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Impact of mastication on maxillofacial morphology and on the construction of the occlusion

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Abstract

Mastication, one of the functions performed by the manducatory apparatus, constitutes a real «functional matrix» to stimulate the growth of the jaws and dental arches. Its physiological development, unilateral and alternating, in the presence of an untenderized natural food, will progressively shape and level the occlusal reliefs, facilitating mandibular movements, but also adapting the size, shape and position of the dental arches, leading them to a normal and sufficient development to progressively allow the arrival of all the permanent teeth in a correct morphological and functional occlusion.

In our modern civilization of the «premade», the muscular masticatory solicitations are insufficient and induce numerous orthodontic disorders.

In fact, many malocclusions that already occur in temporary or mixed dentition are the result of impotence or functional alteration of mastication from a very young age, often in the face of a modern, inconsistent or semi-liquid diet.

Keywords: Mastication; Maxillomandibular growth; Construction of occlusion; Mmalocclusions

1 Introduction

Maxillofacial growth depends on both: the base of the skull (to which it is appended) and its chondro-cranial facial expansions, and therefore on genetic and constitutional conditions [1, 2, 3, 4], and on the growth of its own bones, also influenced by loco-regional conditions, particularly muscular and functional [3, 4].

It is thus easy to understand why the face is the result of the "transmitted" and the "experienced" and therefore:

- So variable according to the individuals ;
- Partially predetermined by origin, type, family... ;
- So frequently affected by dysmorphosis whenever there are dysfunctions;
- Sensitive, withinpreciselimits, to functional and orthopedic actions (of certain appliances), providedthatthese are early and welladapted.

At the level of the orofacial sphere, there are several functions that can disrupt the craniofacial developmental pattern. The fact that our study focuses on mastication should not obscure the fact that they are fully interactive.

The main functions are:

- Ventilation, phonation...;

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- And the motor functions of manducation which have the particularity of appearing progressively in time.
- Thus, chronologically, in the fetus, sucking then swallowing appear. At birth, sucking-swallowing is operational. And finally, "mastication" appears [5].

In addition to the fact that mastication is necessary for human beings to feed themselves, it is, as we shall see later, a means of ordering the teeth arranged in arches and it conditions their stability throughout life.

For Raymond [6], occlusion cannot be dissociated from the architecture of the dental arches and their primary function, mastication.

Studies carried out by certain authors (Kiliaridis, Mavropoulos, etc.) confirm the impact of the mastication function on craniofacial morphology and the important role of modern dietary habits in the appearance of malocclusions.

This work is proposed to discuss the current knowledge on the mastication function and its responsibility in a number of pathologies.

2 Development of the mastication function

The nutrition praxis of the newborn consists of sucking-suckling-swallowing. To feed from the breast or bottle, the baby performs this function in the anterior oral mode. This visceral activity is completed by mandibular movements that are strictly symmetrical in relation to the median sagittal plane [7].

Sucking-suckling-swallowing is ephemeral, 20 months in non-industrialized societies and hardly more than 6 months in our industrial societies. However, during this short period of time, the mandible develops in a way that it never does again [8].

A study [9] has shown that the rate of retromandibulia in a group of Bolivian Indians who have retained this method of breastfeeding is less than 10%, compared with almost 50% in our modern societies.

With the advent of solid food and the eruption of teeth, the sucking and swallowing practice will be progressively abandoned in favor of alternating unilateral chewing.

For Gaspard [5], "*man is not born a chewer but becomes one*" and a long period of learning is necessary before the appearance of chewing.

Around the fifth month of post-natal life, the infant, without visible teeth, begins to perform a few iterative chews, indifferently to the right or to the left, by rubbing the lower gingival pad against its upper antagonist, at the points where the teeth will appear. The mandible then begins to move diagonally and the antimother muscles no longer contract identically (as in breastfeeding). All this kinematics prefigures, with a lesser amplitude, that of unilateral alternating mastication.

True mastication develops after the evolution of the temporary teeth when the first occlusal keys are established.

This mastication is rapid and the masticatory type is stable and well coordinated at around 4 or 5 years of age according to Lund [10], Le Révérend[11] and soboleva[12] or during the occlusion of the first molars according to Le Gall [13] and Lucend[14].

Between the ages of 3 and 6 years, the temporary teeth wear out and the attritional occlusion is a sign of the efficiency of mastication. This attrition allows the unlocking of occlusal obstacles that limit mandibular lateral movements.

However, it is important to note that a child who has been fed liquid foods, porridges and mincemeat during the period of acquisition of unilateral alternating chewing may have the correct transition from unilateral alternating mouthing to unilateral alternating chewing compromised. This may lead to the lazy adoption of bilateral chewing which will cause the child to prefer the ingestion of foods that do not require grinding (puree, yoghurt...).

It is clear to what extent the masticatory function, which of course depends on the anatomical and physiological characteristics of the individual, also depends to a large extent on the physical and rheological characteristics of the food [15].

Thus, a hard, dry diet contributes to the development of physiological, unilateral and alternating mastication with a distribution of stress on the right and left sides. In contrast, a soft diet is likely to encourage the development of pathological mastication.

3 Forces delivered during mastication

During mastication, the force developed by the elevator muscles varies greatly depending on the subject, the food and the measurement methods [16, 17, 18].

The forces deployed in normal subjects range from 25 to 50 kilograms. Forces of 150 kilograms have been reported in Eskimos and some bruxism patients.

However, these forces are not evenly distributed along the dental arches. In fact, some "too hard" foods cannot be crushed between the teeth of the anterior sector, whereas they can be crushed in the premolar-molar sector.

Furthermore, using mathematical calculations, Gaspard [19] demonstrated that the forces developed during alternating unilateral mastication are twice as great as those deployed during bilateral mastication, the author adds: "*this is why the action on morphogenesis is more important in unilateral than in bilateral mastication*".

4 Impact of mastication on craniofacial morphology

For Planas[20, 21], whatever the genotype, on which for the moment we do not know how to act, development requires normal paratypical stimuli to achieve a physiologically good result.

If the paratypical influences are insufficient or in excess, for example not enough or too much mandibular propellant muscle activity, the resulting phenotype will be abnormal.

Planas imagined a pair of monozygotic twins that would be separated, raised in very different climates and with very different diet and masticatory function, and he states that they would have very different phenotypes.

After the Hitler debacle, more than twenty pairs of monozygotic twins were reunited by the International Red Cross. It was observed, after comparing these twins, that all pairs were very different, and the heights of the twins often differed by 20 centimeters!

This proves that the environment and the functions have a determining morphogenetic part, besides the genes.

The articles of Cohen-Levy [22, 23] confirm that the growth of the face depends on genetic, constitutional conditions and the growth of its membranous bones, influenced by muscular and functional conditions.

This shows the validity of the notion of “adaptive growth” without which it would be impossible, whatever the device used, to influence the growth of the jaws.

This adaptive morphogenesis requires constraints, which must be sufficiently repeated and intense. Triggered by functioning organs i.e. by the local paratypic factors, they are perceived by the proprioceptive sensitivity which leads in return to an adaptation response.

Adaptive growth has a vector which is « the chondroid tissue ». Lengele[in 6], showed that the ontogenesis of membrane bones always begins with the deposition of a chondroid primordia. The edges of the cranial sutures of the newborn and the facial sutures are abundantly provided with them. There are also large nodules at the level of the alveolar processes of the maxillary and premaxillary bones which seem to adaptively follow the expansion of the dental germs.

Delaire[24], showed in his article “Considerations on facial growth”, that craniofacial sutures are both force breakers and *« marvelous dilatation joints with automatic adjustment by adaptive conjunctiva proliferation and marginal ossification »*.

For Raymond [6], the functional role of the “force breaker” is crucial given the importance of the constraints delivered by mastication.

Each of these constraints is perceived by the mechanoreceptors with which the cranial sutures are very abundantly provided and causes mobilization of the suture.

In infants, breastfeeding at the breast leads to a direct separation of the edges of the intermaxillary suture, a source of development with secondary adaptive ossification.

After the establishment of mastication, the constraints triggered by the chewing functions on the sutures will be transmitted via the mechanoreceptors of the temporomandibular joint, the elevator muscles and the periodontium and lead to the appearance of chondroid tissue.

4.1 Mastication and basic research

The role played by mastication in craniofacial development has aroused the curiosity of fundamentalists who have also questioned its impact on the health of the masticatory system.

Experiments [25, 26] on animals and numerous clinical studies have shown that the forces delivered by the masticatory muscles during mastication stimulate bone apposition and sutural growth in the maxilla and alveolar processes resulting in wide arches[27].

Furthermore, increased masticatory muscle function [28] is often associated with an anterior growth pattern of the mandible [29].

Studies [30, 31, 32, 33, 34]done on animals fed a soft diet show a reduction in maxillary and mandibular width as well as very little craniofacial growth.

In contrast, significant bone apposition has been observed in the vicinity of the insertion of the elevator muscles such that the bone is able to withstand the high forces delivered by the masticatory system during mastication in animals fed a hard, fibrous diet [35, 36, 37, 38].

Several studies [39, 40] carried out in children and adults have shown a significant correlation between the activity of the masticatory muscles (masseter in particular) and vertical facial morphology.

4.2 Mastication and growth

The principle of Claude Bernard (1813-1878): «*the function creates the organ and the organ adapts to the function* » is the basis of much of Planas' philosophy. Planas perfectly described the impact of dietary functions on maxillomandibular morphology in his developmental laws.

During the postnatal period [20, 21], the physiological act of breastfeeding stimulates the TMJ, leading to the development of the stomatognathic system.

Breastfeeding requires significant muscular activity from the baby and precise synchronisation of the various functions that it requires: sucking, swallowing and ventilation.

This function will call upon the lateral pterygoids which, through their meniscal insertion, will lead to an adaptive growth of the condyle. As the traction and sliding of the meniscus are carried out simultaneously on both sides, the mandibular growth will be total, i.e. bilateral.

Thanks to this mechanism, the infant will not only correct his natural mandibular retrognathia, but will also develop his middle stage through the nasal breathing that he performs simultaneously. The growth response will be much lower with the use of the feeding bottle.

After the appearance of the teeth and the establishment of unilateral alternating mastication, mandibular growth will no longer be bilateral but unilateral and will occur only on the orbiting side or rather on the non-working side.

On the working side, the condyle, which only performs a rotational movement, will not lead to a growth response, but on the orbiting side, the condyle performs a translational movement and it is this translational movement which, by pulling on the retromandibular ligament, will lead to an adaptive growth response, which will then only interest the homolateral hemi-mandible. Simultaneously, the occlusal friction of the teeth of the lower hemi-arcade, working against their upper antagonists, will lead to a mechanical stimulation of the periodontal receptors responsible for an adaptive growth response in the form of enlargement and advancement of the upper jaw on the chewing side.

Thus, a chewing movement to the left will induce:

- An elongation of the right hemi-mandible.
- A widening and advancement of the left hemi-maxilla.

If mastication is unilateral and alternating, the two phenomena compensate each other alternately so that one has the impression that nothing has happened.

If mastication is not, as in primitive man, in alternating laterality, as a result of the modern, more or less soft and tender diet, it often takes place in opening-closing: this movement leads mainly to rotations of the condyles on themselves and so little meniscal and condylar protraction that the mandibular development no longer receives the stimuli necessary for its full development.

The opening-closing mastication or Walter's movement **(Fig. 1)** is not « functional » for Planas[20], but rather a parafunction.

Moreover, as lateral movements disappear, any stimulus capable of soliciting maxillary transverse growth ceases to act: the perversion of the masticatory function by its under-use leads to an under-development of the dental arches.

The result will be the appearance of certain malocclusions. In individuals with this type of mastication, we find a very deep Spee's curve and condyles that are often huge with very steep right and left condylar slopes. This functional impotence is of course a cause of temporomandibular disorders (TMD) and/or periodontal problems.

Figure 1 Opening-closing mastication

In other cases, the mandible does not function in the alternative laterality, due to dental pain, for example: if this pain persists long enough, the habit is acquired, and a frequent clinical picture will result.

There is indeed protraction of the condyle on the non-working side, and therefore growth stimulus, but only on this side, since the working side never propels itself: the hemi-mandible on this side therefore has a lack of growth stimulus, while the orbiting side is excessively solicited and creates, by lengthening too much, a mandibular asymmetry.

This is how a right unilateral mastication, for example, will lead to an overgrowth of left condylar origin, while the right side of the mandible will see its growth diminished or interrupted **(fig. 2)**.

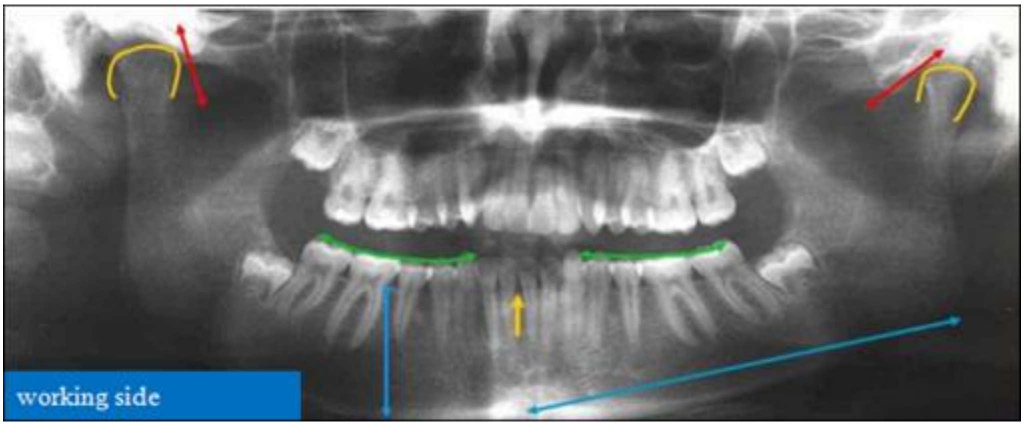

Figure 2 Development of the mandibular arch: mastication on the right

But the maxillae will also suffer as a consequence: due to the same habitual right mastication, the right maxilla develops more forward and outward, but the left does not, resulting in asymmetry with deviation of the median line **(fig. 3)**. «*The more lame mastication persists, the more the asymmetry worsens both in the maxilla and in the mandible*»[20, 21].

Figure 3 Deviation of the lower inter-incisal point to the right, i.e. on the working side, and a deviation of the upper inter-incisal point to the left, on the non-working side

Unilateral mastication will also affect the orientation of the occlusal plane, which will rise in its anterior part on the working side and fall in the same area on the non-working side.
The description of this unilateral mastication syndrome **(fig. 4)** was first presented by Planas[41], and was taken up in 2002 by Catalina Canalda[42] and Jean Louis Raymond in 2006 [43].

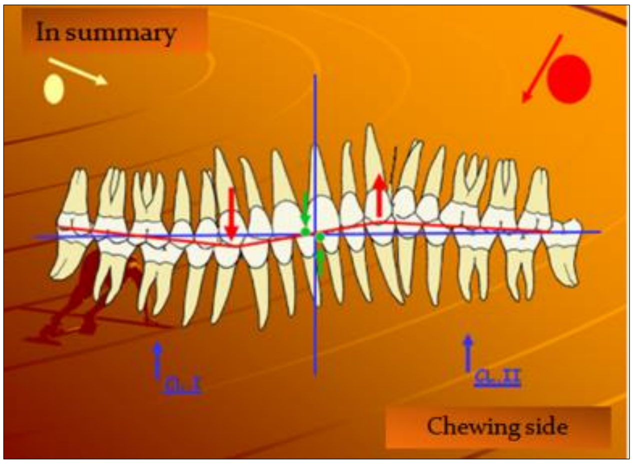

Figure 4 Left unilateral mastication syndrome

5 Mastication and construction of the occlusion

For Raymond [6]: « the occlusion is the emerging anatomical part of the dental arches whose shape is the result of the multiple interactions of the elements of the masticatory system caused by mastication».

This definition is rich in meaning. In addition to specifying the structural origin of occlusion, it highlights the fundamental preponderance of mastication in its construction. It is because mastication solicits the movement that confronts the elements of the masticatory system and that it dispenses forces that the morphology of the arches is organised.

By emphasising the functional nature of occlusion, this definition also suggests the possible implications of mastication in certain pathologies.

Occlusion is therefore the image of mastication and its eminently functional nature is intrinsic. It is, in a way, the materialization of this intimate relationship between form and function.

6 Masticatory function and malocclusions

Until fairly recently, human populations had well-aligned dental arches. Epidemiological data show that the decrease in tooth wears and the increase in malocclusions (skeletal Class II, dental crowding...) have taken place at the same time as the adoption of a modern lifestyle [44].

Anthropological studies [44, 45, 46, 47], have shown the low frequency of malocclusions in populations with primitive living conditions. While the frequency of malocclusions has increased considerably in populations living under the influence of industrialized civilisation[48].

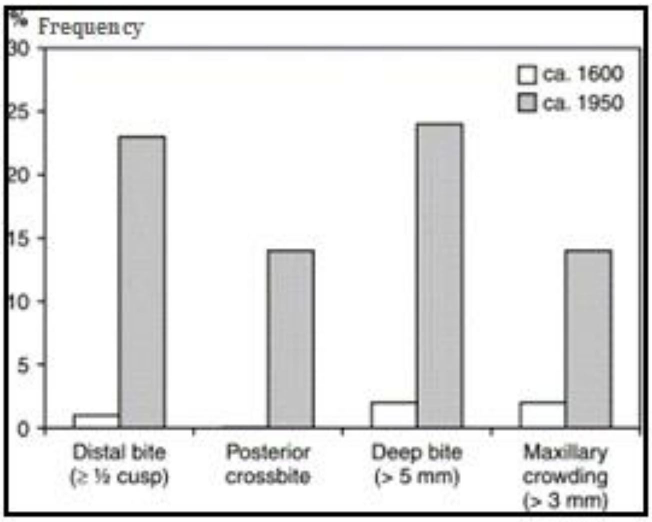

Figure 5 Frequencies of distal bite, posterior cross bite, deep bite, and maxillary crowding in Finns born around the year 1600 and around 1950[44]

Begg[47] was the first to attempt to explain the role of masticatory activity in the development of malocclusions, after studying the dentitions of Australian Aborigines.

The Australian Aboriginal way of life, observed by Begg, shows the connection between an untenderized diet, attritional occlusion, and well-developed jaws. These aborigines do not suffer from dental alignment problems, the eruption of third molars is even made possible thanks to a mesial migration of all the teeth following significant interproximal wear. Children, at the age of 6 years, show worn cuspal tips, no crowding and an end-to-end position of the incisors.

Loreille[45], shows that the jaws of the Altamira men, living 14,000 years ago, are wide and harmonious, they present muscular insertion surfaces which are true ridges. No notable alignment problems were observed and an end-to-end occlusion was found in adults by the mechanism described by Begg; the inter-proximal abrasion of the dental surfaces caused the transition from an interlocking occlusion to an end-to-end occlusion.

Finally, Corruccini[49] suggests that occlusal disturbances in modern humans exist because of insufficient jaw growth. According to this hypothesis, the hard diet requires vigorous chewing which in turn stimulates the growth of the facial bones, in particular the transverse growth of the maxilla and mandible.

Thus, the masticatory work that was done with natural meat, wholemeal bread, vegetables and chewy fruit has gradually disappeared, requiring very little masticatory movement, thus depriving children of functional stimulation for the growth of the masticatory system.

In addition, the increased consumption of sugars leads to the development of caries. This excessive consumption has a very harmful effect on chewing behaviour, because it is enough to consume very little to satisfy energy needs [50].

The hardness of the food is reduced and the energy content of the food is increased at the same time. So if food is more energetic, we only need to consume less of it to satisfy our calorie needs, which further reduces the chewing time required. In addition, when provided in a softer form, these foods will require very little chewing.

An important clinical implication of the data reviewed above is that chewing function has an important role in increasing occlusal variability and thus in the etiology of malocclusions, which has led to **an increase in the orthodontic population.**

7 Conclusion

Even today, many practitioners are unaware of the close relationship between mastication and occlusal construction, and even worse, it is simply excluded from the possible causes of certain disorders.

Chewing influences the shape of the arches and the arrangement of the teeth. The alveolodental micro-adjustments triggered and repeated during each meal shape the morphology of the arches over time.

The adaptation of the position of the teeth and the shape of the arches to the mode of mastication means that mastication organises and builds the occlusion.

With an inappropriate diet, at each meal, the organisation of the arches is undermined and undergoes a tiny but real disorganisation.

Successive disorganisations take place at each meal depending on its composition. These disruptions are integrated into the form, in other words recovered as an organising factor by the masticatory system through alveolodental adjustments.

We have seen that mastication has a very important role in maxillofacial development. Knowing that an alternating unilateral mastication is the one that allows the most harmonious development of the maxillae, we believe that the early treatment of this function allows the craniofacial structures to adapt to a now physiological mastication, thus catching up with the growth delay thanks to the time they have.

On the other hand, any orthodontist concerned with the interests of his patients knows that at the end of his orthodontic treatment, he must not be satisfied with an anatomically normal occlusion, he must also think of the second factor of the occlusal binomial: the function.

Sometimes an oversight is of no consequence [51]: after a few months of break-in, form and function adapt to each other to recreate a morpho-functional harmony.

In other cases, the discrepancy between the mandibular function and the occlusal arrangement (established by the orthodontist) becomes more pronounced and progressively worse.

The result is a state of morpho-functional disharmony which will lead to recurrences and, in a more or less short time, to lesions at any point of the masticatory system or of the neighbouring systems which act in co-function with it.

For Chateau and Planas[20, 21], a rehabilitated mastication function ensures incomparable post-orthopedic and post-orthodontic stability because we use «*the same means as Nature, when it is not disturbed*». Thus, restoring physiological unilateral alternate mastication ensures the durability of the treatment undertaken.

Given the knowledge outlined in this article, we believe that mastication is often involved in the development of certain malocclusions. In some cases, it may be the causative agent, in other cases it may be the aggravating agent.

The lack of knowledge of the masticatory function could be detrimental to our therapeutic effectiveness.

Compliance with ethical standards

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Disclosure of conflict of interest

I declare that there is no conflict of interest regarding this article.

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