MASTICATION

WILMA ALEXANDRE SIMÕES

咀　　嚼

ウィルマ・アレクサンドラ・シモー

日本矯正歯科学会雑誌　第38巻　第3号　別刷
昭和54年9月1日発行

Reprinted from THE JOURNAL OF JAPAN ORTHODONTIC SOCIETY
Vol. 38, No. 3, Sep 1979

日矯歯誌 38：322～332，1979.

MASTICATION

WILMA ALEXANDRE SIMÕES*

咀　　嚼

ウィルマ・アレクサンドラ・シモー*

（昭和54年5月29日受付）

Ⅰ. INTRODUCTION

Each individual has a characteristic way of walking, according to his sensorial mechanism which, although similar in every human being[1,2,5,15], acquires its own patterns, subject to specific genetic instructions and outside influences. Likewise, each individual has a different way of chewing, caused by either genotypic or paratypic influences[19,30]. This means that the mastication is determined by the variation of periodontal (dental and surrounding dental contacts), periostal, articular, muscular, lingual and mucosa afference, integration and efference, in each person[16-18,20,23,25,32,33,35,37].

Mastication (a function which appeared with the mammiferous in the phylogenetic scale, but not with the surging of teeth and jaw bones)[5], is of utmost importance for good health. It must be borne in mind that the mouth is one of the main inlets of energy[14] for the maintenance of a dynamic balance[30].

Ⅱ. PHYLOGENY

The whole head suffered modifications in order to make mastication mechanically possible. This ability altered the structure (the enamel's wearing and consequent dentine exposure determine formation of the secondary dentine, etc., contrary to what happens with the reptiles).

The distribution of the teeth in the dental arch (cutting, piercing and crushing sections), the musculature (positioning of food) caused the appearance of salivary glands with a much wider function (including remineralizing action, supplying the necessary substructure for the good functioning of the masticatory surfaces)[5,22].

With the appearance of mastication functions, the anatomo-functional consequences described above, and many others, including constant teething, were reduced (in man to only two teething), thus becoming compatible with use and consequent attrition. In order to have a satisfactory occlusal pattern＝Basic crown (genetic and congenital) plus Functional crown (masticatory use), some mammals start the process of attrition while still in the womb (guinea pig)[3,26].

Ⅲ. ONTOGENY

Ontogenetically, we could say that mastication functions appeared early but not concomitant with human life. The SN must mature reflexes, establish sinapses and adequate pathways to the muscles develop force and movement; blood nutrition needs to create essential conditions; altogether, the whole body, as the Open System it is[14], requires preparation at the beginning of life, during a certain period, to create the proper conditions for mastication[11,21].

This preparation time is usually completed when the first teething is fully established, －4～5 years old. By this age the cuspids will have served as guides during and thru to the end of the eruption. (Poole - 76, personally believes that after this they are no longer needed and could disappear). The cuspids' small round and conic points and their geometrical disposition have possibly the function of making a better wearing out possible and consequent achievement of the functional

*Address: Av. Brig. Faria Lima, 613 Cj. 51, 01451 São Paulo, BRASIL

crown (Ian Maddick). The cuspids would have facilitated the piercing and tearing of food when the periodontum was still in its primeval stage of evolution (Ian Maddick)[5,21].

It can also be added that the cuspids are the very first tooth portion to mineralize (while the human being's dimensions are still extremely small). This perhaps explains the cuspids' pointed shape: they occupy less space (Picton). Besides, these points tear the gums more easily[5].

The teething process continue in a manner to allow adequate masticatory efficiency to each age until adulthood and permanent dentition is reached[26,30]. Obviously, in the post-ontogenetic evolution, the functional crown is extremely important for the maintenance of a dynamic occlusal balance. However, the stimulus of mastication is the great responsible for the Stomatognathic System development. The movements of the jaw should be executed on the different supporting dental surfaces, free from interference which might cause changes in the normal patterns. Also the whole synew-muscle-occlusion dynamics should follow the right vertical dimension, in the centric - obeying the functional occlusion - in the bolus side (functional or working side) in the oppositeside (supporting or balancing side)[11,21,29,30,32,33,34].

While growing up, individuals with normal occlusion can develop a vicious mastication (exclusively unilateral). This, for instance, may be caused by a tooth ache.

Normal occlusion (tooth ache on one side)⟶ vicious mastication (exclusively unilateral opposite to the pain's side)⟶bad occlusion (crossed bite on the vicious side).

Unfortunately, after a bad-occlusion is established, the returning circuit must be made through treatment. Inasmuch as the oclusopathy is established this treatment is at Inferior Prophylatic Level (not Noble Level): Primary (without use of appliances) and Secondary (when appliances are essential)[31,34]. Ontogenetically and post-ontogenetically, mastication will always depend on each individual (biotype, occlusion, time he takes for eating, sofistication of feeding methods, illnesses, dental treatments, lack of teeth, artificial recuperations, age, etc.) and on the bolus[1,2,5].

Ⅳ. MASTICATORY CYCLE

A sequence of masticatory blows is necessary to grind the bolus down until it is reduced and swallowed. Each of these blows has an architecture more or less defined according to the moment, kind of food and also determined by all the above mentioned factors.

We call each masticatory blow a cycle, because it starts from and ends in a maximum intercuspidal position (PIM).

Mastication = total sum of masticatory cycles necessary to reduce all food to a size and shape adequate to allow, through successive swallowings, its complete consumption.

The natural mastication pattern (neither induced nor oriented), typical, normal and effected by natural teeth, consists in alternating the most homogeneously possible, the working side: food should be regularly sent from right to left in an equal number of times (Hedegard et al - 67; Wictorin et al - 68); toothless patients or those using dentures do this bilaterally (Lundberg et al-67), at the same time[9,25]. Beyron, in 1964, observed in Australian aborigenes (living yet under primitive conditions) natural, alternated, bilateral balanced occlusion.

J. Ahlgren - 66[5], found out that, regretfully, most Europeans have vicious mastication.

The greater the number of cycles with dental contacts during mastication, instrumenting the process, the more efficient it is. The masticatory efficiency of Europeans is diminished due to the reduced number of masticatory cycles with dental contacts ($\simeq 54\%$), grinding being limited to a vertical distance of $\simeq$ 1mm and to a horizontal distance of 1.75mm, in cases of good occlusion, whilst in other cases considered of bad occlusion, it does not exceed 1.3mm (Hildebrand - 31). The reduced masticatory efficiency becomes evident when we examine the final angle of the closing movement in relation to the occlusal plane ($\simeq 40°$). The grinding capacity is in inverse ratio to the angle (FIG. 1). In the aborigenes, this angling comes down to 18° which consequently increases the grinding capacity. Also, their vertical surface

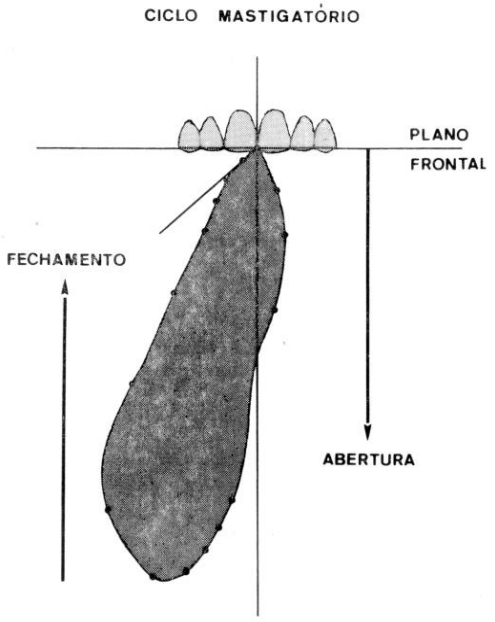

FIG. 1 MASTICATORY CYCLE in a Frontal Plane, Final angling of the closing movement with the occlusal plane is approximately 18° in peoples with much attrition and approximately 40° in those with less masticatory efficiency.

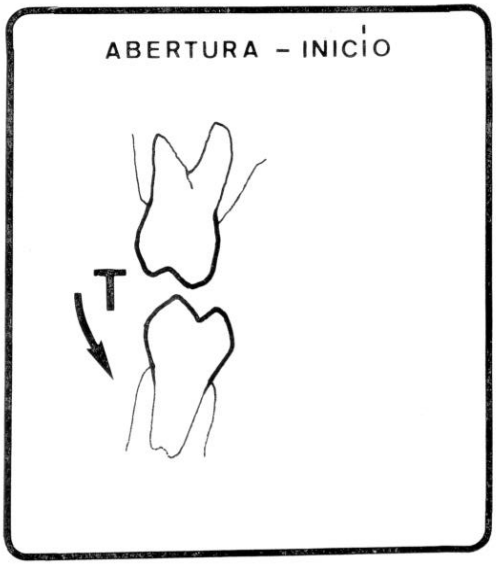

FIG. 2 The mandible starts the opening, usually in the opposite direction to that of working side.

is 0.7mm, while the horizontal is larger; after the contact till the PIM, the average is up to 2.8mm. The masticatory capacity of these aborigenes is much bigger, so much so that in nearly all their masticatory cycles, there were observed dental contacts[6,9].

Soft food reduces the need of horizontal movements, while hard and dry food increase this need.

An efficient mastication is the adequate performance of masticatory cycles, offering compensatory

physiological, not pathological, mechanisms.

Which are these mechanisms?

They are those resulting from the eruption and attrition, and from a sensorial mechanism adequately elaborated to each age, arranging the TMJs and muscles in perfect functional adaptation.

Two cycles never repeat in the same way[15]. but they can be described (frontal plane)[1,2,5,12,13,24] through a vertical movement (16 to 20 mm) and a lateral deflexion (≃3 to 5mm). The vertical movements rarely cross each other in normal occlusion, but in occlusopathy they not only cross but are irregular and uncoordinate. Obviously, the same happens in TMJs Syndroms. In cases

FIG. 3 At this stage the periodontal afference informs presence of the bolus on W side. No dental contacts.

FIG. 4 During crushing, the mandible first executes movements towards side W and then continues towards the PIM. This phase till PIM represents 28% of the cycle.

of big overbites (deckbiss), for example, the cycles have the horizontal vector reduced, and then the verticality predominates to compensate interferences in the front zone of the arches[25].

The jaw (according the frontal plane) has an initial opening movement, normally toward the balancing side (Fig. 2), and (according to sagital plane) forward, that is, protrusively.

Grinding, therefore, does not occur with the closing only, it also happens during opening.

According to the sagital plane, the cycles are not so well defined, the closing and opening movements cross each other constantly.

Further to the cycles' description, according to the frontal plane, the open jaw has a 7.5 cm/sec speed, and occupies 35% of the cycle, not exceeding much the space required by the food's size.

After opening, the jaw gyrates to the functional side, and when it pierces the food, it reduces its speed. This stage represents 12% of the cycle (Fig. 3).

The closing movement begins at this stage with an $\simeq$ 6 cm/sec average speed, crushing triturating grinding (28% of the whole cycle). (Figs. 4 and 5).

The first dental contacts occur during grinding [1,22,25] on the side opposite to where the food is (Balancing - B), called, for this reason, supporting side. This is how this side behaves while the functional side pierces the food (Work - W). (Fig. 5). Thirty msec after the jaw has revolved around this first dental contact, executed on side B, supporting side, contacts on working side begin (Fig. 6) (molars, pre-molars, canines and, finally, incisives) obeying the anatomy of each tooth, gradually increasing the muscular force till it reaches the PIM, when there is a 100-120 msec pause (25% of the cycle) before a new blow starts (Fig. 7).

The dental contacts do not exist in the first cycles, until the food is properly reduced, but the architecture is the same and the time varies from 0.6$\sim$1 sec[1,2,5,22,25].

Planas used to say, years ago, that it is not possible to establish a typical chewing by separating the maxillaries and reducing the dental contacts. This has probably been invented by modern man, whose contact with Nature has been lost through 10,000 years of an ever increasing sofistication of his feeding methods[30].

It should be mentioned that the time of 30 msec is extremely small, and that the contact on the supporting side is just a glide, with absolutely no overcharge (which would be traumatic). As there

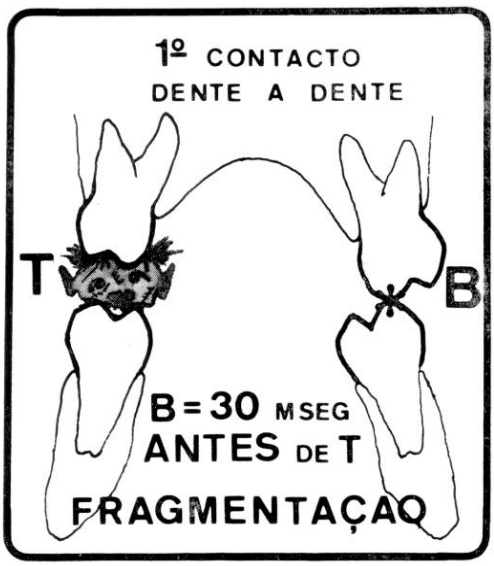

FIG. 5 The first dental contact is made on side B and only 30 msec will there be dental contacts on side W.

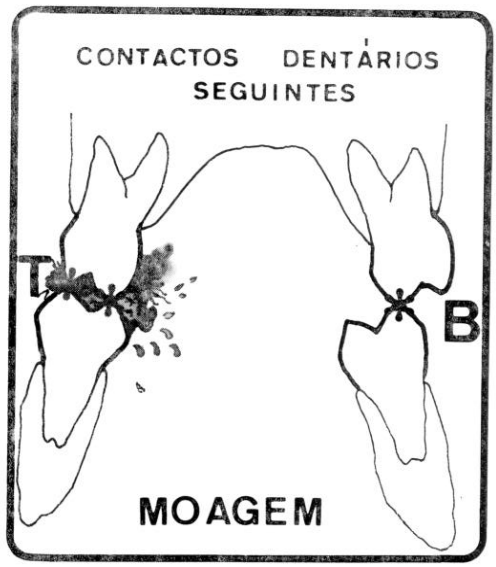

FIG. 6 When dental contacts are made on side W until PIM, we have grinding of food. It is then that the harmony between all stomatognathic structures is extremely important. It is better when the food slides toward the tongue than toward the vestibule. This way there is less solicitation of the muscular force. The highly flexible tongue with more convenient exteroception will help the mechanism considerably in reducing the bolus and has, therefore, an important role in the masticatory efficiency.

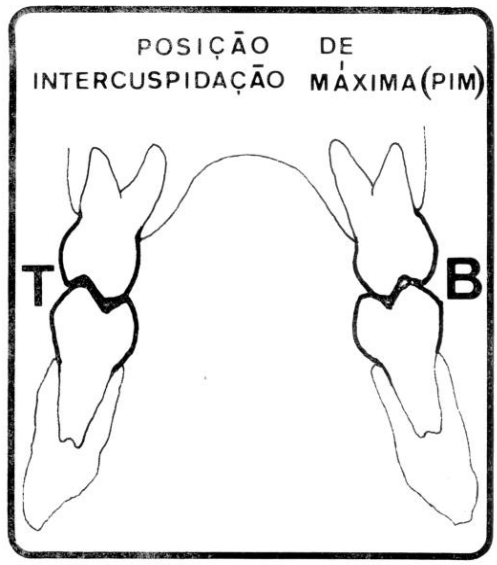

FIG. 7 There will be a $\simeq$ 100 msec pause at the PIM, before a new cycle begins (25% of the cycle).

is contact, there also is a quick and mild stimulus supporting the jaw (its action on the food), which in turn contacts side W, 30 msec later.

These numerous contacts during mastication produce the natural attrition which, more than age, determine the post-ontogenetic eruption, the con-

tinuous growth of the alveolar bone, secondary dentine formation, etc., maintaining the face level [4,7,21]. The cuspids disappear gradually, the crowns become less sinuous in shape, but the efficiency of the masticatory function remains[4,7,21].

Poole states that although the fact that the cuspids remain whole throught out the individual's life is considered normal (including the spares), it determines an occlusion, usually considered natural, which however is not at all physiological. On the contrary, this occlusion is completely antagonic to the conservation parameters of the stomatognathic structures during their existence[5,8].

When Planas controls periodontum disease, he works upon the surface of the teeth in such a way that he leaves carved on them the story of masticatory use, and thus avoids a precoccious ageing of the mouth. In Orthodontics, he watches and protects the eruption and attrition already when the first teething appears, elaborating a better development of the sensorial mechanism of the whole system. This phylosophy and the clinical procedures involved, create the Neuro-Occlusal Rehabilitation[28].

With the progress made in Biophysics, Biochemics, Biology, etc., this so-called Neuro-Occlusal rehabilitation, by Prof. Pedro Planas, became unquestionable; other fields of science confirm his concepts.

When looked at from a phylogenetic, ontogenetic and post-ontogenetic point of view, the oral neurophysiology is the constant beacon for the achievement of the occlusion's [dynamic equilibrium in patients of any age. In Medicine, the Technique is merely the triggering resource of the treatment's purpose, developed and accomplished in and by the patient himself[33].

V. MASTICATION AND THE MINIMUM VERTICAL DIMENSION LAWS OF DEVELOPMENT

It was through careful observation of masticatory functions that Planas established the Laws ruling the transversal, sagital and vertical development of the maxillaries (Fig. 8 and 9)[29,30,34] and, still, the Minimum Vertical Dimension[27].

If an individual develops a vicious mastication while growing up: His masticatory cycles compress, crush and grind the food using only one side. When this happens the lower jaw strikes the upper jaw, resulting in a greater sagital and transver-

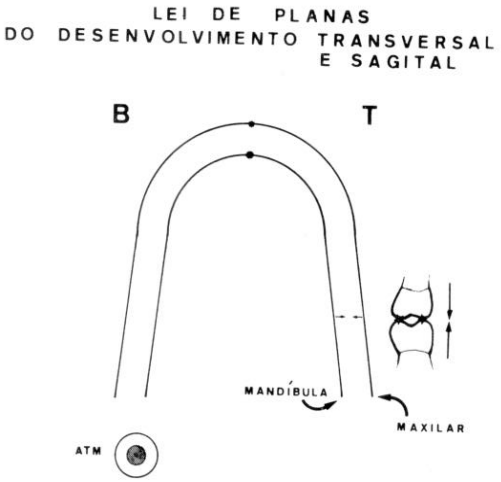

FIG. 8 Law of Sagital and Transversal Development:
"a. The condilar movement on the balancing side produces a neural excitation which provokes growth of the hemi-mandible on the same side.
b. On the working side, the excitation, provoked by the contact of the occlusal faces, stimulates the development of the hemi-arcade of the upper jaw on this side."

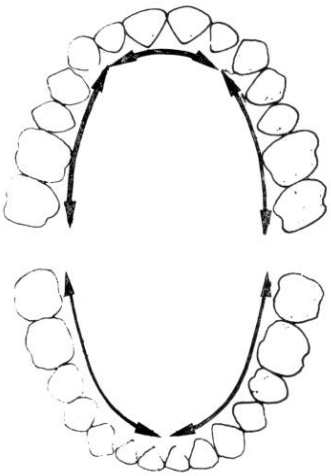

FIG. 9 Law of Vertical Development:
"a. The neural excitation of a dental piece of one group gives response to the entire group.
b. There are two groups in the mandible: teeth of the hemi-mandible right and left. In the upper jaw there are three groups: molars, pre-molars (right), molars and pre-molars (left) and incisive group. The canines belong to the posterior teeth group."

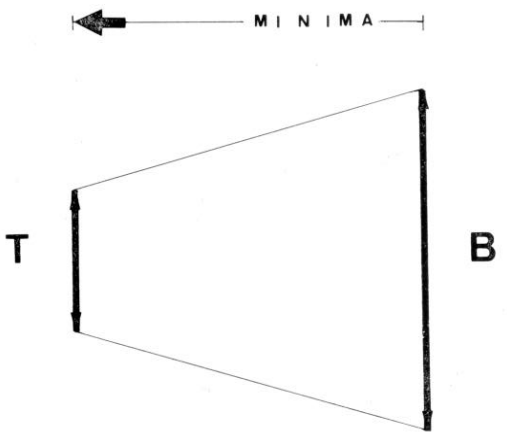

FIG. 10 In a vicious mastication the vertical dimension height is lower in the Working side. (Law of Minimum Vertical Dimension, Pedro Planas).

sal development of the upper jaw on the functional side (W side). In order to capture the bolus in the working side, the jaw moves downwards, inwards and forwards (BENET angle) on the opposite side, i.e. on the supporting side. Since the jaw is a single bone with two joints, to pierce, compress, crush and grind food on the working side, it will put more stress on the condile of side B and excite much more the TMJs of this same side. Result: a vicious mastitication, the lower jaw becomes more sagital and transversally developed on the side opposite to the bolus. This is responsible for the Medium Line Deviations, incorrectly interpreted as being caused by the position of the jaw or of the teeth, but which would be really provoked by an assymmetric growth of the maxillaries; this growth may be followed or not by a deviation of the jaws or of the teeth.

Mastication and the Law of Minimum Vertical Dimension - When the jaw do movements to reach the maximum dental intercuspidation, it will be at the cost of a greater approximation between the maxillaries[27]. Therefore, after the first contacts have been made, the maximum point of intercuspidation will be accomplished through reduction of the vertical dimension.

If can be verified that in a wrong mastication (always on the same side) the working side is always the one with a lower vertical dimension (Fig. 10).

Ⅵ. CONCLUSIONS

1. The ontogenetic and post-ontogenetic study of natural mastication shows the use of dental surfaces in an efficient mastication.

Being a mammal, Man is able to masticate. His teeth (shape, number, disposition, etc.), muscles, sensorial mechanism, saliva, etc., make this possible.

If, during his life Man had various teethings alternated between losing and gaining teeth, mastication would not be possible for it implies in using dental surfaces during a certain period of time.

Mastication carves its history upon the dental surface[3,7,21,22,26,28,30], and because of this attrition, Man teethes only once in his life[26], unlike animals (their digestion do not begin in the mouth) with several teething[10,11], Therefore, at various ages, we can find evidence of the work done by mastication carved upon the teeth surfaces.

A tooth anatomically intact, without any traces of attrition long after having erupted, shows a masticatory defficiency and interferes with the development and performance of its role in the dynamics of the Stomatognathic System.

2. The ontogenetic and post-ontogenetic study of natural mastication demonstrates how essential it is for a healthy development.

3. The study of the cycles which compose mastication, in the various planes (sagital and frontal) which we owe to men of science such as Kawamura, T. Brown, Moller, Hannam, Ahlgren, Picton, Poole, Sessle, Griffin, Harris, Munro and others, confirm the Laws of Development - sagital, transversal and vertical - of Pedro Planas[27,30].

4. The Medium Line Deviation should be interpreted having three aspects in mind, so that the best technique is chosen for each case:

a. Medium Line Deviation caused only by deviation of the teeth;
b. Medium Line Deviation caused only by deviation of the jaw;
c. Medium Line Deviation caused by assymmetric growth of both maxillaries (Planas' Laws of Development make understanding easier).

Two or more of the above may be found combined in one case.

We shall analyze for instance the cases of crossed bite, where we might find more than one of above hypothesis together, provoking Medium Line Deviation.

We shall first observe the mastication and later we shall interpret Planas' Laws. If possible, as a complement of the diagnosis, we can use Planas" gnatostathic and calcographic analysis[30,36] which may help in the choice of the therapeutics process.

Mastication is vicious in cases of crossed bite, and the working side is the crossed one. The movements of entire opening phase are totally deviated toward side B. The closing is contrary to normal: it goes from supporting side to functional side[5].

The upper jaw will be hit from outside (contrary to what normally happens), and as a result the upper jaw might atrophy on this working side. As a compensation, the jaw may adapt itself to posture patterns of deviated movements (to the crossed side), in order to avoid greater interferences. When this compensatory pathological mechanism exists (chain lesion), one notices a great sagital and transversal development of the upper jaw on the crossed side, in spite of being hit from outside, which should result in atrophy (see Planas' Laws of Development).

The mandible will get more excitation on side B, and the Hemimandible of same side will be more developed sagital and transversally (see Planas' Laws of Development).

5. The recuperation of a correct, typical and

natural mastication in our patients prevents by itself a relapse. This mastication becomes the only device of contention to be maintained after completion of the treatment.

Interpreting the posture conditions in cases of distocclusion, according to the Law of Minimum Vertical Dimension, we know that the jaw in these cases will be assuming a posterior position. In inverse cases (Class Ⅲ) it will be finding a posture more anterior, also during mastication. The cycles are different and individual, and provoke different types of gothic arches. Mastication will always be vicious and there will be and undesirable circuit of lesions, leading to an ever increasing masticatory defficiency.

Finally, in cases of bad occlusion, considering also those cases with Class Ⅰ symptoms, crossed bites, etc., or the partially or totally toothless patients, the treatment must be carried out, technically, aiming at the sensorial mechanism, therefore the dynamics of the entire system. The symptoms themselves will give the diagnosis. The techniques, in Oral Medicine, follow a neural-occlusal phylosophy, for use in modern Odontology. The results are better and longer lasting.

This means that the treatment should aim at the correction of the masticatory cycles, so that the mastication itself prevents relapse.

SUMMARY

この研究は咀嚼の個体発生的および系統発生的な現われを分析したものである．われわれは顎の矢状，側方，垂直方向への発育に関する Planas の法則を確認し，咀嚼の生物学的重要さと動的に調和のとれた咬合の重要さを確認するために，咀嚼サイクルの構成を分割して把握した．

その結果，これらの構成要素を明確に理解することが矯正学，とくに矯正学の主張の意義と矯正治療の目的を考える上で，最大の価値を示すことが明らかとなった．

BIBLIOGRAPHY

1) Ahlgren, J.: Mechanisms of Mastication. A quantitative cinematographic and electromyographic study of masticatory movements in children, with special reference to the occlusion of the teeth. Acta Odont. Scand. 24 : suppl. 44, 1966.

2) Ahlgren, J.: Kinesiology of the mandible. An EMG study. Acta Odont. Scand. 25 : 593–611, 1967.

3) Ainamo, J.: Prenatal occlusal wear in guinea-pig molars. Scand. J. Dent. Res. 79 : 69–71, 1971.

4) Ainamo, J. and Talari, A.: Eruptive movements of teeth in human adults, *In*: The eruption and occlusion of teeth, 97–106, 1975.

5) Anderson, D.J. and Matthews, B.: Mastication, Bristol, 976, John Wright and Sons Ltd., 1, 2 and 15. 1

6) Beyron, H.: Occlusal relations and mastication in Australian Aborigenes., Acta Odont. Scand. 22 : 597–678, 1964.

7) Box, H.K.: Significance of wear, Oral Health 29 : 387, 1939.

8) Berry D.C. and Poole, D.F.G.: Masticatory function and oral rehabilitation, J. Oral Rehab. 1 : 191–205, 1974.

9) Campbell, T.D.: Dentition and Palate of the Australian Aboriginal, lst ed, The Hassell Press, Adelaide, 1925.

10) Davis, D.D.: Origin of the mammalian feeding mechanism, Amer. Zoologist, 1 : 229–241, 1961.

11) Darian-Smith, I.: The Trigeminal System, *In*: Albe-Fessard, D. *et al* ; Somatosensory System, 9 : 271–273, Ed. by Ainsley Iggo. Springer-Verlag, Berlin, 1973.

12) Gibbs, C.H., Messerman, T., Reswick, J.B., and Derda, H.J.: Functional movements of the mandible, J. Prosth. Dent, 26 : 602–620, 1971.

13) Gillins, B.R.D., Graham, C.H., and Duckmanton, N.A.: Jaw movements in young adult men during chewing, J. Prosth. Dent. 29 : 616–627, 1973.

14) Hermann, H. and Cier, J.F.: Précis de Physilogie; 4 ed., Paris, Masson, vol. 1, 4 : 37–59, 1976.

15) Hildebrand, G.Y.: Studies in the masticatory movements of the human lower jaw, Scand. Arch. Physiol. suppl. 61, 1931.

16) Kawamura, Y. and Fujimoto, J.: A study on the jaw opening reflex, Med. J. Osaka Univ. 9 : 377–387, 1958.

17) Kawamura, Y., Funakoshi, M., and Takata, M.: Reciprocal relationships in the brain stem among afferent impulses from each jaw muscle on the cat, Jap. J. Physiol. 10 : 585–593, 1960.

18) Kawamura, Y.: Mecanismos Sensoriais de retro-alimentação; Trad. W.A. Simões. Encarte Científico no 1. Ano 1 - Jornal APCD, São Paulo, 1975.

19) Kawamura, Y.: Role of sensory factors in chewing and feeding behavior. Dental neural control of eating and obesity. Pharm. Bioch. and Behavior, 3, (Suppl. 1) : 163–173. Ankho Int. Inc., 1975.

20) Kawamura, Y. and Abe, K.: Role of sensory information from temporomandibular joint, Bull Tokyo Med. Dent. Univ., 21 (Suppl.): 78–82, 1974.

21) Lammie, G.A.: Dental Orthopaedics. 4 : 31–34; 6 : 48–51, 11 : 109–117, 12 : 118–155, The Alden Press, Oxford, 1966.

22) Lavelle, C.L.B.: Applied Physiology of the mouth. Bristol, John Wright and Sons Ltd., 5: 114. 7 : 175–179. 10 : 202, 205–207, 227, 230, 1975.

23) Murphy, T.: Control of the pressure strokes at the temporomandibular joint. Austr. Dent. J. 1 : 276–287, 1956.

24) Murphy, T.: The timing and mechanism of the human masticatory stroke, Arch. Oral Biol., 10 : 981–993, 1965.

25) Møller, E.: Frontiers of Oral Physiology, 1: 134, 151–152 (Karger Basel, 1974)
- Human Muscle patterns. *in*: Sessle, B.J. and Hannam, A.G. : Mastication and Swallowing, 128–138, Univ. of Toronto Press, 1976.

26) Provenza, D.V.: Fundamentals of oral Histology and Embriology. S.A.S., J.B. Lippincott Co., 3 : 94–106, 1972.

27) Planas, P.: La Ley Planas de la Mínima Dimension Vertical. Rev. Española de Parodoncia, 6 : 215–247, 1968.

28) Planas, P.: Rehabilitacion neuro-oclusal. XLIV Congreso dela Sociedad Francesa de Orthopedie Dento-Facial. Lyon, May 1971, 333–347.

29) Planas, P.: As Leis de Planas, pistas Planas e o Equiplan. O Incisivo XV: 4 e 5 (Trad. Dra. Wilma A. Simões), 1975.

30) Planas, P.: Gênesis de la Rehabilitacion neuro-oclusal. la. ed. Ed. México, 397 p., 1972.

31) Planas, P.: La thérapeutique orthodontique la plus précoce. L'Orthodontie Francaise, 48 : 177–185, 1977.

32) Simões, W.A.: Propriocepção, Exterocepção e Aparatologia de Bimler, Fränkel e Planas. Ortodontia 7 (2): 153–161, mai/ago., 1974.

33) Simões, W.A.: Alguns recursos de neurofisiologia oral aplicados na prática das técnicas ortopédicas funcionais. Ortodontia, São Paulo, 11(1) : 9–17, Jan/abril, 1978.

34) Simões, W.A.: Prevenção das Oclusopatias. Ortodontia, São Paulo, 11(2) : 117–125, mai/ago., 1978.

35) Simões, W.A.: Fundamental principles and basic characteristics of functional orthopedic techniques. Int. J. Dent. Med. 6 (1) : 107–115, 1977.

36) Simões, W.A.: Ortodontia. *in*: Alcantara, Pedro de, e Marcondes, E. : Pediatria Básica, 2 (5) : 1307–1331, 3a. ed., 1970 e 1974, Sarvier, São Paulo, Brasil.

37) Takata, M., Ito, K. and Kawamura, Y.: Inhibition of Hypoglossal Motoneurons by stimulation of the jaw-opening muscle afferents, Jap. J. Physiol., 25 : 453–465, 1975.