1). Deepening these grooves also increases the 'illusionary' height of the cusps. The overall cusp design is called a spheroidal cusp. Spheroidal cusp tips allow for easy marking of articulating paper and have no sharp edges for parafunctioning.

These spheroidal cusp tips should hit the opposing tooth at right angles to a flat, near-circular platform

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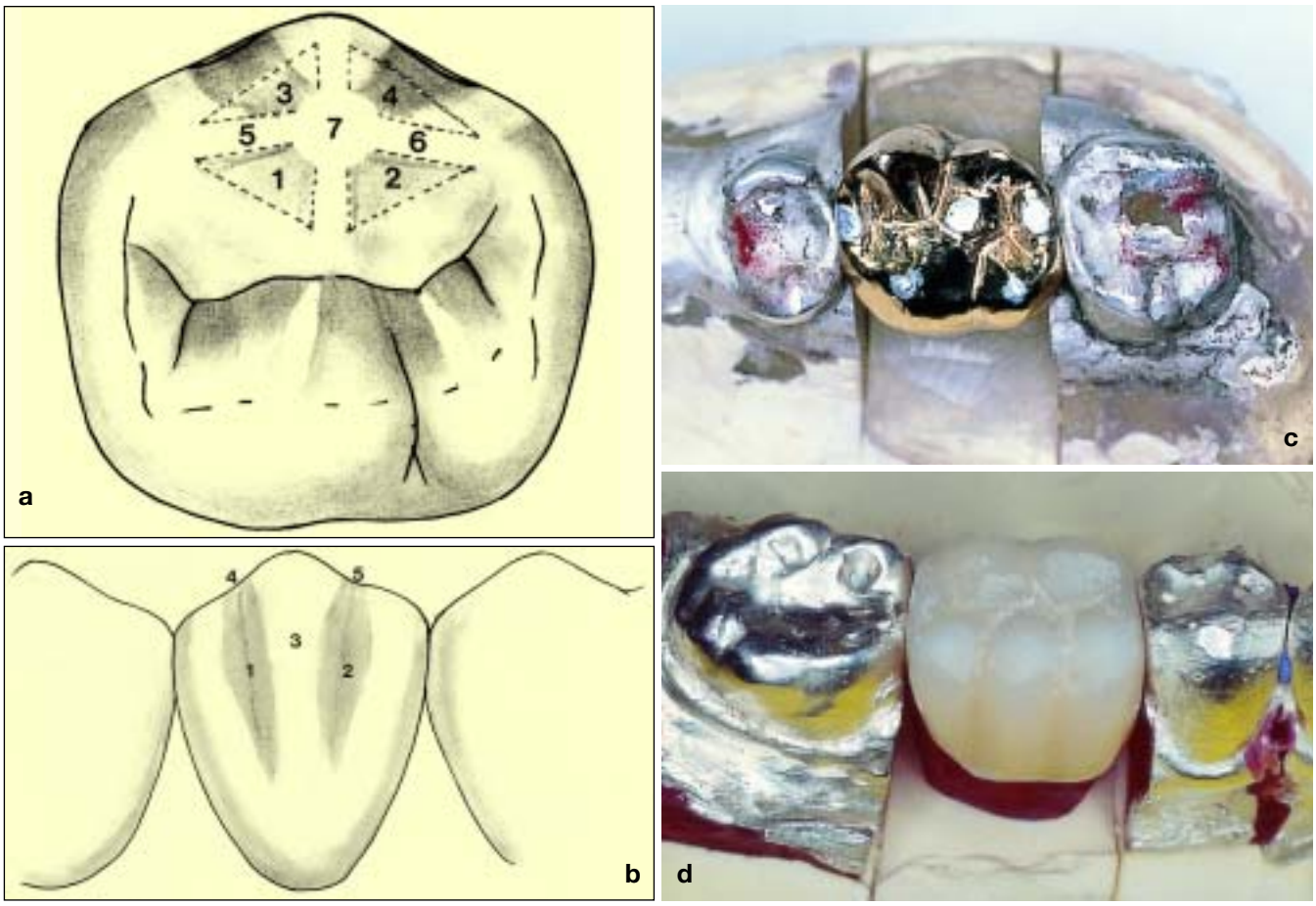


Fig 1a. Occlusal view of a lower second premolar illustrating the seven geometrical shapes that create a spheroidal cusp. Shapes 1 and 2 are the triangular cuspal inclines, shapes 3 and 4 the buccal triangular surfaces with buccal fossae, shapes 5 and 6 mesial and distal cuspal inclines and shape 7 the rounded cuspal tip.

Fig 1b. Buccal view of a lower second premolar illustrating the deep buccal fossae (1 and 2) each side of the buccal cusp (3) which runs on to the mesial and distal inclines (4 and 5) to create a spheroidal cusp.

Fig 1c. An occlusal view of three centric platform stops (silver painted). They are flat, near-circular and 1.5mm in diameter.

Fig 1d. A buccal view of three buccal spheroidal cusps, illustrating the deep buccal grooves.

(Fig 1) raised above the central groove plane (a centric platform stop). These platforms are similar to the Clayton centric stops developed by Dr JA Clayton[17] and have dimensions that exceed the actual point of contact of the cusp tip and at least equate with the size of the immediate side shift of the jaw joints. Since 1985, the author's clinical Pantronic* findings of immediate side shift showed readings 0-2.2mm, with many patients in the 0.1-0.3mm range, and most patients not exceeding 1.5mm.

The size of these centric platform stops should be slightly wider than the immediate side shift to allow for difficulty in accurately transferring occlusal records and fabricating crown cusp tips and centric stops with articulators. Oversizing of the centric stops allows for age-related mandibular repositioning. In practical terms, these centric platform stops should vary between 1-2mm in diameter depending upon the above factors (Fig 1). Because of their axial loading, these centric platform stops fully stabilise hinge occlusion by achieving a compressive and supporting force between opposing teeth.

The combination of the overjet of the buccal cusp of the upper posterior tooth and the overjet of the lingual cusp of the lower tooth and the centric platform stop design creates a protective occlusal freedom space (Fig 2). The design ensures incline-to-incline contacts don't occur in the short term, preventing mandibular deflection and possible concomitant TMJ and muscle strain. In the long term, with condyle repositioning and tooth movement, these large area centric platforms accommodate cusp tip relocation, often without incline interferences, allowing the development of a point centric at the reconstruction stage and at future occlusal adjustment aided by the T-Scan† computer occlusal analyser.

The centric platform design varies slightly from Dr Clayton's centric stop[17] and, as no proprioceptive holding contact is made, the cusp tip is not short and blunt and the flat area never small (a larger area is chosen to match the immediate side shift and the practicality of occlusal table fabrication). This platform design is not associated with a long or wide centric concept but rather a point centric in the central region of a circular flat platform.

*Pantronic Denar, Anaheim, US.

†T-Scan. Tekscan Inc, Boston, US.

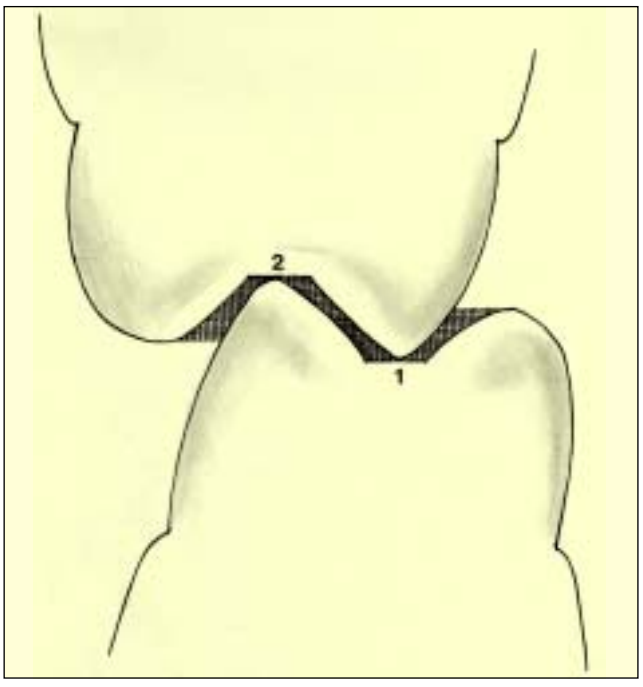


Fig 2. A longitudinal section of molars illustrating centric platform stops (1 and 2), generous overbite and overjet bucally and lingually to create an occlusal freedom space (hatchet area) devoid of incline-to-incline contacts.

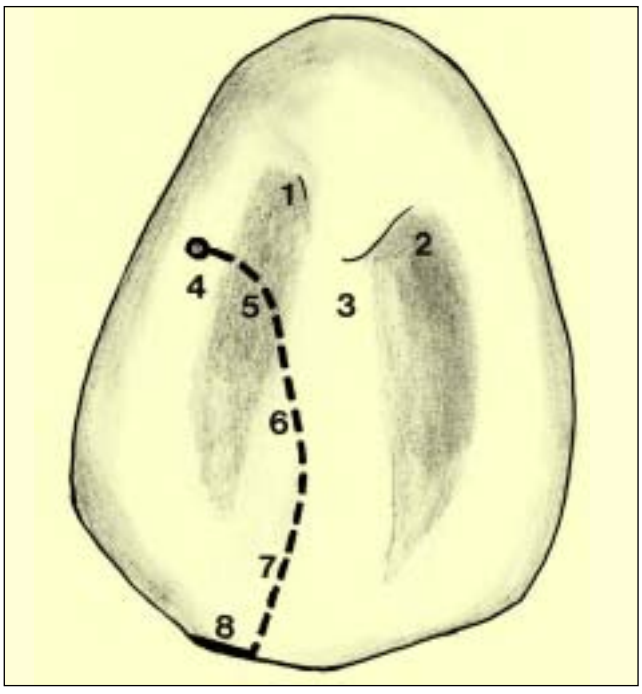


Fig 3. A palatal view of an upper canine illustrating palatal fossa (1 and 2), median palatal ridge (3), centric stop (4), early canine rise path (5), mid-canine rise path (6), final canine rise path (7) and canine rise landing pad (8).

In most cases, there should be a centric platform for each opposing supporting cusp. However, the palatal cusp of the upper first premolar may hang down a long way inferiorly to meet a lower first premolar platform. In this case, the platform could be lifted or alternatively only one contact per opposing teeth, as advocated by Wiskott and Belsen,[18] is acceptable.

The lower canines should have a well defined rounded cups tip and should hit where possible in a shallow concave platform on the mesial marginal ridge of the maxillary canine. This mesiodistal relationship of the opposing canines is an Angle's Class I relationship.

For an Angle's Class II Division 2 relationship, the incisal edge of the lower incisor teeth should contact the cingulum of the maxillary incisors on a flat ledge platform. However, except in open bite and extreme Class III cases, a light contact of the mandibular teeth on to a shallow concave platform on the palatal of the maxillary incisors is preferable. This light contact is either shimstock (approximately 11µm thick) free contact or a 25µm opening contact.[1] Either is acceptable as it is the posterior teeth that should take the bulk of the oral forces in hinge occlusion.

In anterior open bite and Class III cases, where possible and necessary, anterior contact should be established. Anterior contact can be achieved using a combination of treatment modalities such as orthodontic, osteotomy, resin overlaying, crowns or radical occlusal adjustment for open bite cases.[19]

Lateral occlusion

An ideal lateral occlusal scheme is one that directs and supports the mandible during 4-6mm or more

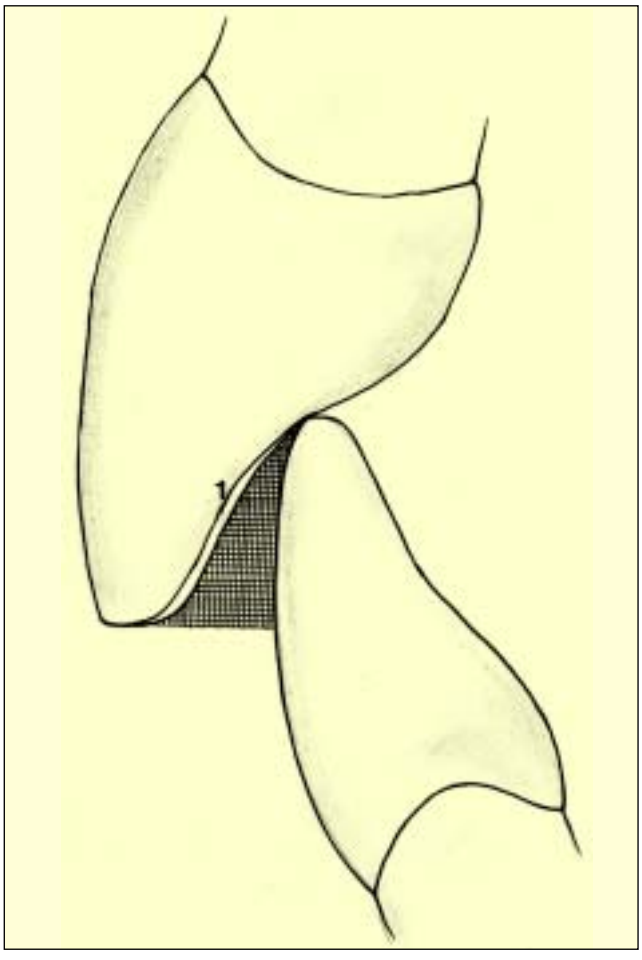


Fig 4. A longitudinal view of the central incisors illustrating a raised protrusive ramp (1) 0.1-0.2mm above the palatal fossa. An occlusal freedom space (hatched area) created by an approximately 3mm overbite and 2mm of overjet.

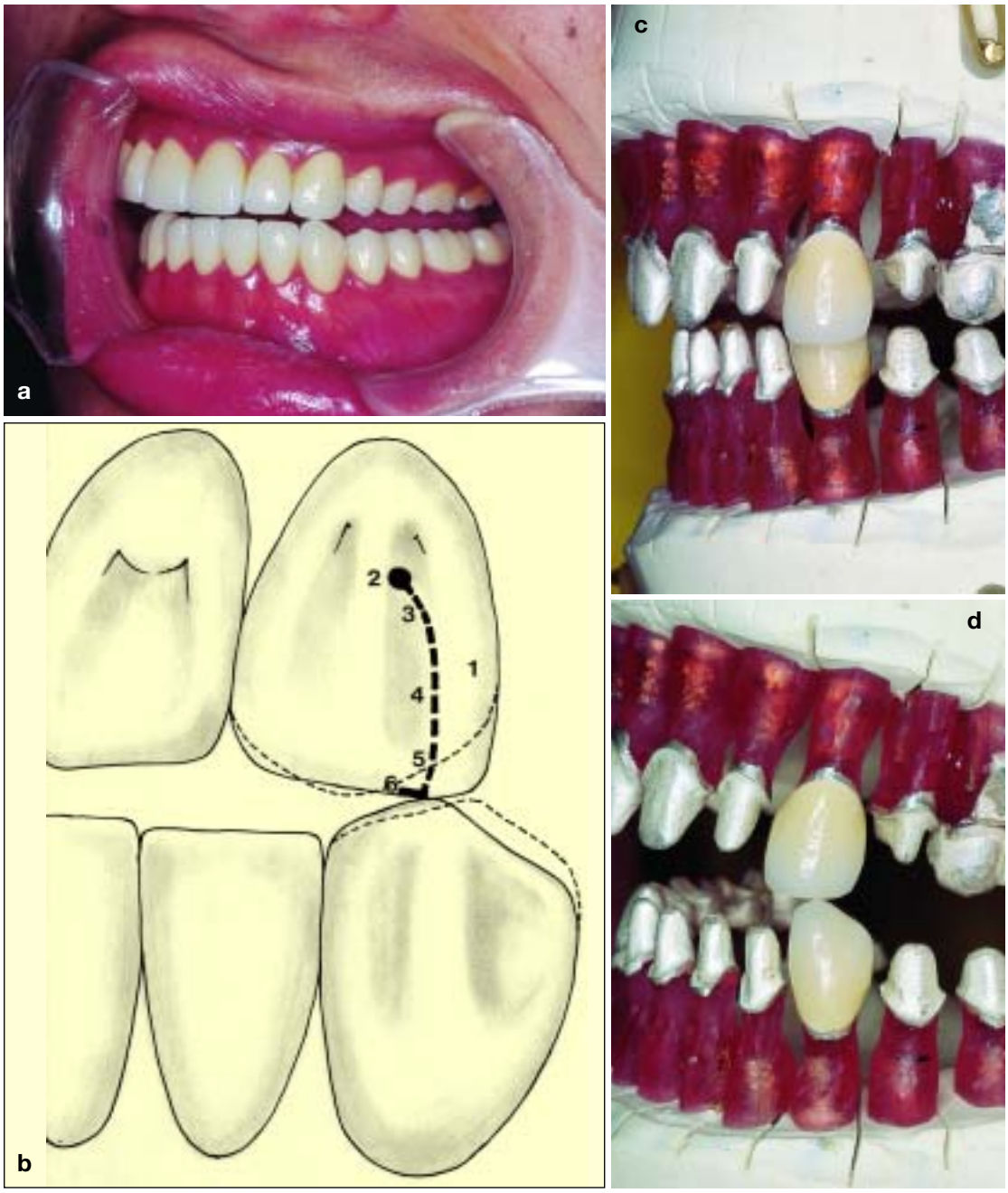


Fig 5a. A buccal view of edge-to-edge lateral occlusion, illustrating a fully protective occlusion indicated by a 1mm gap between lateral incisorsand an approximate 2.75mm gap between the mesiobuccal cusps of the first molars.

Fig 5b. A labial view of the canines illustrating the outline of the canines in an Angle's Class II relationship at edge-to-edge lateral occlusion. Normal tooth anatomy (thin broken line) and restorative anatomy (continuous line) required to create a fully protective canine rise path (thick broken line). The canine rise ridge (1) is present at the distal marginal ridge region. The canine rise path starts at the centric stop (2), early canine rise path with lateral motion (3), mid-canine rise path with vertical motion (4), late canine rise path with a slight anterior motion (5) ending at a canine rise landing pad (6).

Fig 5c. A labial view of canines showing an Angle's Class II canine relationship.

Fig 5d. A labial view of canines illustrating a bio-designed occlusal scheme with the lower cusp mesially positioned and the upper cusp flatter and more distally positioned. The result is a fully protective canine rise path.

lateral movement. Full support should be afforded to the contralateral condyle-disc assembly during its path from the fossa toward the articular eminentia. Generally, full occlusal protection is afforded by the canine teeth or the existing tooth found at the corner of each arch.

The overbite between opposing canines causes a restriction in the amount of horizonto-lateral forces that can be generated during lateral mandibular movement. Specifically, the lower canine scribes a path on the palatal surface of the upper canine in such a manner as to direct the mandible laterally, then downward and finally slightly forward. The downward and forward component is governed by the size, position and angulation of the median palatal ridge on the palatal surface of the maxillary canine (Fig 3).

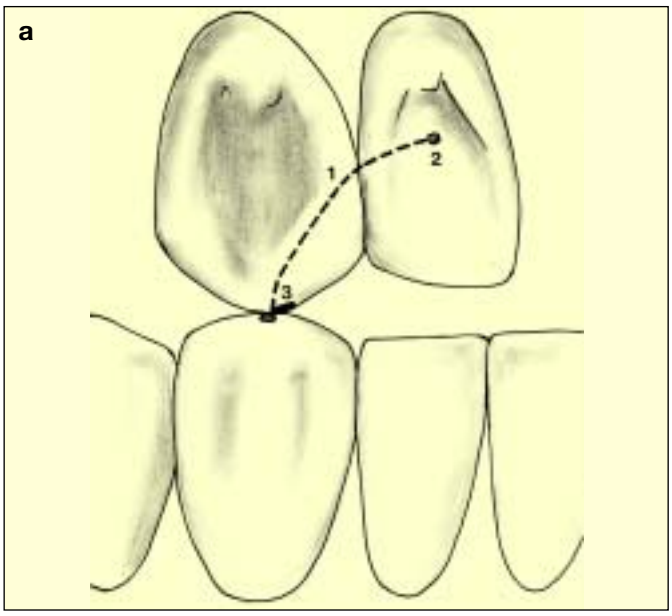


Fig 6a. A palatal view of an Angle's Class III relationship at edge-to-edge lateral occlusion. The mesial marginal ridge (1) of the upper canine is designed steep and acts as a canine rise ridge to create a fully protective canine rise path (broken line) from the centric stop (2) to canine rise landing pad (3).

Fig 6b. A palatal view of the centric stop on a plaster model of an upper lateral incisor in Class III relationship. The bio-designed mesial marginal ridge of an upper canine acting as a deflective canine ridge (red line).

Fig 6c. A labial view of the patient, plaster model illustrated in Fig 7b, at edge-to-edge fully protective lateral occlusion.

In an Angle's Class I relationship, the lower canine cusp tips occlude with the mesial marginal ridge of the upper canines. As the mandible moves laterally, the lower canine cusp moves laterally from the centric stop into the palatal fossa of the maxillary canine. When it reaches the median palatal ridge, the mandible is forced downward (mid-canine rise path) and then slightly anteriorly to the cusp (final canine rise path). It is this median palatal ridge that prevents the development of a pure horizonto-lateral (bovine-like) movement and possible concomitant strain in the contralateral TMJ and corresponding muscles of mastication. From an occlusal point of view, this deflective ridge can be called a canine rise ridge or a lateral occlusal guidance ridge (Fig 3) -– for a Class I canine relationship, the tip of the lower canine and the restrictive anatomy of the median palatal ridge are the key elements in a fully protective lateral occlusion.

The lower canine cusp also has key elements in its spatial relationship with the maxillary canine – the lower canine should have a rounded cusp (both mesiodistally and labiolingually) and overjet of 2-3mm and an overbite of 3mm or more with the upper canine tooth. Similar dimensions are desirable for central incisors (Fig 4).

These dimensions result in a desirable intra-tooth or occlusal freedom space (Fig 4) which allows a canine and protrusive rise path that is neither too steep nor too shallow. If the rise path is too steep, the labial surface of the lower canine will bind in any small excursive movement with the palatal surface of the upper canine. This binding contact can become an interference for parafunctioning. If the rise path is too shallow (for example, a 6mm overjet), a restriction in the amount of horizonto-lateral mandibular movement is difficult to attain. On average, the height of the lower canine cusp should be 1.5mm above an ideal lower incisal plane. The preceding dimensions of overbite, overjet and cusp height are essential in the creation of a long canine rise path of 4mm or more and a fully protective lateral occlusion (the contralateral condyle/disc assembly is mechanically supported by the canines as it translates along this path from the fossa toward the articular eminentia).

The ideal upper canine rise path has a characteristic shape from the centric stop to the canine cusp tip landing pad (Fig 3). The upper canine landing pad is a 'restorative flat' placed on the cusp tip and is angled very slightly mesial to create an anterior vector of mandibular movement (Fig 3). The landing pad should end at least 4mm from the centric stop and should equate with a clinical end point called edge-to-edge canine rise. Movement past this landing pad is called mandibular crossover. A fully protective occlusal scheme cannot be designed in the mandibular crossover position, hence the requirement for a long canine rise path of 4mm or more.

When the lower canine of a fully protected lateral occlusal scheme stops at the upper canine landing pad,

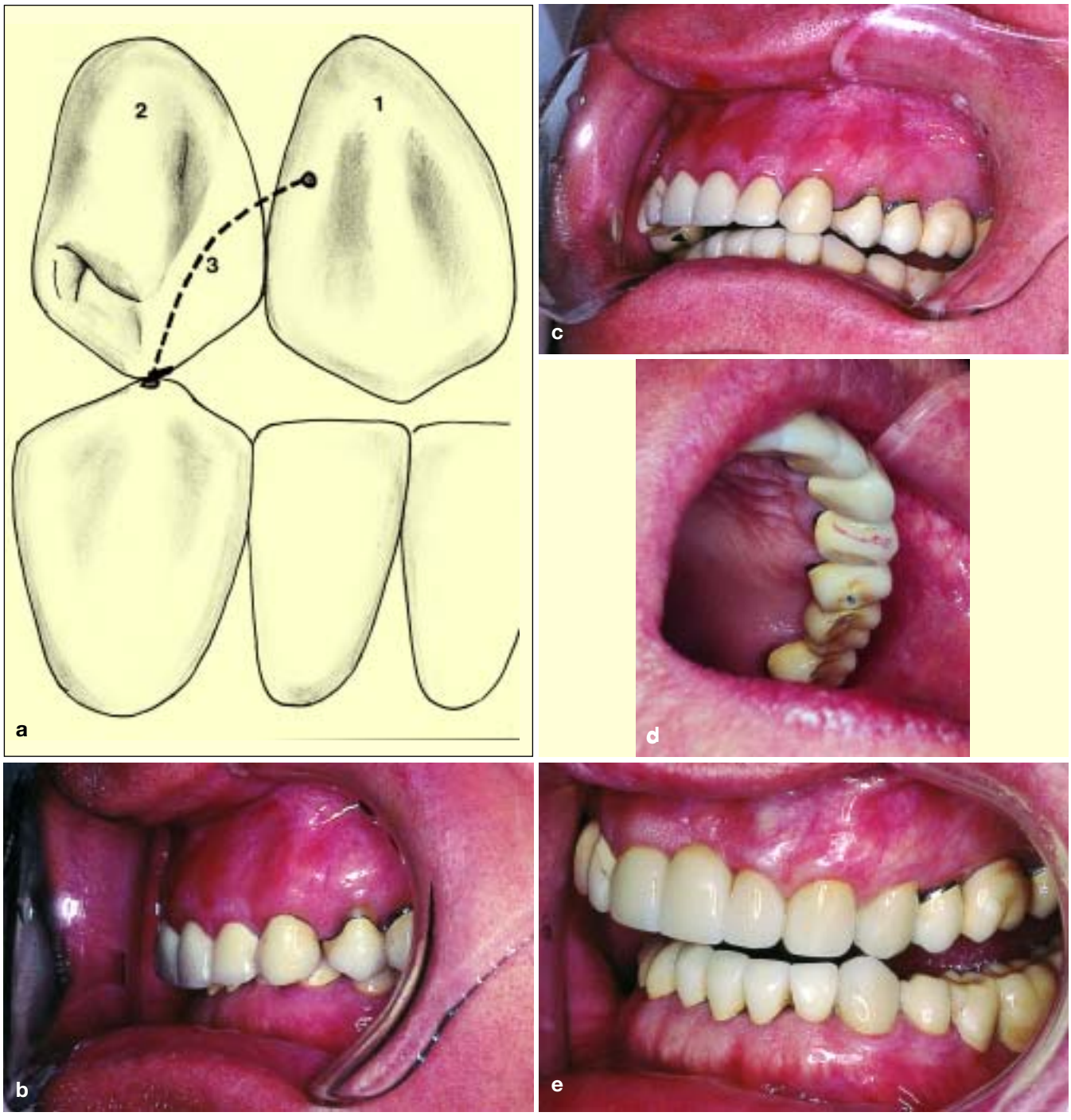


Fig 7a. A palatal view of an upper canine (1) and a canine look-alike crown (2) on a first premolar. The lower canine is in an Angle's Class II relationship at edge-to-edge lateral occlusion. However, aided by a canine look-alike crown (2) for the first premolar, a fully protective canine rise path (3) has been created.

Fig 7b. A labial view illustrating a Class II relationship of 33 between 23 and 24.

Fig 7c. A pre-treatment labial view of 32 guiding along 23, producing a horizontal-lateral movement with gross contra-lateral non-working side interferences and lateral crossover (not shown) on a vertical root fractured 21 crown.

Fig 7d. An occlusal view of 24 showing a canine look-alike crown with canine rise ridge (red line).

Fig 7e. A facial view of a new 33 crown at edge-to-edge fully protective lateral occlusion with a canine look-alike crown 24. This produced a vertico-lateral mandibular movement and was a necessary occlusal scheme prior to the placement of bridge 11, 21, 22.

there will be disclusion of upper and lower lateral incisors by 1mm or more and first molars by 2.5mm or more, measured between buccal cusps (usually the mesiobuccal cusps) (Fig 5a). This amount of disclusion is another clinical indication of a fully protective lateral occlusion. Conversely, contact of lateral incisors and/or first molars is an indication of an unprotected occlusal scheme. Clinical assessment of the loss of protection can be gauged by a decrease in these parameters.

Angle's Class II canine relationships involve the lower canine positioned directly above and opposite to the upper canine. The resultant canine rise may be protective

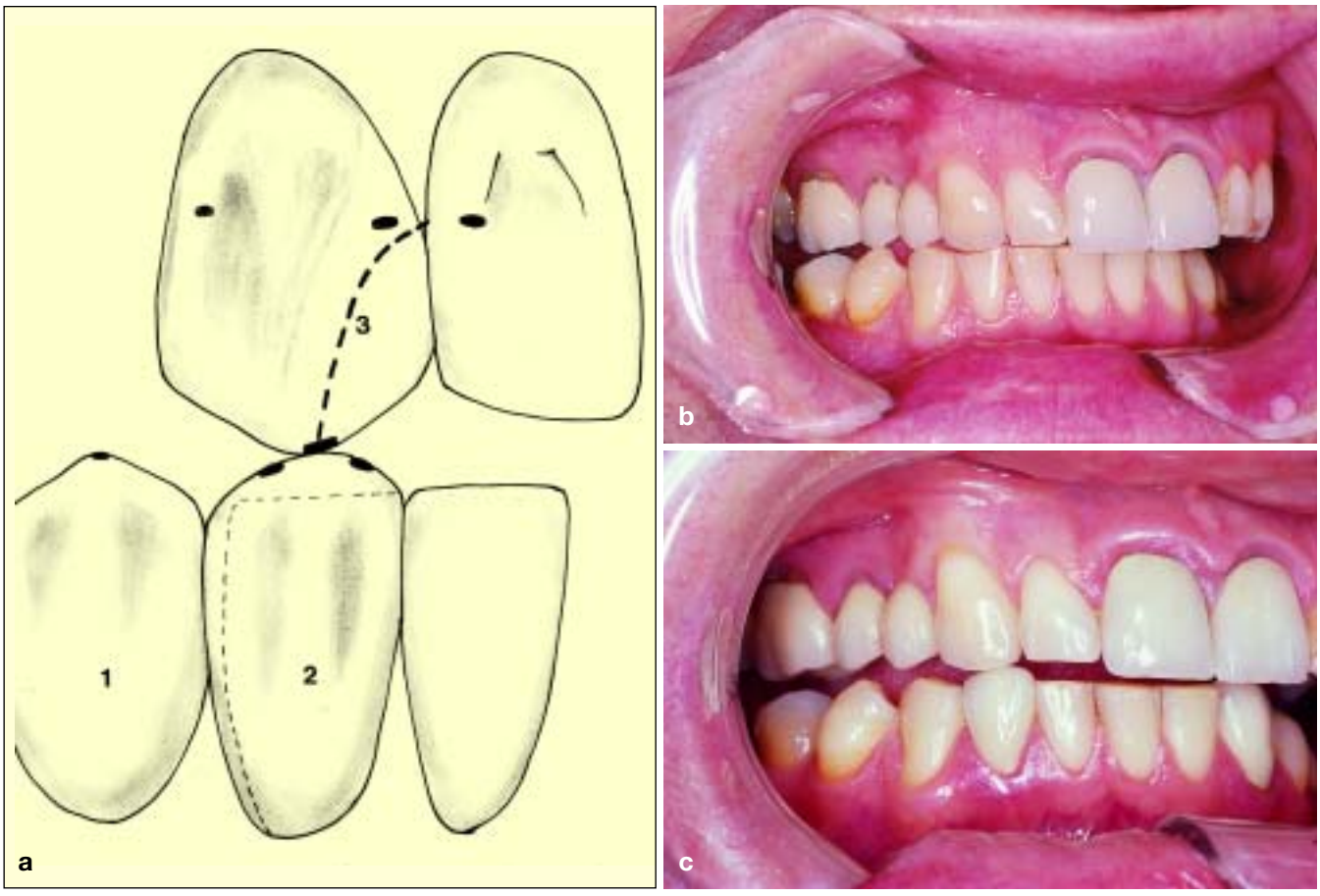


Fig 8a. A labial view of a lower canine (1) and a canine look-alike crown (2) on a lower lateral incisor (thin broken line). The lower canine (1) is in an Angle's Class II relationship at edge-to-edge lateral occlusion. However, aided by a canine look-alike crown (2) for the lateral incisor, a fully protective canine rise path (3) has been created on the palatal surface of the upper lateral incisor and canine.

Fig 8b. A facial view of a group function, a horizontal-lateral mandibular movement and premature tooth wear.

Fig 8c. A facial view of a canine look-alike crown on 42 in a fully protective edge-to-edge lateral occlusion with 13.

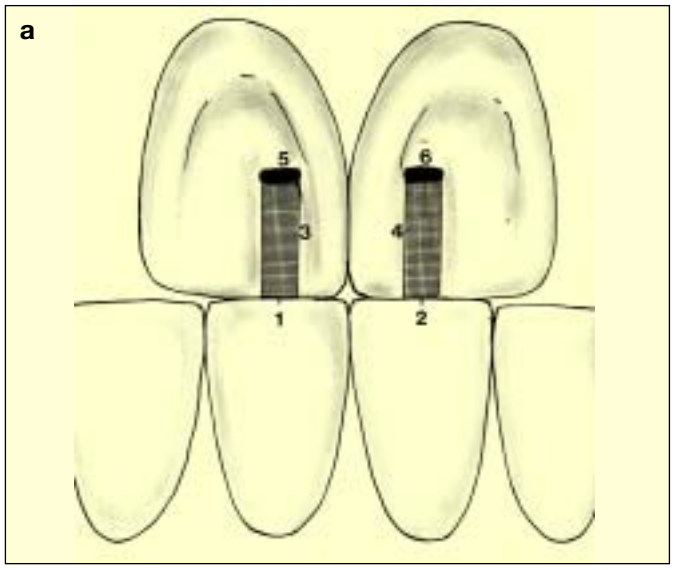
in early mandibular movements but during the midway and final excursive movement the lower canine slides over the median palatal ridge of the upper canine and skids horizonto-laterally (bovine-like jaw movement) into the occlusal embrasure space between the upper canine and first premolar. Such a chronic horizonto-lateral movement is often responsible, in part, for antero-medial displacement of the contralateral TMJ disc.

A fully protective occlusal scheme for a Class II canine relationship can be created by altering the restorative tooth anatomy in a mesiodistal direction (Fig 5). The lower canine cusp is positioned more mesially and lingually and more spheroidal labio-lingually and mesiodistally and the distal fossa on the labial surface is widened mesiodistally and deepened to prevent an incline-to-incline contact forming with the canine rise ridge of the upper canine.

The medial palatal ridge of the upper canine is placed more distal and occupies the space of the distal marginal ridge. The distal incline of the upper canine cusp is built flat so as to distalise the upper canine landing pad (Fig 5), resulting in a fully protective occlusal scheme. The term used for this transformation from a Class II canine relationship is a 'psuedo-Class I restorative canine rise'.

In an Angle's Class III canine relationship, with positive overjet, where the lower canine is positioned directly opposite the upper lateral incisor, the resultant canine rise may be protective in early mandibular movement. During midway and final excursive movements, it is often not protective and will depend upon the rotational position of the upper canine tooth. If it is unprotected, redesign of the two canines may be necessary. Make the lower canine cusp a little shorter, 1mm above the lower incisal plane, and the cusp tip flatter (more like an incisor) but with very rounded incisal corners. Build the mesiopalatal wall of the upper canine to form a vertical ridge 1.5-2.5mm high to allow mechanical deflection of the mandible in a vertico-lateral direction during the remaining excursion to the landing pad. In essence, this ridge is a median palatal ridge that has been located on the mesial marginal ridge (Fig 6).

Creating a fully protective occlusal scheme when the lower canine occludes between the upper canine and upper first premolar involves redesign of the mesial half of the occlusal surface of the first premolar. The tooth must be shaped to remove the palatal cusp and develop a median palatal ridge similar to an upper canine and the buccal surface shaped to look like a canine, with a canine rise landing pad on the buccal cusp. When a



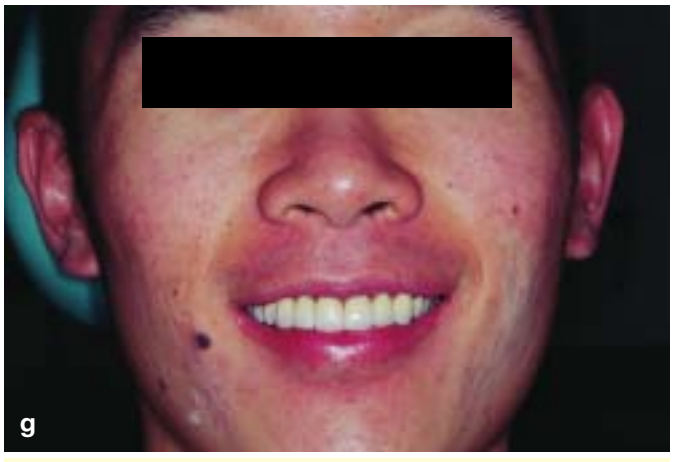


Fig 9a. A palatal view of the central incisors in edge-to-edge protrusion. The midpoints (1 and 2) of the lower central incisors align with the protrusive ramps (3 and 4) which are 1-1.5mm wide mesiodistally andcentric stops (5 and 6).

Fig 9b. A labial view of an ideal lower anterior plane. The canines are 1.5mm above the incisors and the central incisors are 0.25mm above the lateral incisors to allow for a fully protective protrusive path and thickness for protrusive equilibration.

Fig 9c. A palatal view of the mutually protective occlusal scheme. Protrusive ramp (red lines) on the centrals and canine rise ridges (red lines) on the canines have created a fully protective anterior guidance.

Fig 9d. Anterior view of a fully protective edge-to-edge protrusive rise path.

Fig 9e. An occlusal view of a lower Procera occlusal reconstruction illustrating centric platform stops and spheroidal supporting cusps.

Fig 9f. An anterior view of a completed full mouth occlusal reconstruction with full occlusal protection.

crown is made in this shape, it is termed a 'canine look-alike crown' (Fig 7).

To create a fully protective occlusal scheme when the lower lateral incisor occludes between the upper canine and lateral incisor, the lower lateral incisor should be redesigned. A cusp approximately 1.25mm above the incisal plane should be added and the contour of the labial surface changed to look like a canine. Adding a cusp will involve allowing space or spot grinding the mesiopalatal of the upper canine and distopalatal of the upper lateral incisor to fit the canine look-alike tooth (Fig 8).

Protrusive occlusion

As the mandible translates forward, each condyle/disc assembly should ideally move forward in unison, with no unilateral mandibular deviation. This sagittal movement of the mandible is normally guided by bilateral support from the incisors. The central incisors are usually the most anterior teeth and hence mechanically most supportive for protective guidance in protrusion.

The ideal anatomy of the lower anterior plane is for the canine cusp to be 1.5mm above the lower incisor plane. The lower canine should be 1.5mm above the lower first premolar buccal cusp and 2-2.5mm above the lower second premolar buccal cusp, resulting in the lower incisal plane being slightly taller than the premolar plane for aesthetic prominence of the anterior teeth. The lower central incisors should be a fraction taller (about 0.25mm) than the lower lateral incisors to predominate in the protrusive path and to allow for some occlusal equilibration. These anterior teeth should make contact with the upper teeth and an intra-tooth freedom space is required (Fig 4).

The restrictive anatomy necessary for the creation of an uninterrupted fully protective protrusive path is by use of (0.1-0.2mm thick) protrusive ramps, slightly raised above the palatal surface of the upper central incisors (Fig 4). These 1-1.5mm wide ramps start at the centric stop and end at the incisal edge. The ramps on the upper central incisors are aligned with the mesiodistal midpoint of the lower central incisors and are adjusted to bilaterally balance the protrusive path and allow for Bennett movement at the centric stop (Fig 9).

If the lower central incisor is missing, the two ramps are usually aligned with the two most laterally positioned incisors, not just the remaining central incisor, ensuring bilateral support by teeth 32 and 42 along with simultaneous guidance from the remaining central incisor. Once the ramps have been positioned, spot-grinding equilibration will create a fully protective protrusive occlusal scheme and allow for a stable unidirectional sagittal movement of mandible and condyle/disc assemblies.

In anterior open bite cases, a protective protrusive path can be created by utilising inclines of the premolars and canines that make contact to produce bilateral support during the full range of protrusion.

In anterior, premolar and first molar open bite cases, a protective protrusive path can be created by placing a protrusive ramp on the oblique ridge of each upper and second molar. The distobuccal cusp of each lower second molar can then be used to track along a corresponding protrusive ramp. As the mandible moves sagitally forward, the buccal guiding cusps will track from the centric platforms along the protrusive ramps until the incisors meet.

Discussion

In the last 14 years, the implementation of the full occlusal protection theory in occlusal therapy has helped resolve the symptoms of TMJ patients with displaced clicking discs and has significantly helped manage bruxers so that often only the canine crowns undergo premature wear. Full occlusal protection has helped increase the longevity of complex crown and bridgework and protect against the unnecessary fracture and dislodgement found in previous restorative work.

The author is aware many clinicians are of the belief that a functional envelope of masticatory function is within a 3mm range of excursive movements from centric relation. However, Hildebrand[20] described large variations in the size of the chewing stroke, ranging from 2-10mm. The full protection regime advocates a fully protective path of a minimum of 4mm and often 5-6mm. This protective path is necessary to accept not only the functional range of movement, but the more destructive range of movements in bruxists.[21-23] However, as extreme protrusion of a large lower jaw is not common, some Angle's Class III occlusal schemes are fully protective with only a 3mm long excursive path.

Horizonto-lateral mandibular movement is highly destructive to TMJs, muscles of mastication, teeth and prostheses stress these structures in different ways. In engineering terms, loading a structure such as a china plate or a glass with a horizonto-lateral force will result in gross tensile fracture of the structure.

Group function[24] in lateral occlusion with concomitant horizonto-lateral forces results in group destruction when the tensile forces exceed the fatigue limit of the structures involved. The cracked tooth pain syndrome is often a direct result of this fatigue process.

The full occlusal protective regime includes a range of measurements for tooth position found in a fully protective occlusal scheme. This range of measurement is similar in principle to that given for a denture setup taught in a dental school and is necessary as a guide for dentists and technicians in occlusal reconstruction cases.

The everyday clinical occurrence of non-Class I occlusal schemes has heralded the need to modify tooth anatomy by biodesigning crown shapes to create fully protective occlusal schemes. Many clinicians and technicians have reproduced precise tooth anatomy and created mediocre occlusal schemes with destructive consequences, resulting in confusion and misinterpretation of the theories of occlusion. This fully protective occlusal regime has bypassed the need for classic tooth

anatomy and moved occlusion into the arena of restorative anatomy which has predictable occlusal schemes and results.

The author and many clinicians believe in the mutual protective theory of occlusion,[1] a canine protected occlusion with mutual protection of incisors and posterior teeth – the canines and incisors protect each other in corresponding lateral and protrusive guidances. Collectively, they protect the posteriors in excursive movements whereas the posteriors protect the anteriors in hinge occlusion. Canine protection[25] is a form of mutually protected articulation in which the vertical and horizontal overlap of the canine teeth disengage the posterior teeth in the excursive movements of the mandible. However, the full occlusal protective theory takes the concepts further and in more detail. Canine rise should be thought to be more than the bumping of canines during lateral occlusion.[26] In the full occlusal protection theory, canine rise is a precise movement designed to prevent the development of horizonto-lateral destructive forces and allow only vertico-lateral motion of the mandible. It can be claimed if there is a protective canine rise there is no need to design wide centric stops. However, during retrusive parafunctioning, as a protective mechanism, patients can retrude their mandible posterior to hinge occlusion and render the canines ineffective. During this bruxism activity, destructive incline-to-incline interferences can be minimised if suitable size centric platforms are present.

The concept of occlusal schemes should be considered not only in terms of Angle's classification[16] but the degree of protective paths present in excursive movements. In clinical terms, occlusal examination should reveal anterior guidance to be fully protective or protective or no longer protective during a significant clinical range of mandibular movement. The health of TMJs and the muscles of mastication and longevity of natural teeth and prostheses should be evaluated against what mechanically destructive or protective force is present in hinge occlusion, lateral occlusion and protrusive occlusion.

Conclusion

The theory and practice of a fully protective occlusal scheme for varying Angle's malocclusions warrants discussion. While this paper has presented a number of clinical cases with biodesigned occlusal schemes to illustrate the theory of a fully protective occlusal scheme, future temporomandibular and occlusal research should determine what degree of protection is present before evaluating and comparing data.

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