

Kinesiographic analysis of lateral excursive movement on the horizontal plane: the retrusive component

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How to cite this article:

Papini A, Cesaretti G, De Fabianis P. Kinesiographic analysis of lateral excursive movement on the horizontal plane: the retrusive component. *J Oral Science Rehabilitation*. 2017 Mar;3(1):60–7.

Abstract

Objective

The temporomandibular joint (TMJ) has a functionally complex articulation that during phylogeny underwent an adaptation also linked to posture change after the acquisition of upright posture and subsequent reduction of the postglenoid process. This articulation supports numerous functions of the stomatognathic apparatus, and the part physiologically designed to withstand greater loads associated with mastication is essentially the frontal one; the rear portion of the TMJ is unfit to absorb retrusive forces owing to the poor support of the thin bone component and the histological characteristics of the tissue component. The purpose of this article was to analyze the angles of lateral tracings both on the frontal plane and on the horizontal one through kinesiographic analysis (functional masticatory angle of Planas and functional horizontal masticatory angle) in seeking to observe their mutual relations with respect to those planes.

Materials and methods

The study was performed on 115 patients who presented with asymmetrical laterality movements. The sample was made up of 32 males and 85 females aged between 17 and 84.

Results

Ninety-eight (85%) of the lateral tracings examined showed a consistency between the inclination of the tracings on the frontal and horizontal planes. Seventeen (15%) showed an inconsistency between the inclination of the tracings on the horizontal and frontal planes.

Conclusion

The study found a correspondence on the working side between a steep laterality on the frontal plane and a posterior trajectory on the horizontal plane. The reduction of the steepness of the functional masticatory angle of Planas tends to reduce the posteriorization of the functional horizontal masticatory angle, promoting the recovery of alternating unilateral masticatory function.

Keywords

Temporomandibular joint (TMJ), Gothic arch, functional masticatory angle of Planas (AFMP), functional horizontal masticatory angle (AFMO), masticatory cycle, lateral retrusion Posselt volume.

Introduction

The phylogenetic evolution has produced a number of postural changes related to the attainment of the upright position, and the TMJ, in its relationship to the tympanic cavity, has undergone a transformation. In fact, while both in anthropomorphic and in nonanthropomorphic monkeys, the rear portion of the TMJ is bounded posteriorly by the postglenoid process¹—a bony protuberance of marked thickness that delimits and separates the mandibular fossa from the tympanic cavity²—in *Homo sapiens*, this process has had a progressive thinning, ending in a factual disappearance. Therefore, in modern man, the rear wall of the mandibular fossa forms the front wall of the tympanic cavity. It is a thin layer, crossed by a canal (named Huguier's or Civinini's canal, after the researcher who first described it) that connects the two structures.^{3, 4} The soft-tissue that makes up the retrodiscal portion of the TMJ is histologically unfit to withstand compressive forces, as the retrodiscal portion of the TMJ, richly vascularized and innervated,⁵ essentially acts as a hydrodynamic support. It is worth considering that some of the connective fibers of the retrodiscal tissue penetrate the Huguier's canal,⁶ forming the discomalleolar ligament and reaching the tympanic cavity, attaching to the malleus head and neck. In summary, these characteristics make the posterior region of the TMJ unsuitable for bearing the functional loads of mastication and swallowing, since, under optimum conditions, the condyle should never cause excessive compression of retrodiscal tissue. In fact, prolonged and constant compressive stress, linked for instance to dysfunctional situations, determines stresses that tend over time to result in reparative fibrotic processes,^{7, 8} leading to structural changes^{9, 10} responsible for a different biomechanical response of the tissue.

The study of mandibular movement on the horizontal plane is associated with the interincisal point movement. Gysi in his records¹¹ was the first to describe the Gothic arch: In classic gnathology the lateral tracings on the horizontal plane are described as an anterolateral shift. Symmetrical on both sides, the lateral tracings on the frontal plane are usually described as an anterolateral development. In patients with dysfunction, kinesiographs show as a norm a deformation of the Gothic arch: One of the two lateral tracings tends to lose the anterolateral direction to acquire a tendency to posteriorization (**Fig. 1**). Guichet has described a 60° conic

volume in which the working condyle can shift during the lateral excursion.¹² The interincisal point used in the recording of the Gothic arch can be placed geometrically in relation to the condyles.^{13, 14} Mongini has described in the position of maximum intercuspatation the relationships between the interincisal point and the position of the condyles.¹⁵

Through the aid of a kinesiograph during lateral excursion, the tracing of the interincisal point on the horizontal plane can be placed in relation to the movement of the working condyle: during lateral excursion, the balancing condyle always shifts in the anteromedial direction, while the working condyle can move both in the anterolateral direction and in the posterolateral one. The interincisal point will have the same tendency of the working condyle movement (**Fig. 2**). The Gothic arch, which highlights the excursive interincisal movements of the point on the horizontal plane, can be considered a horizontal section of a volume defined by Posselt with the trajectories of maximum movements of opening, laterality and protrusion.¹⁶ The volume of Posselt can be defined as a 3-D perimeter within which the jaw can achieve its functional movements.

In patients with dysfunction, an asymmetrical Gothic arch, altered and reduced in its developments, is practically the norm and must be interpreted as a planar representation of the deformation of the entire Posselt volume (**Fig. 3**). Alternating unilateral mastication allows better control of the food bolus and of the forces that develop during mastication; from a biomechanical point of view, it tends to symmetrically allocate the distribution of load on the dental, periodontal, bone, joint and muscle structures. This alternation of the masticatory cycles is permitted by the symmetry of the functional masticatory angles of Planas (AFMP, angles fonctionnels masticatoires de Planas). The AFMPs are the angles that are created on the frontal plane between the lateral distances and the horizontal plane, while the functional horizontal masticatory angles (AFMO) are those that are created on the horizontal plane between the lateral distances and the frontal plane (**Fig. 4**). In the presence of a retrusive AFMO, there will be a deformation of the Gothic arch structure (**Fig. 1**).

The purpose of this work was to analyze the angles of lateral tracings, seeking to observe the relation of coherence between the frontal plane and the horizontal plane (AFMP/AFMO). This consistency respects the correspondence

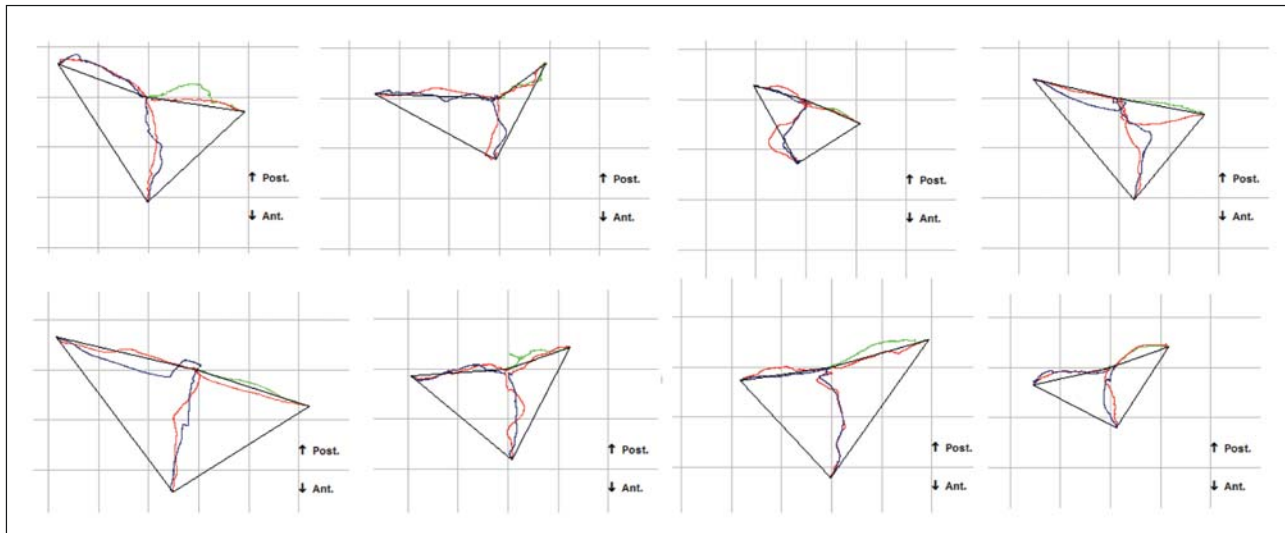


Fig. 1

Fig. 1
Kinesiographic tracings:
dysfunctional Gothic arches.

Fig. 2
Relation between the
interincisal point movement
and the working condyle
movement.

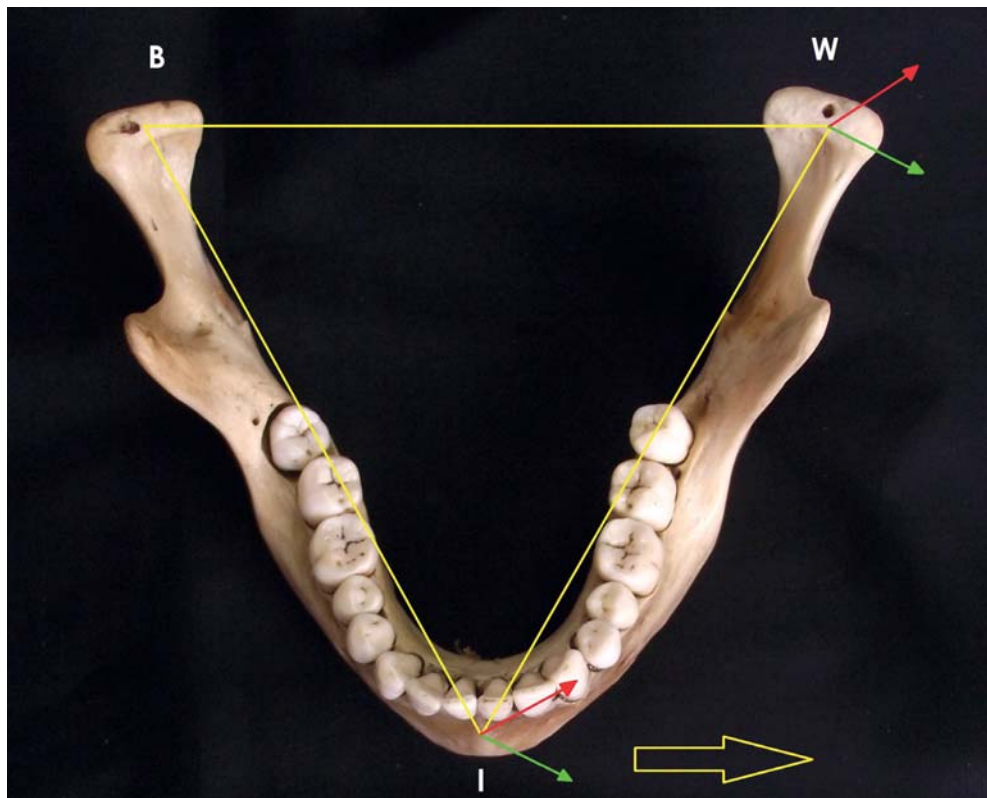


Fig. 2

Fig. 3

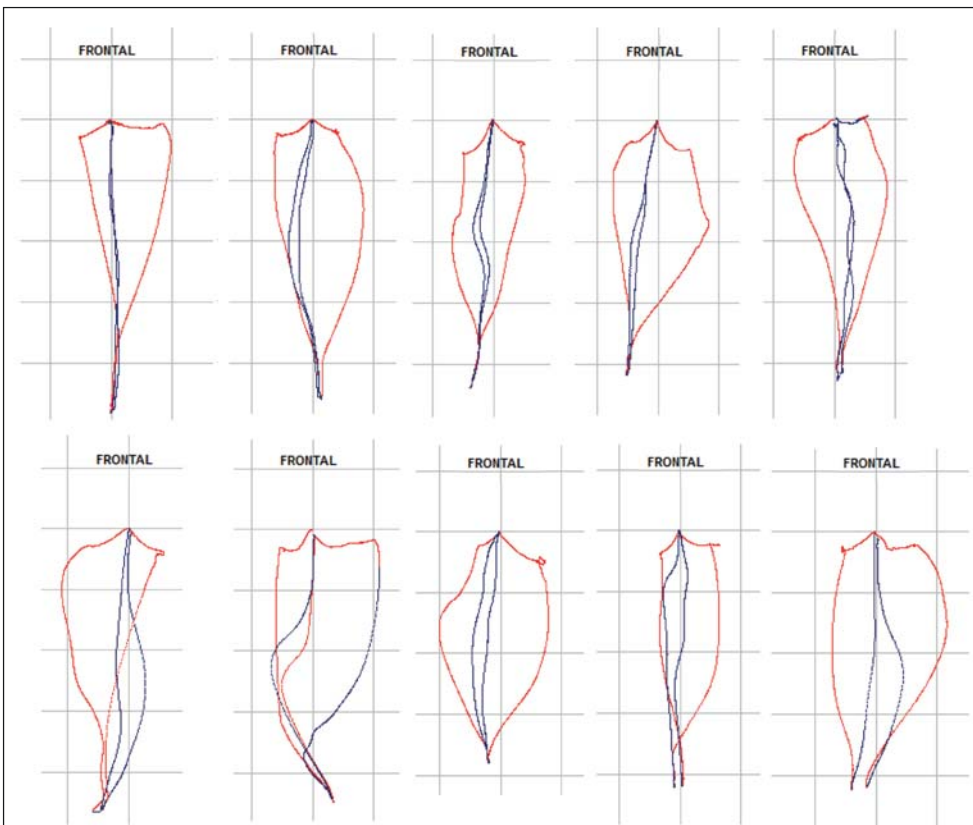


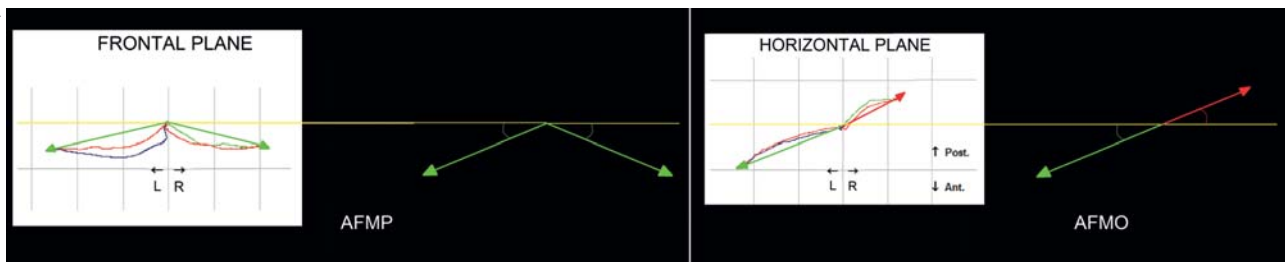
Fig. 3

Posselt diagrams in patients with dysfunction.

Fig. 4

Frontal plane: AFMP.
Horizontal plane: AFMO.

Fig. 4



between the front slope of the AFMP and anteroposteriority of the AFMO.

plane, and the magnet was placed in an equidistant position with respect to the two detectors of the kinesiograph.

Materials and methods

The study was performed on 115 patients who presented with asymmetrical lateral excursion. The sample was made up of 32 males and 85 females aged between 17 and 84. The instrument used for this study was a Bioket kinesiograph (Bioket, S. Benedetto del Tronto, Italy). Eligible subjects were placed in a sitting position, not on the dental chair, feet with full plantar support on the floor. The kinesiographic mask was positioned with reference to the horizontal

Results

Ninety-eight (85%) of the lateral tracings examined with respect to the frontal plane showed consistent results, demonstrating the correspondence between the greater steepness of the AFMP and the posteriorization of the AFMO. The steepest laterality in the frontal plane was found to be the most posterior on the horizontal plane. The remaining 17 (15%) tracings failed to show this kind of correspondence

Fig. 5
Correspondence between a steep AFMP and a retrusive AFMO (always found to be < 1).

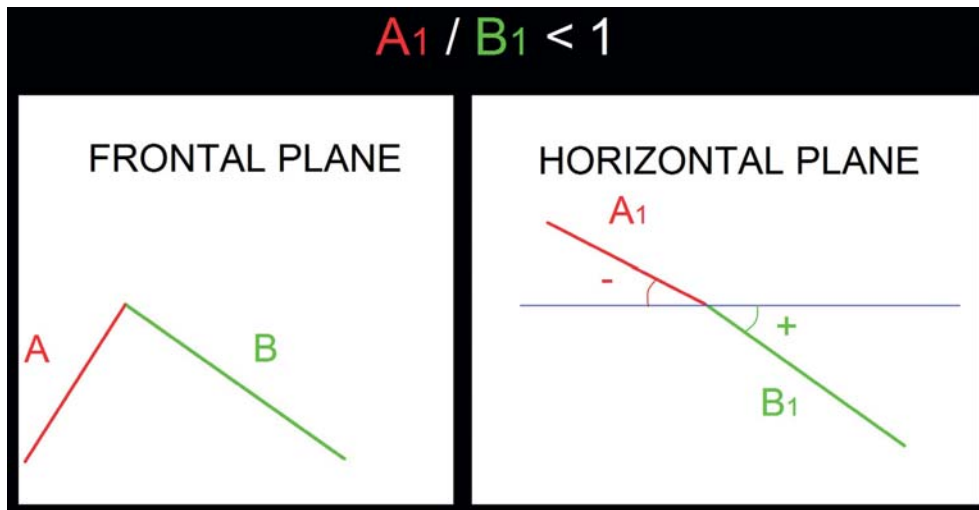


Fig. 5

Fig. 6
Asymmetric lateral excursion.

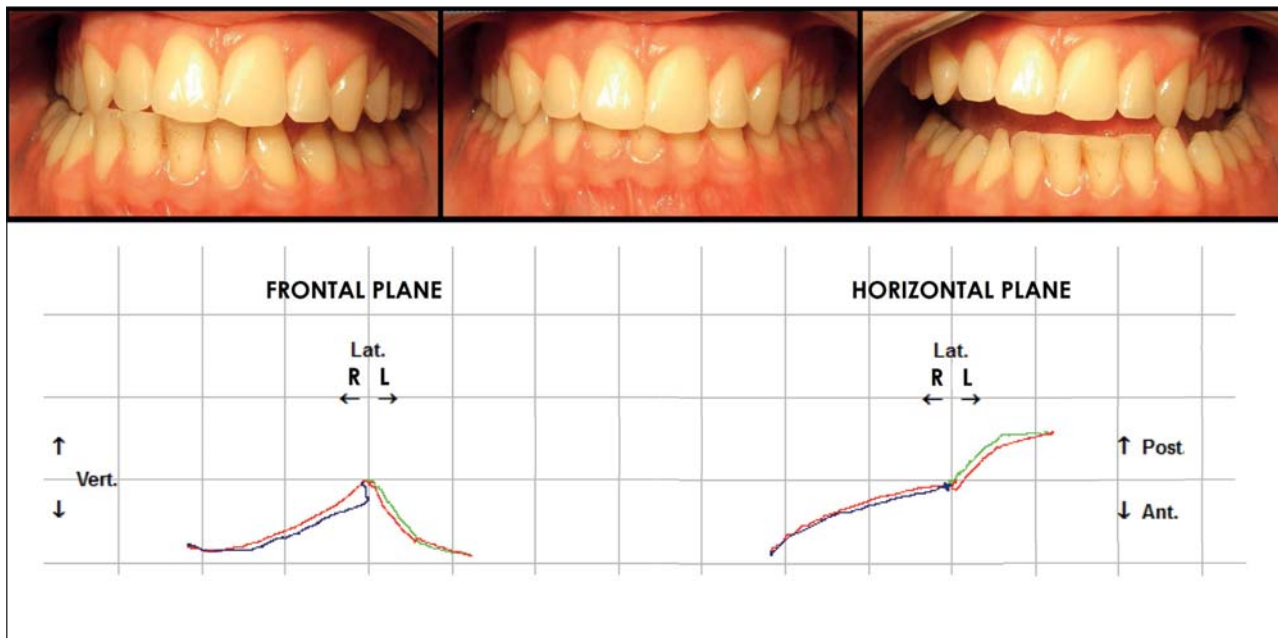


Fig. 6

between the AFMP and the AFMO. On the horizontal plane, the lateral retrusion formed an angle with the frontal plane that was given a negative value, and the angles formed by latero-protrusive tracings were given a positive value. On the horizontal plane in all of the 98 coherent paths, the relationship between the angle of the tracing corresponding to that steeper on the frontal plane and that corresponding to the less steep was always found to be < 1, showing the correspondence between a steep AFMP and a retrusive AFMO (Fig. 5). The average confirmed precisely the correspondence between a steep AFMP and a retrusive AFMO: $A1/B1 = -0.589432199$.

Discussion and conclusion

Planas in defining the AFMP emphasized the pattern of unilateral mastication.¹⁷ Predominantly unilateral mastication usually occurs when there is a side of the mouth in which the function can be performed with more ease and efficiency compared with the contralateral side (Fig. 6). Predominantly unilateral mastication tends to develop from the side with less steep laterality or with a smaller AFMP. The study of laterality with a Bioket kinesiograph has permitted to highlight also on the horizontal plane the asymmetry defined by Planas on the frontal plane: On the horizontal plane, the side with the less

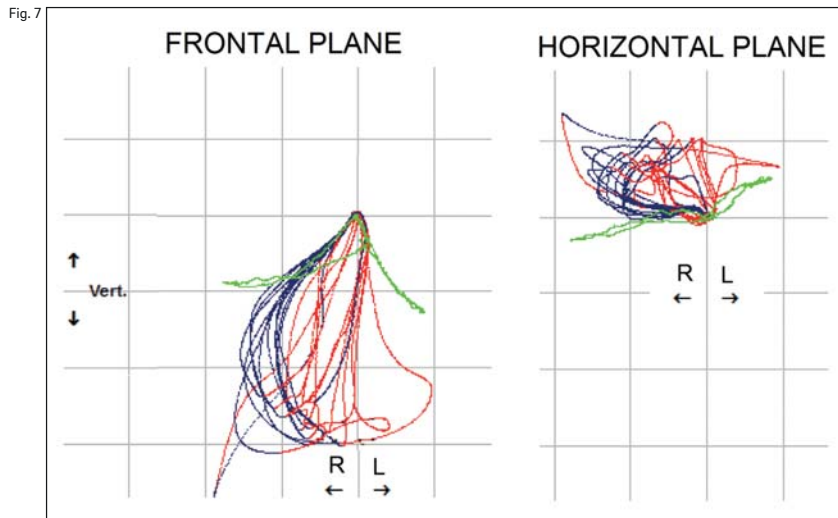


Fig. 7
Frontal plane: masticatory cycles in predominantly unilateral mastication on the side with the less steep AFMP. Horizontal plane: masticatory cycles in predominantly unilateral mastication on the side with the advanced AFMO.

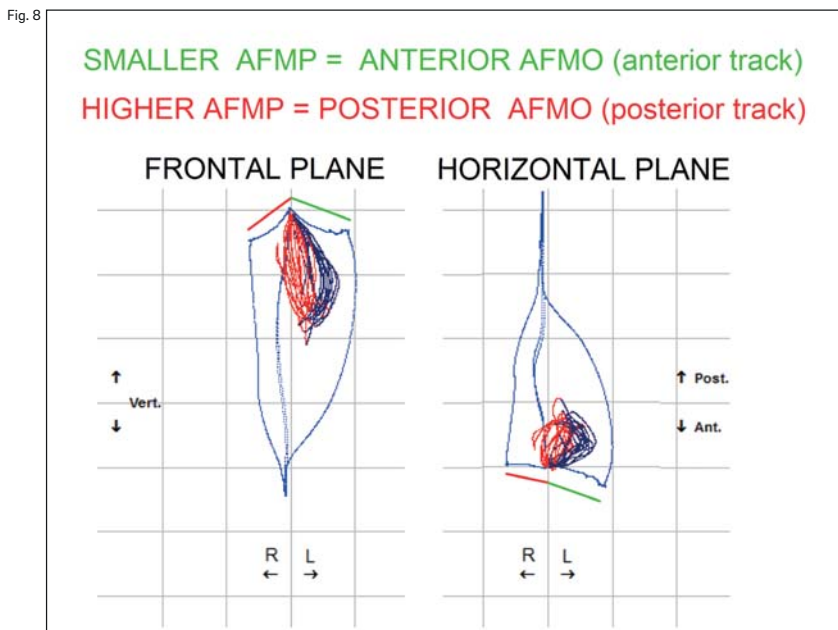


Fig. 8
Unilateral masticatory cycles.

steep AFMP (usually the one with an easy lateral excursion and functionally prevailing masticatory side) tends to correspond to the side with the tracing that is expressed in anteriority (**Fig. 7**) and vice versa. This is referred to as the consistency of the tracings of laterality between the front and the horizontal planes.

An AFMO tending to posteriorization is an index of laterality with a retrusive component: The entry stage of the masticatory cycle (during which the masticatory forces reach their maximum intensity) tends to take place with an unfavorable condyle–fossa relationship. A lateral retrusion tends to create a compression of the retrodiscal tissue, hindering proper mastication

and encouraging mastication on the contralateral side (**Fig. 8**).

By decreasing the steeper slope and the lateral tracings symmetrizing the AFMP on the frontal plane, the retrusion of the corresponding AFMO tended to reduce, resulting in a regularization of the Gothic arch and of the Posselt volume and favoring the restoration of alternating unilateral mastication (**Fig. 9**). Since the tracing of the Gothic arch is a horizontal section of the Posselt volume, the arch regularization determines a volume regularization that allows the jaw to move freely in mastication (**Fig. 9**).

Therefore, analysis of lateral excursion movements with evaluation of the prevailing

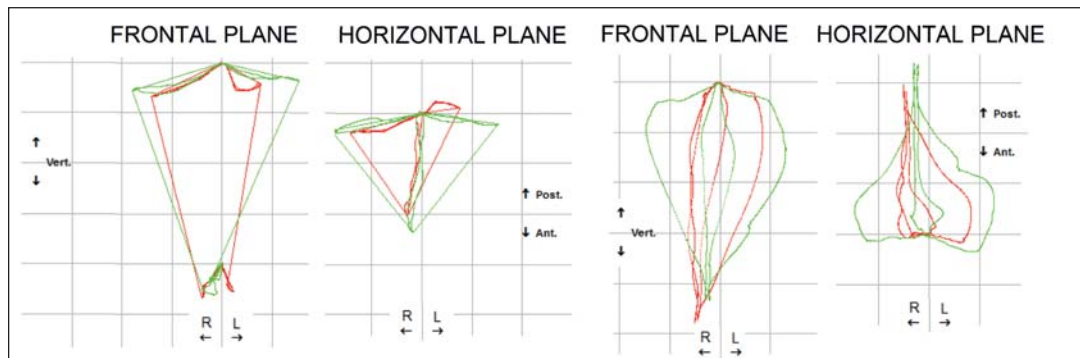
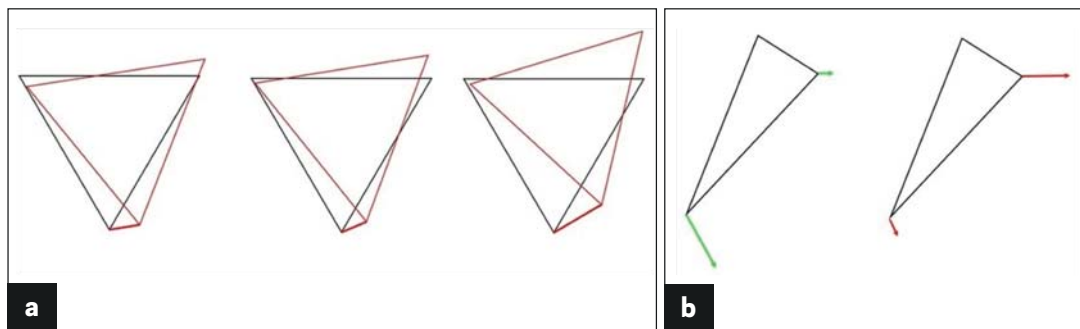


Fig. 9



Figs. 10a & b

Fig. 9

Decreasing the AFMP on the frontal plane tended to reduce the retrusion of the corresponding AFMO on the horizontal plane, correcting and regularizing the Posselt volume.

Figs. 10a & b

Bonwill's triangle.

masticatory side cannot exclude analysis of lateral excursion on the horizontal plane. In kinesiographic tracings of patients with dysfunction, the asymmetries of the AFMP and AFMO (and therefore of the Gothic arch and the Posselt volume) are largely the norm: Steeper laterality on the frontal plane will tend to have a retrusive tracing (absolute or relative to the contralateral side) on the horizontal plane.

The back thrust of the working condyle in lateral retrusive tracings of will tend to be

- directly proportional to the posteriorization of the interincisal tracing;
- directly proportional to the length of the tracing—the more the lateral tracing has to express its posterior movement, the more the working condyle will tend to posteriorization (**Fig. 10a**);
- inversely proportional to the vertical component of the movement: because the lateral excursion is expressed on the different spatial planes, the vertical component is as if it tended to stop the retrusive push of the working condyle (**Fig. 10b**).

A posterior AFMO (absolute or relative to the contralateral side) indicates a difficult, countered laterality and will tend to highlight the side with problematic masticatory function. Reducing the

steeper inclination of the AFMP will tend to reduce the retrusion of the corresponding AFMO, regularizing the Gothic arch and the Posselt volume, and this will promote the restoration of alternating unilateral mastication.

Acting properly on the occlusal surfaces, we are able to influence the whole of the mandibular dynamics by changing not only the movements related to occlusal guides, but also the mandibular movements in full, both in the amount of maximum openness, in their transverse width and in their inclination. Premature contacts or interferences that induce retrusion of the lateral excursion on the horizontal plane with posteriorization of the entry phase of the masticatory cycle will tend to favor prevalent mastication on the contralateral side. With asymmetry correction of lateral excursion, we tend to decrease the condylar retrusion, expand and symmetrize the Gothic arch and the volume of Posselt, thus directing the masticatory function to a physiological alternating unilateral mastication.

Competing interests

The authors declare that they have no conflict of interest regarding the materials used in the present study.

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