Control factors in removable complete dentures: from the articulation quintet to kinetic contact

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Summary
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Hanau's laws and the so-called articulation quintet have contributed greatly to the evolution of the prosthetic dentistry and have been further elaborated by various authors. The main aim of this study was to establish the stability of prosthetic plates by attaining balanced occlusion. Several authors have addressed the problem of removable and fixed prostheses by classifying mandibular movements into functional and parafunctional movements which extends the classical occlusal mechanics for the modern occlusal feedback model. Moreover, they suggest the use of the angle of convergence as a reference plane when manufacturing prosthetic.

Key words: bruxism, occlusal guidance, occlusal plane, cuspal guidances.

Introduction

The adaptive capabilities of the patient are critical to the success of prosthetic therapy. Anochin and Agafonow interpreted the process of adaptation as a series of psychophysical events triggered by a stimulus that induces a behavioral response that serves the dual purpose of restoring the homeostatic conditions before the stimulus and maintaining them thereafter (8).
For the adaptive learning process, without which no behavior can be structured, it is essential to establish - through the maintenance of a neural engram - a "Gestalt" coordination of the various factors underlying the behavior. The initial neural response to a stimulus is the sensory function (3).
The body responds to various peripheral sensory inputs by inhibiting certain signs and amplifying others. During chewing cycles, an enormous amount of stimuli inform the various neural systems about the control and coordination of movement. The control system associated with the texture of the food adjusts the force developed by the elevator muscles of the mandible, and control system associated with the location of food and language avoids traumatic contact, regardless of the amount of olfactory and gustatory stimuli, the reflex control of saliva, and even the emotional component that creates the need for adaptation.
The movement of chewing requires a learning period during the various stages of eruption of the deciduous teeth and changes therein, after which the subject begins to make the first masticatory movements.
The masticatory function contributes to the proper development of the jaw and significantly affects the positions of the structures in the arch. The coordination of motor activity occurs at different times during masticatory movements, and in particular during the final stage of such movements when the arches come into contact during the antagonistic phase, maintaining contact until its return to normal occlusion; this process is called "contact kinetics" (4-9).
The learning of the motor pattern that characterizes chewing is structured based on the morphology of the occlusal plane (5, 10) - every change brings a new motor pattern to a new phase of adaptation and learning. An optimal prosthesis will ensure that the patient applies the lowest adaptation effort. The occlusal morphology of the prosthesis should be integrated as far as possible with the contact kinetics of the existing occlusion, with studies of the neuromuscular factors needing to assess the occlusal morphology (4, 5, 10).
One of the greatest contributions to understanding the anatomical factors that determine the characteristics of the behavior of the occlusal surfaces during contact was from the kinetics analysis of Hanau (1). Hanau's laws concerning articulation and Hanau's quintet have contributed greatly to dental prosthetics (2, 11), clarifying this heretofore confused area of dentistry by simplifying the construction of dentures (Fig. 1). Although Hanau was interested in gnathologic mechanics related to dentures, he considered that the articulator of artificial teeth was related to nine factors: (1) horizontal condylar inclination, (2) sagittal condylar path, (3) plane of orientation, (4) compensating curve, (5) buccolingual inclination of the tooth axis, (6) protrusive incisal guidance, (7) sagittal incisal guidance, (8) alignment of the teeth, and (9) cusp height.
Hanau mathematically traced the above 9 factors and listed the "laws of balanced articulation" as a series of 44 statements. He then reduced the original nine factors to five, showing how they affect one another using a clearer dia-

Annali di Stomatologia 2010; I (2): 14-19

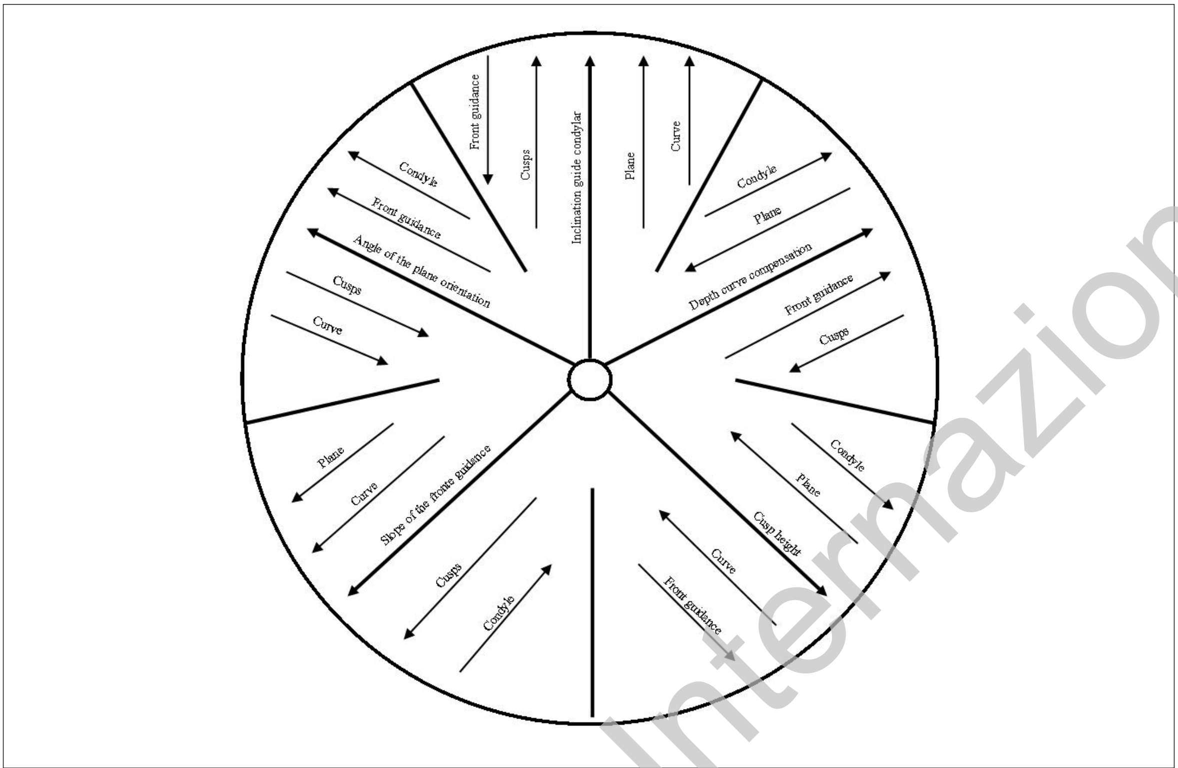

Fig. 1 - The Hanau quintet.

gram called the articulation quintet: (1) condylar guidance, (2) plane of orientation, (3) compensating curve, (4) incisal guidance, and (5) cusp height.

Hanau's laws of articulation and the quintet

The articulation quintet diagram illustrates the relationship between the above five factors, and it constituted the first step toward organizing occlusal factors when producing dentures.

The purpose of the present study was to achieve a balanced occlusion in which the occlusal relationships between antagonist arches are characterized by "balanced" contacts, which might contribute to the stability of inferior dentures during chewing.

The design and realization of a prosthesis with such characteristics required a tool that could restore the lost motion of chewing by ensuring contact between the antagonistic factors in the centric occlusion (a critical time for the stability of the prosthesis) due to the registration of some anatomical values (Eminence and Bennett-angle inclination) (12).

To this end, Hanau designed and constructed three articulators: "Hanau H2-'R", "Hanau 130-7" no-arcon type, and "Hanau XP-51" arcon type (Fig. 2). Contact balancing (B) on the nonworking side was needed to improve the stability of the lower dentures by mounting the teeth according to the Monson curve perpendicular to the crestal axe (A). It is possible for cusp inclination to affect the mastication, with the highest inclination inducing lower prosthesis malocclusion on the nonworking side (13-14).

Hanau and De Pietro showed that these articulators could be used to restore the occlusal kinetics relationship; that is, the way in which the mechanical occlusion acts in movements where there is contact between opposing arches (11). The articulator registrations serve to reproduce the protrusion and lateral movements such that the dental technician would only fit teeth and compensate for spaces resulting from malocclusion (as in the phenomenon of Christensen) and organize the elements of the quintet (plane of orientation, anterior guidance, cusp heights, and compensating curve) by Hanau's scheme.

Boucher concept

Boucher developed his own concepts and ideas following an analysis of the work of Trapozzano and Winter (15, 16, 17). Boucher disagreed with the concept introduced by those authors that the occlusal plane could be located at various heights to facilitate a weaker ridge, instead recommending that the occlusal plane could "be oriented exactly as it was when there were natural teeth". He considered this approach to be essential to complying with the anatomical and functional requirements.

Boucher, unlike Trapozzano and Winter, was convinced of the need for a compensation curve and declared: "The value of the compensation curve is that it allows an alteration of cusp height without changing the shape of the manufactured teeth…If the teeth themselves do not have cusps, the equivalence of cusps can be produced using a compensation curve". The concept of Boucher was based on the following fixed factors: the orientation of the occlusal plane, anterior guidance, condylar guidance, the angulation of the cusps, and the compensation curve; which can

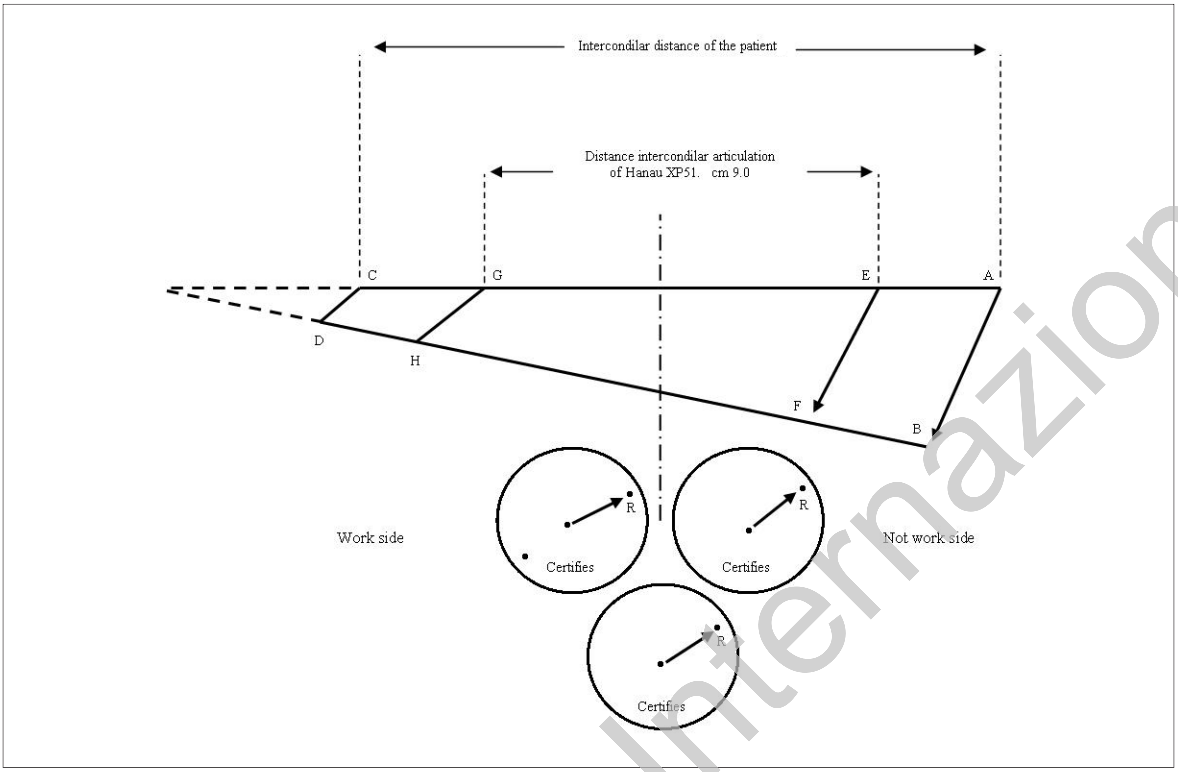

Fig. 2 - Geometric equivalence of the intercondylar distance on the XP-51 articulator for the registration of the Bennett corner.

allow the effective heights of the cusps to increase without changing the shape of the teeth (15).

Further evaluations of Hanau's work

The theory postulated by Hanau has been revised by many authors, each of whom has interpreted the five elements and their relationship with the aim of achieving a balanced occlusion in order to stabilize dentures during mastication. During the 1960s some authors attempted to simplify the theory by reducing the number of the occlusal elements. The "triad of occlusion" proposed by Trapozzano and Lazzari considering only three elements: protrusive incisal guidance, cusp height, and condylar guidance (18, 19, 20, 21) (Fig. 3). Levin proposed a diagram similar to that of Hanau that described relations between four of the five original elements that dominate the plane of orientation (7). Both Trapozzano and Levin realized the importance of a balanced occlusion, and their proposal was similar to that of Hanau (Tab. 4).

Lott (22) retained all the elements in the laws of Hanau but clarified the posterior separation and unbalanced occlusion, stating that increased inclination of the condylar guidance is associated with increased posterior malocclusion (Fig 5).

Lauritzen used mounted the artificial teeth using a technique that differed from that used by Hanau (1). Dorier debated the registration technique of the individual values in an edentulous patient through the vallum of wax on the "Hanau H2-XPR" articulator, such as the phases of the mounting teeth according to the quintet of Hanau to achieve balance according to Lauritzen (10).

Occlusal mechanics and parafunctional movements

Federici and collagues (4, 5, 6) interpreted the quintet and laws of Hanau based on both the construction and usage of removable prostheses, particular in parafunctional patients. Classifying mandibular movements into functional and parafunctional movements, these authors criticized those who applied only the laws of occlusal mechanics to functional movements, pointing out that kinetic contacts need to be included in a new occlusal feedback model. Only in parafunctional movements does kinetic contact occur between antagonist arches. The contact is traumatic because the elevator muscles are activated and exerting forces. Federici argued that eliminating the reflex inhibition is the first feature of parafunctional movements, and the muscular activity can generate forces greater than those produced when functioning. In contrast, any barrier (anterior guidance, cusp heights, compensation curve or Spee curve, or the Monson or Wilson curve) is capped by the action of the horizontal component of parafunctional loads.

Weinberg suggested using removable and fixed prostheses that distribute parafunctional loads between the involved elements (23, 24). During lateral movements they suggested using the group function instead of canine guidance in order to avoid contact on the nonworking side, and placing cusps of the lateroposterior areas in an "anti-Monson" configuration to increase the relation between the occlusal plane and the condylar path (which they referred to as the "angle of convergence") in order to increase the malocclusion in posterior areas and thereby avoid interference. Tsao solved the problem of balanced occlusion by suggesting the use of a plane rather than a spherical surface

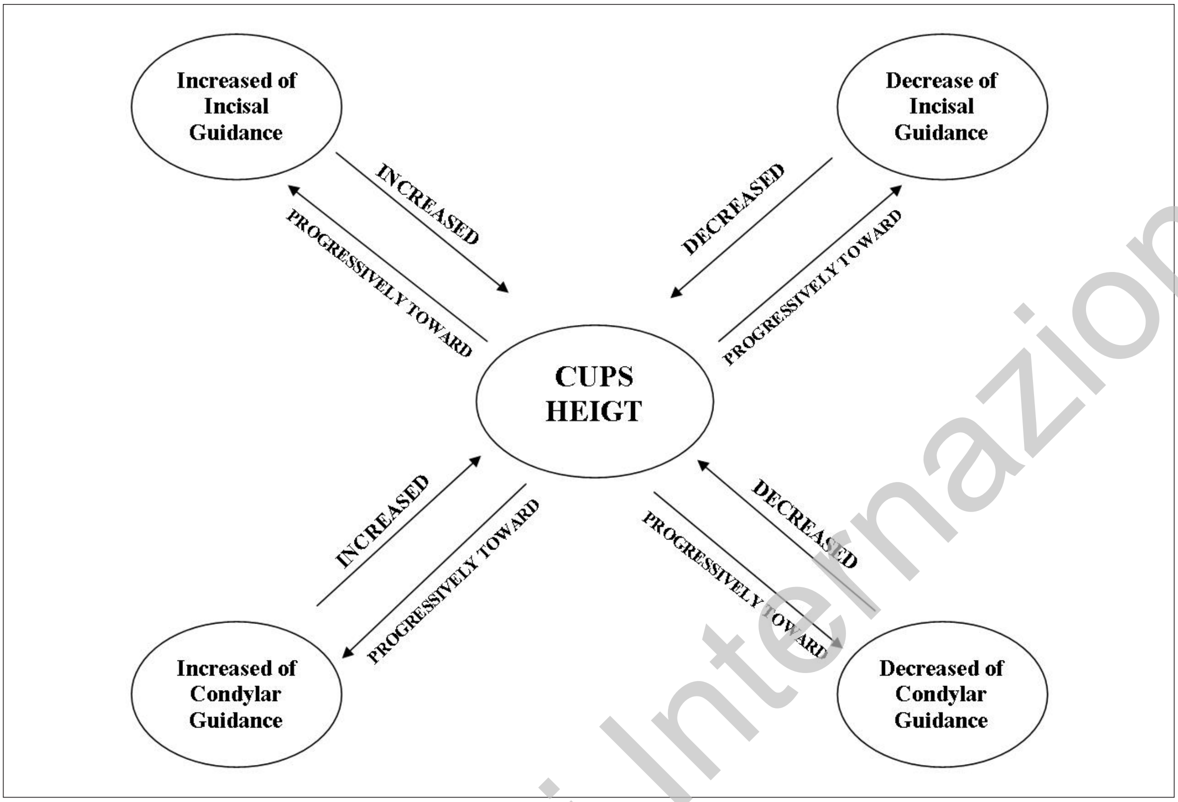

Fig. 3 - Trapozzano's triad of occlusion. IG: incisal guidance; CH: cusp height; CP: condylar path.

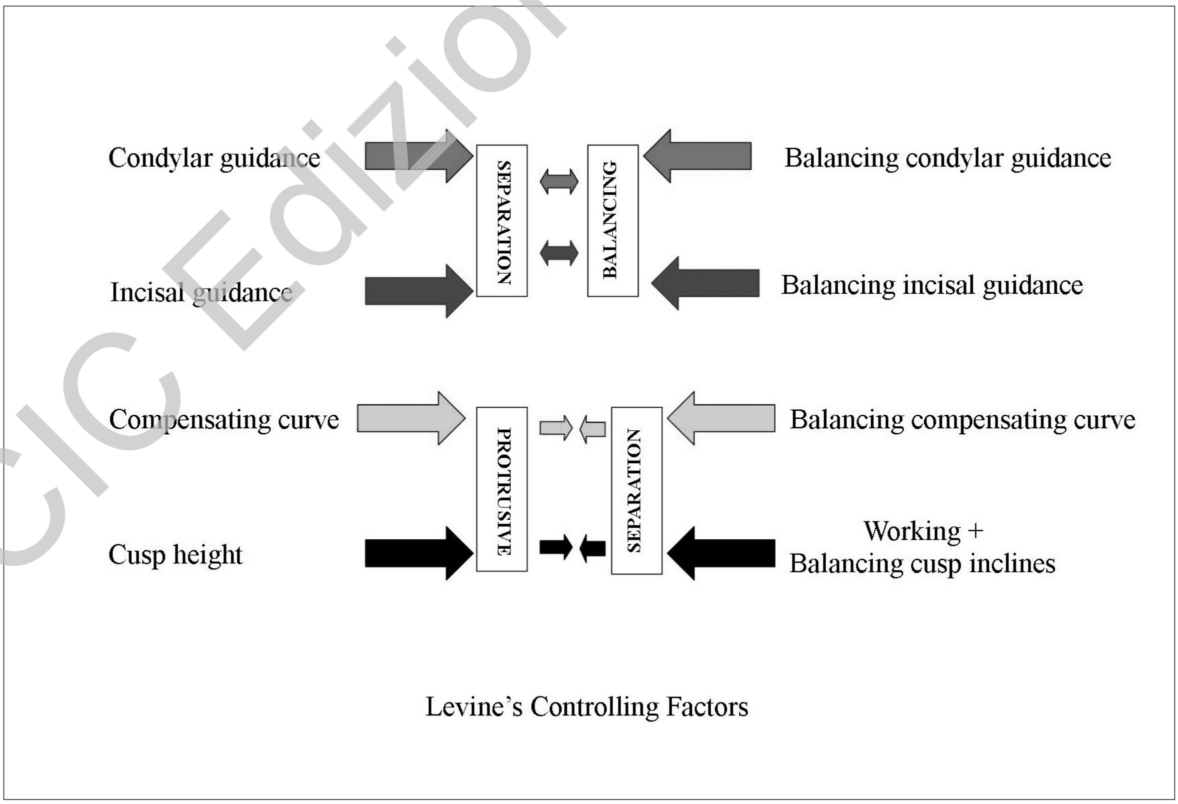

Fig. 4 - Balanced occlusion laws in the protrusive and lateral positions according to Levin.

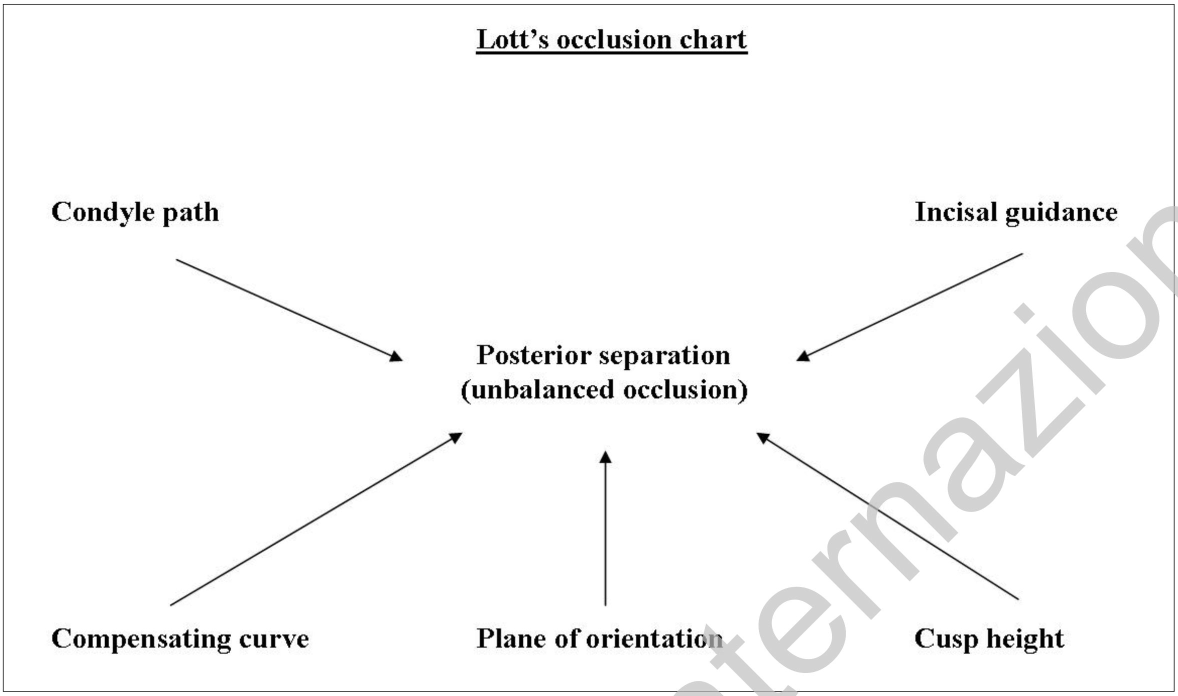

Table 5 - Lott's intuition about the importance of the malocclusion in posterior sectors.

for mounting the teeth in the lower denture (25). The frontal orientation plane of tooth cusps mounted by this method is perpendicular to the chewing forces rather than to the crestal axis according to the theory of classical balancing. Chewing then exerts forces predominantly on the lower denture, promoting stability, and away from the top denture whose stability is guaranteed by a thin layer of saliva.

Federici considered that balancing the contact on the nonworking side would improve the stability of the lower denture, since the presence of food during chewing prevents contact during the nonworking phase.

The convergence angle

The existence of a kinetic contact between opposing arches necessitates a study of the mechanical occlusion in order to produce a model that would allow the operation of the neuromuscular system to be predicted in particular situations (26). Without parafunctional movements, this study would be superfluous and the use of articulator would be unnecessary.

The actions of the top and inferior planes during protrusive sliding is determined by the total denture, primarily in the sagittal plane (without considering anterior guidance, the heights of the cusps, or the curve of compensation), according to Christensen's phenomenon (27, 28). Dorier described it as follows: "When the mandible is in protrusive position, while maintaining contact between the bases of the joint, forming a space between occlusal waxes in the posterior area while anterior area is continuous in contact. This space and the distance of protrusion are necessary to measure the angle formed by the condylar path inclination with respect to the occlusal plane" (10). Federici mentioned the "convergence angle", and argued that the space formed in the posterior areas depends on this angle during protrusive and sagittal movements, when the antagonist arches are in contact.

The results of this study can be summarized as follows:

1. During the individual value registration on the articulator, the Frankfort plane is replaced by the occlusal plane.
2. The condylar inclination is recorded on the occlusal plane rather than on the Frankfurt plane, via the angle of convergence of the patient.
3. In a total or partial denture, the occlusal plane must be inclined so as to increase the malocclusion in posterior areas, without considering the occlusal plane oriented parallel to the Camper plane.
4. Since parafunctional movements can involve totally or partially edentulous subjects, ensuring the correct connection between the occlusal plane and the condyle is also important in orthodontic treatment (Fig. 6).

Conclusion

Separating mandibular movements into functional and parafunctional movements represented a turning point in gnathologic studies from both theoretical and practical viewpoints. Considering only kinetic contacts during parafunctional movements is justified by the removal of the inhibitory reflex.

Practically all dental prostheses must be functionally and parafunctionally corrected on the articulator (the elimination of occlusal interferences). Therefore, the concept of applying gnathologic mechanics to the function (research of balanced occlusion and the terminal condylar axis) is obsolete. With their theory of occlusal feedback, Federici and colleagues have aligned dentistry with the underlying neurophysiology.

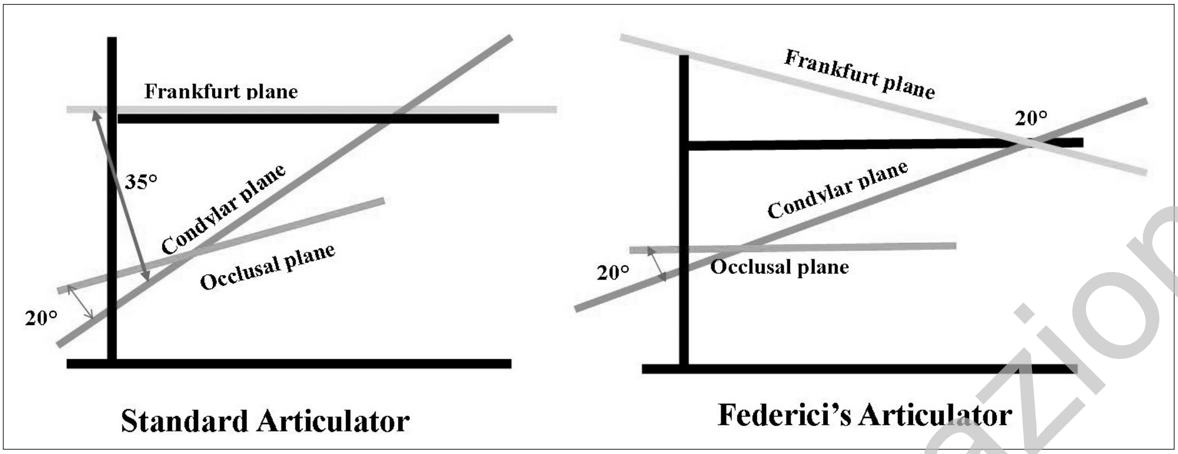

Fig. 6 - The use of Federici's articulator demonstrate the value of convergence angle necessary for Cristensen phenomenon.

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