Occlusal plane: A clinical evaluation

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The observation of the evolutionary characteristics of Hominid, of the ontogenesis of the occlusal biologic system and of the architectural influence of the occlusal field on the craniofacial morphology brings the evidence of the need for a clinical evaluation of the occlusal plane as an alternative approach to diagnosis in each treatment of the child, adolescent, adult or elder person. The purpose of this paper is to specify some indicators on the occlusal plane with regards to its inclination, length, continuity that facilitate the differential diagnosis especially during development, including those related to orofacial pain and TMJ disturbances.

INTRODUCTION

How can we define occlusal plane (OP)? Can we at least have a concept of the OP? This attempt to make a definition of OP is very old, since 3000 BC. The earliest traces of the OP were found on the Egyptian tablets and Hesi-Re was the first known doctor specialized in Dentistry.[1] Even working day by day building and rebuilding patient's occlusion it is still very difficult to define the OP. There are factors influencing the morphology and functioning of the OP such as: growth, intraoral contents, head and neck chain muscles,[2] mandibular rotations, eruption, attrition, feeding behavior[3,4] and many others.

Therefore, the precise location of the OP in the dental space is an obscure concept.[5] However, it is possible to describe OP as a meeting field of opposing teeth[6] where to and where from neuromuscular afferences are directed. The occlusion is the relation of dental contact that results from muscular control. All dental relations are the effect of neuromuscular activity.[7]

OP is the meeting field of the opposing teeth that control the end-stop of the mandible cyclical closure movements during chewing. The OP stabilizes the mandible during deglutition and probably contributes to adjust the head posture besides supporting the head for other functions.[8] The evolving anatomic structures are continuously adapting themselves to the function, and also the function is constantly adapting itself to the changes of form.

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For all the above, and many other reasons, there is not yet an ultimate definition.

Actually, OP is in continuous transformation and so what is normal for the child, may be not so for adolescent, adult or older person.

Clinically, it is extremely important to get a better understanding of the OP anatomical and physiological expression, during development. It must be established what is and what is not appropriate for the best physiological performance.

This attempt was well accomplished[8-10] by many clinical researchers.

PHYLOGENY

Some 300 million years ago during the Permian period, at the end of Paleozoic era, the vertebrates belonged to at least four main classes: cartilaginous and bony fishes, amphibians and reptiles. It was a time of transition. The acanthodians fishes were the first to have jaws and they disappeared 250 million years ago. The xenacanthida fishes had many sharp teeth.[11] Some 150 years million years ago, in the late Jurassic period, Mesozoic era, not all the pterosaurs had teeth, like other prehistoric animals, and the TMJ were below the OP.[12] As the phylogenetic evolution progresses to an erect cephalic posture dramatic changes can be observed, including the flexion of the cranial base and the lowering of the OP in relation to the TMJ.[2] This joint appears in mammals as the result of adaptation to mastication with the presence of a cartilage at the condyle that reacts to mechanical extrinsic stimuli.[13,14] However, the TMJ is an "original creation" and it is not an evolution of an anterior system.[15]

ONTOGENY

By the 8th week of embryonic age the lateral pterygoid muscles have contractions and the first move-

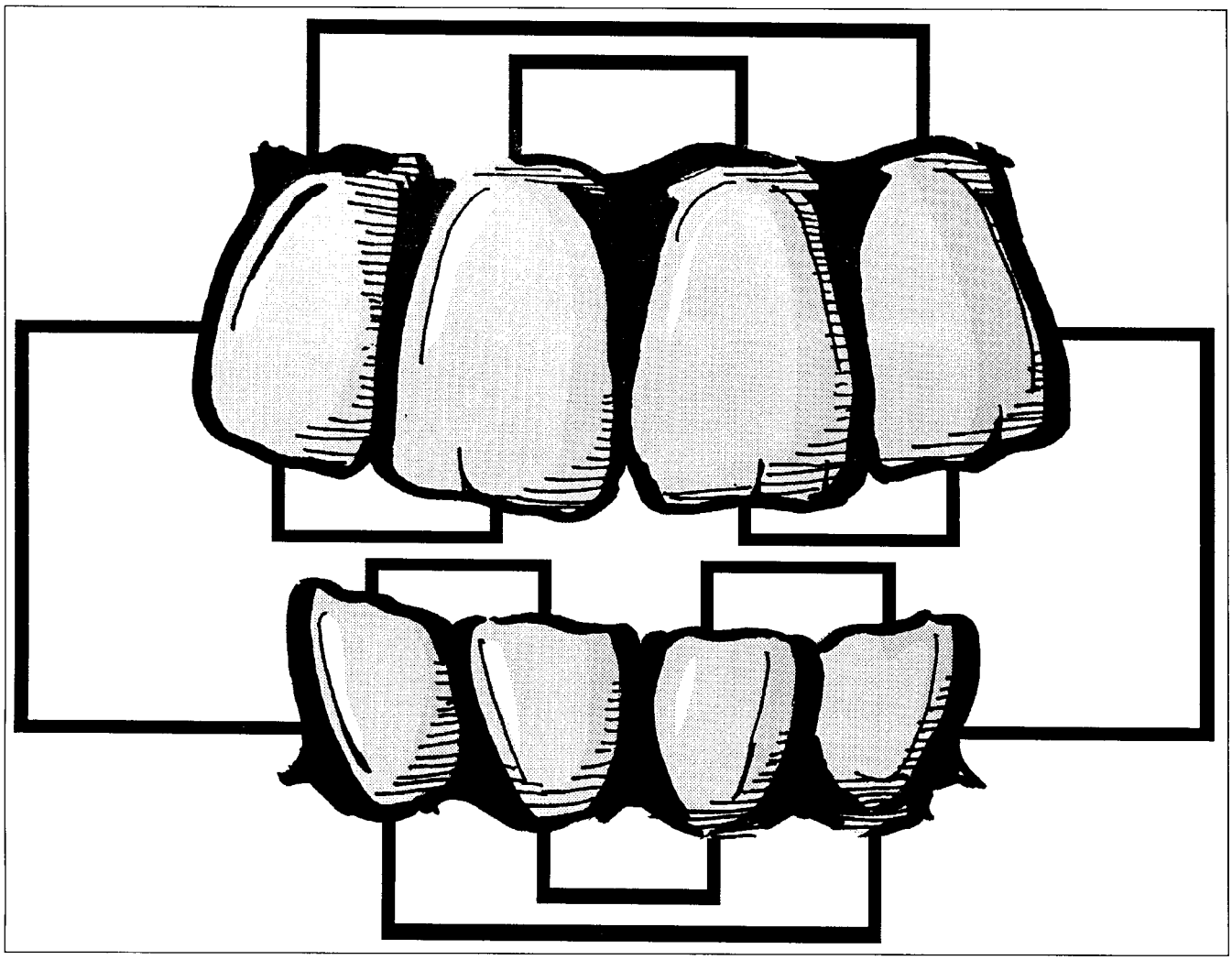

Fig. 1 Each incisor must be proportional to its neighbors, antimere and antagonists. There is a kind of law of proportionality. The connections between teeth indicate the relations of proportionality.

ments of the primary Meckelian joint appear. The acts of swallow and suction are performed when the tongue and lips move (around 12th and 14th weeks, respectively) the palate, the muscular and neural relation including at the nucleus level of integration are sufficiently developed.[16] Mechanoceptors, 40-60 Vater-Pacini, located within the upper and lower ridges occupying the same places of the future primary teeth, provide an important sensory network that can be interpreted as "alveolar OP."[6,17] The tongue and these mechanoceptors reflect their action over the lateral pterygoid muscles whose fibers insert into the pterygoid fovea of the mandible neck, the capsule and articular disk and maintain connection with the meniscotemporomandibular frenum or retrodiscal pad. The responsiveness of condylar cartilage to local biomechanical stimuli is mediated by the lateral pterygoid muscles and the retrodiscal pad.[13,14,17-22] The regulation of growth rate of the condylar cartilage and the optimal adjustment of the intercrest[17] is performed by the tongue, the mucosa sensory network (later by teeth) the lateral pterygoid muscles and the retrodiscal pad. The pterygoid muscles are the "relays" of the jaw development and the concentration of other receptors such as the Golgi tendon organs at the TMJ corroborate for the process that must be considered from a cybernetic view.[13-27] Nasal respiration and posteroanterior movements in breast feeding provide the activation of proper neural circuits for facial development. Later, with dentition the lateral pterygoids and the sliding parts or TMJ, during lateral protrusive mandibular movements become responsible for the balanced occlusion. The muscle effort and the "neural incisive circuit" are the keys for the development and management of treatment by neuro occlusal rehabilitation.[23]

The occlusal line of the primary dentition is flat. The teeth have their long axis perpendicular to OP and the incisors have no inclination. The first permanent molars also follow the same pattern mesiodistally and buccolingually. The occlusal line in permanent dentition is slightly bent.[29]

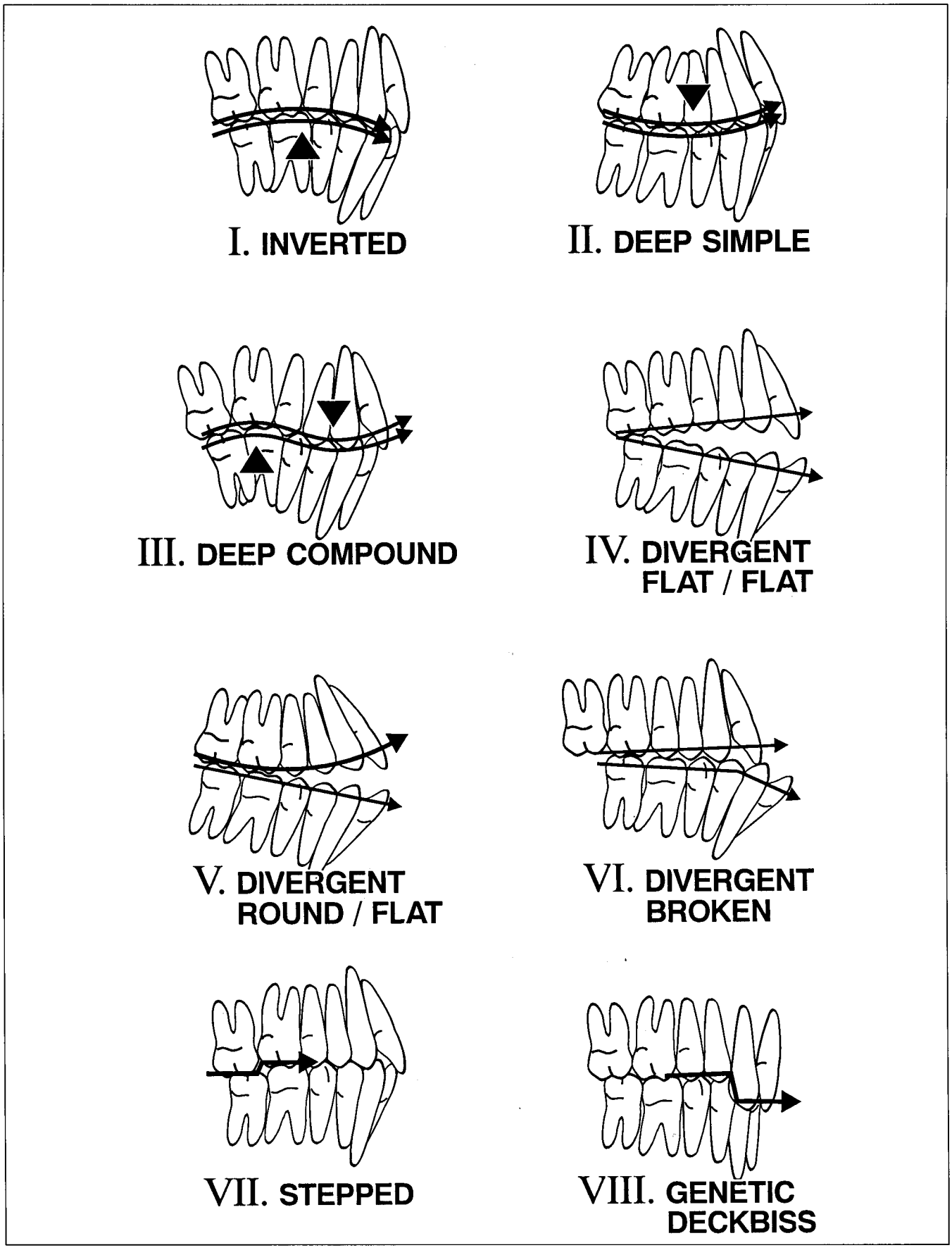

Fig. 2 Occlusal line types.

The curve of Spee is formed in the sagittal sense by the contact between the upper and lower teeth with an axis in the area of the lachrymal bone and the radius is 46 mm in children and 65-70 mm adults. This curve also passes by the most anterior point of mandibular condyle[30] and begins with first permanent molars, suffering an inflexion with the premolars. This curve stabilizes in the adult.[29,30]

There is also a curve of Wilson in the transverse sense. These two curves produce on the OP an helicoidal movement that increases with the masticatory use.[31] Therefore, with age the curves of Spee and Wilson are compensations related with functional maturity, anatomic evolution of TMJ and dental alveolar joints. The OP, during a lifetime can assume different profiles according to its use; physiologically, it changes by functional adaptation. These mechanisms lead to a pure physiological OP that is always being compensated by function.

Under certain circumstances, it is impossible to maintain a physiological compensatory mechanism and the OP extrapolates to a pathological situation. For example, the presence of "steps" can lead to problems of distraction, where the TMJ space is increased and, with time, it can be filled with a thicker disk and hyperplastic cartilage.[32] The stepped OP is a kind of compensatory adaptation and the distraction is caused by lack of compensation, and consequently, by a pathological OP.

TOOTH SIZE AND SHAPE

Morphological gradients in size and shape of teeth are determined by genetic endowments. The teeth obey certain rules within morphogenetic fields.[33] There is a proportion between neighboring structures. The size and shape of the teeth are related to craniofacial morphology[5,33] and obey a law of proportionality. Otherwise they can cause alterations on the OP. Figure 1. Many times when a tooth is smaller or bigger a compensation should be looked for in the same morphogenetic field, or in another field, and they are called local and distant compensation, respectively.

The incisors at centric position have no contact to allow excursive jaw movements with smooth light touch. Incising and chewing maintain a stable position of the incisors and corroborate to healthy periodontium. Problems may occur every time the proper interproximal or occlusal contact is not evaluated for rebuilding. In cases of deckbiss, for example, after the overbite is corrected, the upper lateral incisors often need reshaping to maintain the dental arch perimeter and avoid relapse. Composite material is indicated.

When there is compensation, sometimes the reshaping of the affected teeth is not necessary. It seems that the width is more often affected than the height and that nowadays, there are more sizes, shapes and number of teeth affected.

CLINICAL INDICATORS

Some features must be observed such as: the orientation of OP in the anterior/posterior, left/right segments; the presence of "steps," open bites and overbites. Each one of these features brings a different approach to the diagnosis. It determines the treatment because the conditions are different not only at the OP itself, but also in the TMJ and in the muscular activity. For example, the edge bite has a very low temporal and masseter activity while the overbite has an hyperactivity of these muscles.[34]

A proper OP must be:

- approximately parallel to the Camper's Plane.
- even in the right and left sides.
- flat in the primary dentition.
- slightly bent in the permanent dentition.

In the mixed dentition the sustenance zones must be correct and have a harmonious touching area with all teeth, and the soft physiological attrition curves on the OP must be present according to age. However, to facilitate the clinical observations it is interesting to categorize some occlusal line types as follows: near flat; slight curve; inverted; deep; different right/left curves or inclinations; upper/lower divergent lines; stepped; with buccolingual irregularities and belonging to an incomplete dental arch.

The deep curves of Spee can be vertically simple and compound when it bends downward posteriorly and then upward anteriorly. The divergent occlusal lines can be either upper and lower flats or upper round/lower flat. Divergent broken, is when at the same upper and/or lower OP, the posterior and anterior teeth follow different inclinations. The broken divergent occlusal line (caused mainly by under erupted lower teeth[35]) is very useful to identify skeletal open bites. Generally, if the upper occlusal line is round, and the lower is flat, the prognosis of open bite treatment is worse than if the upper occlusal line is flat. Genetic deckbiss has stepped OP with all posterior upper segment higher than the anterior. Figure 2.

The vestibular crossbites with buccolingual irregularities cause transverse displacements of the condyles[32] and sometimes compression at the TMJ on one side and distraction on the other side. Genetic deckbiss can produce posterior displacement at the TMJ because of the loss of posterior support.

Usually the OP is worse for the TMJ if one tooth is missing at the end of the dental arch than when there is a gap of two missing teeth in the middle. Shortened dental arches, specially the free end cases, can lead to compression or distraction of the TMJ depending on the previous conditions and coadjuvant factors; such as absence of artificial dental replacement for a long period, or prosthesis and / or unsuited material for the case.

Selection of material for rebuilding

The material of occlusal and dental contacts is also a factor to be considered. The OP can be entirely or partly covered by acrylic, composite materials, ceramics, silver amalgam, alloys, gold and enamel. Enamel, being a natural material, is the best for the physiological attrition, proper neural circuits and muscular activity. The prosthetic surface can be dangerous if it does not get near the physiological attrition capacity of enamel.

Transverse displacement of the condyle is rare, but it can be triggered very often by the excessive wear of acrylic resin temporary restorations that is time - dependent and consequently provokes loss of vertical dimension. In such cases, it is useful to consider metal centric stops.[32]

Iatrogenic imbalances at the OP can affect TMJ if:

- the material does not maintain the vertical dimension because of excessive wear;
- the hardness, the resiliency, the abrasion on surface, the stress concentration, the toughness and the occlusal impact transmitted or absorbed is not closer to the conditions of enamel - on - dentin complex;
- the impact strength in compression is not comparable to tension.

The compression and distraction are frequent in cases of extensive posterior segments made in ceramics or composite materials. The difference will be dependent on the time of actuation and kind of premature contacts. These contacts on molar lead to distraction; molar absence leads to compression; premolar extraction producing a step with the mesialization of the molars leading to distraction. Figure 2.

Concerning the material, what may be good for the anterior teeth may not be good for the posterior teeth. Aesthetics is a factor to be considered for the anterior teeth whereas the posterior teeth require strength for masticatory efficiency.

The priority must be the maintenance of the occlusal balance. Ceramics and composite materials are extremely effective for anterior teeth. Gold is a good conductor while ceramics is an insulator. However, with gold the TMJ is better protected from impacts. When the posterior tooth is properly lined with a good quality cement, with the correct thickness, the gold prosthetic work can last a very long time without affecting the tooth and/or the TMJ. On the other hand, ceramics on the same tooth even being accurately executed often, depending on the case, provokes impact on the TMJ.

The criteria used to select different materials must be considered from yet another angle: material behavior versus physiological attrition.

Even knowing that structural pathological changes at joint level may take a very long time (from 10 to 30 years)[32], one must pay attention to OP in every detail in order to preclude such situation.

Stages of development

The clinical evaluation during two very important neuroendocrinological periods of the OP must be considered separately. The first period seems to be product of the adrenarche at 6-7 years in boys, and 7-8 years in girls.[36] This is when the OP has no anterior support. Subsequently, the OP will be supported by the permanent first molars and incisors. This is a very important stage for the architectural influence of the occlusal field on the craniofacial morphology.

The upper incisor touching area lies on a very sensitive tactile location[37-39] on a flat palatine surface after a smooth concavity at the incisal third. The lower incisors touch on this area with its flat labial surface at the incisal third also.[40-43] Such contacts cause an unstable position.[44] This paradox is quite understandable if the contact is compared to an instantaneous, directional electromagnet closing a neural circuit on the lower-upper incisors.

The inferior head of the lateral pterygoid muscle brings the mandible to this position and the superior head would move it back a little,[45] when the contact is on that determined area (DA).[40-43] This movement opens the "neural incisive circuit."[23] It is understandable that these tiny back and forward movements increase the activity of lateral pterygoid muscles and retrodiscal pad,[45] as demonstrated experimentally.[24,27] This represents a part of the causal chain conducting the stimulation of the cartilage growth rate and the mandibular lengthening.[23-27] It is an indirect way of stimulating effect on the condylar cartilage growth.[45] The maxilla, a secondary aspect, will be influenced sagittally and transversely by the movements of the mandible and the incisors contact will stimulate forward growth.[22-27,45]

If the incisal contact is made on metal , ceramic or composite material rather than on enamel the reaction magnitude will be different[46] but not significant because of the richness of the neural receptors.[37-39]

This biological process will allow for conditions of vertical and dental arches spaces for the primary teeth loss/permanent teeth eruption balance in the lateral posterior segment of the OP.

Nature never skips a stage of development. If a malocclusion must be corrected, it is important to change the mandible posture until the incisor contact limit[45,47] on DA[40-43] is obtained, moving the mandible forward, in cases of distocclusion, or backward, in cases of mesiocclusion.[40-43] In the latter case, by controlling the mandible position from advancing, the maxilla is stimulated forward.

The following factors are part of a servosystem[23-27] for the whole growing process:

- the fact that the CNS receives much more information around the resting posture than in the MIP due to increased static sensitivity of the receptors;[48]
- the muscle spindles capacity to register movements below one millimeter;[49]
- the interdental discrimination whose contribution is much more effective from the primary endings of the muscle spindles in the elevators than from TMJ;[50,51]
- the lateral pterygoid muscles contribute to the position sense of the mandible;[52]
- the teeth feedback determinant role on the mandibular movements related to tactile thresholds for central incisors with incomplete root formation is lower than those with mature periodontium.[53]

During development, these elements corroborate with the electromagnet mechanism of the incisors contact on DA.[40-43] Later on in adulthood the incisors contact at MIP does not exist anymore. This contact would not be desirable because the growing process is over. It remains only at the lateral protrusive mandibular movements. However, they maintain a neural circuit during right and left lateral protrusive movements for dynamic occlusal equilibrium and the best architecture of the masticatory cycle.[9,25] The OP is a peripheral comparator that repetitively provides the central comparator with adequate engrams.[23-27] This concept fits with neuro-occlusal rehabilitation.[9,25]

The second neuroendocrinological important period of the OP is product of puberty growth. The CNS controls the onset of pubertal maturation.[54]

The action of hormones and CNS during prepuberty and puberty are related with changes on the craniofacial morphology[55] and on the OP.[56-59] Special clinical observations must be made on the growth rotation of maxilla-morphological and mandible-morphological and position.[60]

The rotational phenomenon influences the OP and there is an expressive interocclusal distance.[57-59] Eruption, maxilla and mandible growth are not uniform processes.[26,27,57-59,61,62] The interplay of all these elements corroborates with the timing and intensity of the interocclusal distance.[59] Statural, vertebral, sexual, dental and chronological ages are hormone dependent and the OP adjusts its variations following the biological rhythms.

From approximately 14-15 years to 16-17 years the spot contacts at maximum intercuspation position (MIP) gradually increase in number and after this age the lateral protrusive mandibular movements gradually increase the functional process of maturation until approximately 18-19 years.[59]

The OP needs time to mature, and the diagnosis and treatment must focus on this approach. Any interference in the natural sequence, rate and mechanism of the various parts growth may disturb the final harmony.[63] Despite general characteristics and growth patterns each OP must be considered individually and according to age.

REFERENCES

1. Ring, M.E. Dentistry an illustrated history. NY Abrams Mosby pp 32-33, 1986.
2. Delaire, J. The occlusal plane and maxillo-facial surgery. L'Orth Fr 59:811-890, 1988.
3. Simoes, W.A. Occlusal Plane: a clinical evaluation. J J Orth Soc 51(special issue)306, 1992.
4. Simoes, W.A. Ortopedia funcional de los maxilares vista a traves de la rehabilitacion neuro-oclusal. Tomo I Venezuela, Ed Isaro. pp lO7-138, 1989.
5. Ausburger, R.H. Occlusal plane relation to facial type. J Prosth Dent 3:755-770, 1953.
6. Mauran, G. et al. The occlusal plane.Ed Soc Fr D'Orth Dento-Faciale. pp l7,32,50, 1988.
7. Kawamura, Y. Oral physiological basis for future dental practice. J Int Coll Dent 6:7-14, 1975.
8. Ricketts, R.M. Provocations and perceptions in cranio-facial orthopedics. USA, RMO, Inc. II vol. p 501, 1989.
9. Planas, P. Rehabilitacion neuro-oclusal. Barcelona Ed Salvat pp 9-102, 1987.
10. Slavicek, R. L'Occlusion. Revue D'Orth Dento-Faciale 17:449-545, 1983.
11. Heyler, D., Poplin, C.M. The fossils of Montceau-les-Mine.Am Scient 259:70-76, 1988.
12. Langston Jr,W. Pterosaurs. Am Scient 244:92-102, 1981.
13. Petrovic, A. Recherches sur les mecanismes histophysiologiques de la croissance osseuse cranio-faciale. Ann Biol IX:63-71, 1970.
14. Petrovic, A. Mechanisms and regulation of mandibular condylar growth. Acta Morphol Scand 1:25-34, 1972.
15. Loreille, J.P. Phylogenese et embriogenese de l'articulation temporo-mandibulaire. Revue D'Orth Dento-Faciale 21:347-362, 1987.
16. Sperber, G.H. Craniofacial embryology. 4th Ed Cambridge Wright pp l61,198, 1989.
17. Couly, G. Les neurocristopathies du bourgeon nasofrontal (les syndromes ethmoidiens) Rev Stomat Chir Maxillo-fac 82:213-225, 1981.
18. Couly, G. Developement Cephalique. Paris. Ed CdP pp56-61, 1991.
19. Petrovic, A., Charlier, J. P. Organogenese experimental. CR Acad Sc Paris 265 pp l511-1513, 1967.
20. Charlier, J.P., Petrovic, A., Herrmann, J. Determinisme de la croissance mandibulaire effects de l'hyperpropulsion et de l'hormone somatotrope sur la croissance condylienne de jeunes rats. L'Orth Fr 39:567-579, 1968.
21. Petrovic, A., Stutzmann, J. Le muscle pterigoidien externe et la croissance du condyle mandibulaire. Recherches experimentales chez le jeune rat. L' Orth Fr 43:271-285, 1972.
22. Gasson, N., Petrovic, A. Mecanism et regulation de la croissance anteroposterieure du maxillaire superieur. Recherche experimentales chez le jeune rat sur le role de l'hormone somatotrope et du cartilage de la cloison nasal. L'Orth Fr 43:255-270, 1972.
23. Petrovic, A., Gasson, N., Schlienger, M.A. Dissymetrie mandibulaire consecutive a la perturbation occlusale unilaterale provoquee experimentalement chez le jeune rat. Conception cybernetique des systemes de controle de la croissance condylien et angulaire. L'Orth Fr 45:409-420, 1974.
24. Stutzmann, J., Petrovic, A. Le muscle pterygoidien externe un relais de l'action de la langue sur la croissance du condyle mandibulaire. L'Orth Fr 45:385-399, 1974.
25. Stutzmann, J., Petrovic, A. Effects de la resection du muscle pterygoidien externe sur la croissance du cartilage condylien. Bull de L'Assoc des Anatom 58:163, 1974.

26. Petrovic, A., Stutzmann, J., Oudet, C.L. Control process de jeune rat in the postnatal growth of the condylar cartilage of the mandible. In:Determinants of mandibular form and growth. Ed J Mc Namara Michigan, pp 101-153, 1975.
27. Stutzmann, J., Petrovic, A. Role of the lateral pterygoid muscle and menisco-temporomandibular frenum in spontaneous growth of the mandible and in growth stimulated by the postural hyperpropulsor. Am J Orth and Dent of Orthop 97:381-392, 1990.
28. Planas, P. Ortodoncia preventiva vista desde el angulo de la rehabilitacion neuro-oclusal. Rev Espanola Parodoncia 8:13-34, 1970.
29. Linden, F., Van Der Development of the dentition. Chicago, Quintessence Pub. pp 33,60, 1983.
30. Dale, J. Occlusal curve analysis. L'Orth Fr 59:773, 1988.
31. Ackermann, F. Les Mecanismes de marchoires. Paris, Masson. pp 239-269, 1953.
32. Gerber, A., Steinhart, G. Dental occlusion and TMJ. Chicago, Quintessence Pub. pp 28-36, 1990.
33. Brown, T. Morphogenetic fields within the dentition. Austr Orth J 7:3-12, 1981.
34. Kayukawa, H. Malocclusion and masticatory muscle activity. A comparison of four types of occlusion. J Clin Ped Dent 16:162-177, 1992.
35. Lowe, A.A. Neural control of tongue posture. In: Neurophysiology of the jaws and teeth. A.Taylor. London, Macmillan Press Ltd. pp 322-368, 1990.
36. Griffin, J.F., Ojeda, S.R. Textbook of endocrine physiology. Oxford, Univ Press. pp 154,176, 1988.
37. Darian-Smith, J. The trigeminal system.In: Somatosensory system, D.Albe-Fessard. NY, Ainsley-Iggo Springer Verlag. pp 271-315, 1973.
38. Griffin, C. J., Malor, R. An analysis of mandibular movement. In: Frontiers of oral physiology. Vol I. Y. Kawamura. Basel, Karger. pp 159, 1974.
39. Kawamura, Y. Recents Advances in physiology of mastication. In: Oral Physiology. N. Emmelin, Y. Zotterman. Oxford, Pergamon Press. pp 163-204, 1972.
40. Simoes, W.A. Fundamental Principles and basic characteristics of functional orthopedic techniques. J Dent Med 6:106-115, 1977.
41. Simoes, W.A. Some oral neurophysiological resources applied in the use of functional orthopedic techniques. J J Orth Soc 38:40-48, 1979.
42. Simoes, W.A. Functional jaw orthopedics-better oral neurophysiological information gives better clinical results. J Pedodontics. 8:108-115, 1983.
43. Simoes, W.A. Orthodontie fonctionnele. Prevention. Odontologie sociale. L'Orth Fr 58:693-708, 1987.
44. Kulmer, S. Periodontics, orthodontics and restorative dentistry. In: Orthodontics and Periodontics. E. Hosl et al. Chicago. Quintessence Pub pp 53-77, 1985.
45. Simoes, W.A., Petrovic, A., Stutzmann J. Modus operandi of Planas's appliance. J Clin Ped Dent 16:79-85, 1992.
46. Azerad, J. Physiologie de la manducation. Paris, Masson. pp 25, 1992.
47. Carels, C., Steenbergue, D. Van Changes in neuromuscular reflexes in the masseter muscles during functional jaw orthopedic treatement in children. Am J Orth 90:410-419, 1986.
48. Bonfil, J.J. Sensibilite fusoriale des muscles elevateurs, intercuspidation canine et position mandibulaire de repos. Etude chez le chat aigu. J Biol Buccale 3:77-90, 1975.
49. Aubert, M et al. Donnes experimentales recentes sur la sensitivite de l'appareil manducateur. Actual Odont-Stom 112:635-649, 1975.
50. Morimoto, T., Kawamura, Y. Conditioning effect of vibratory stimulation of objects held between human tooth arches. Archs Oral Biol 21:219-220, 1976.
51. Morimoto, T. et al. Effects of the interpolated vibratory stimulation on the interdental dimension discrimination in normal and joint defects subjects. J Dent Res 58:560-567, 1979.
52. Christensen, L.V., Troest, T. Clinical kinesthetic experiments on the lateral pterygoid muscle and TMJ in man. Scand J Dent Res 83:238-244, 1975.
53. Greenberg, R.S. A study of pressoreceptive thresholds of teeth in children. Master's Thesis. Univ of Michigan, Ann Arbor, 51, 1966.
54. Kelch, R.P. Endocrinology of adolescence. In: Craniofacial growth during adolescence. D. Carlson, K. A. Ribbens. Michigan. Craniofacial growth series.Monograph 20:23-30,1987.
55. Nanda, S.K. The developmental basis of occlusion and malocclusion. Chicago, Quintessence. pp52-79, 1983.
56. Hagg, U., Taranger, J. Maturation indicators and the pubertal growth spurt. Am J Orth 82:299-309, 1982.
57. Darling, A.I., Levers, B.G.H. The pattern of eruption. In: The eruption and occlusion of teeth. D.F.G. Poole and M.V. Stack. London, Butterworths. pp80-97, 1976.
58. Tanner, J.M. Growth at adolescence. 2nd ed Oxford, Blackwell Scient Pub, p 13, 1962.
59. Simoes,W.A. Occlusal Plane: an up-to-date approach. J J Orth Soc 51:320, 1992.
60. Lavergne, J., Gasson, N.: Operational definitions of mandibular morphogenetic and positional rotations. Scand J Dent Res 85:185-192, 1977.
61. Dibbets, J.M.H. et al. Shape change in the mandible during adolescence.Michigan. Craniofacial growth series. Monograph 20 pp 23-30, 1987.
62. Proffit,W. The control of tooth eruption. J J Orth Soc 51:26-36, 1992.
63. Simoes,W.A. New concept of serial extraction. J Pedod 6:91-113, 1982.