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Electromyographic and cephalometric correlation with the predominant masticatory movement

Maria Julia P. Coelho-Ferraz, Fausto Berzin, Cesar Ferreira Amorim, Fabio Lourenco Romano, Dagmar de Paula Queluz

SUMMARY

Objective. This study aimed to evaluate the chewing muscular dynamics and correlate the side of the masticatory movement that is more vertical and/or more horizontal established by the photomeasurement Masticatory Functional Angle (MFA) to the muscular activity behavior, showed in the surface electromyography and in the radiographic images.

Material and method. Seventeen people were selected of both genders, with the average age of 25 years, without signs or apparent symptoms of masticatory muscular disorders. The teleradiographies were done in lateral norm and surface electromyography of the masseter muscles, anterior portion of temporal and supra-hyoids in rest position and maximal bite. The bite force measured with a metallic transducer that was connected to a force sensor (Strain Gauge) to measure the deformation of the material model SF4 (EMG SYSTEM DO BRASIL). A mandibular goniometer of the EMG System of Brazil was used to measure the opening size. Results: The comparison and correlation were established between the groups with MFA>5° and MFA<5° by the t-test of Student or test of Mann-Whitney conform the distribution was normal or not, respectively. The results showed significant differences between groups, although without sexual dimorphism, to masseter muscle in maximal bite.

Conclusion. In conclusion, the anatomic-physiological aspects of temporomandibular disorders are related to the asymmetrical mandible function.

Key words: mandible biomechanics, electromyography, cephalometry.

INTRODUCTION

The knowledge about the anatomical and physiological aspects of the dynamic of the masticatory muscles is important for the comprehension of the effects of the mandible biomechanics on the growing and development of the craniofacial complex, serving as a base for the therapeutic planning and understanding of the variations of the development and their relationships with the results reached by the Maxillary Functional Orthopedics treatment and/ or Orthodontic, as well as disciplines, such as Phonoaudiology and Physiotherapy [1-3].

Yamashita, et al. [4] (1999) presented a review of literature relating the masticatory pattern with its performance. It was concluded that the human masticatory behavior is one of the most complex, requiring adjustment and tong coordination, along with facial and masticatory muscles with the individual differences of occlusion and articular morphology present. It was reported that there is no ideal masticatory pattern, which can be used clinically or in research, to evaluate the health of the masticatory system or predetermine the masticatory performance, being useful to measure it according to the texture and the size of the food as element of evaluation.

Several authors related the mandible biomechanics with the study of levers with fulcrum in the temporomandibular articulation (TMA) [5-11]. The importance of analyzing the mandible in the frontal projection showing that the elevator muscles in the side of work generate more strength than the balanc-

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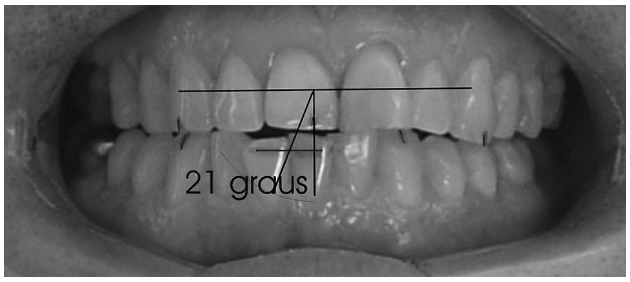

Fig. 1. Right MFA

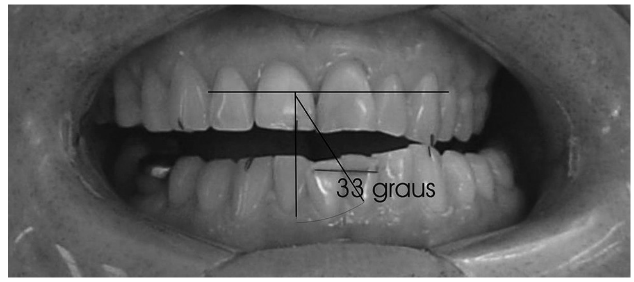

Fig. 2. Left MFA

ing side, being the resultant of the muscular strength located next to the middle line, receiving more load the condyle of the balance side [5-7].

Considering the importance of the study of craniomandibular biomechanics related to the system of levers and the relation among functions and deformations mechanically induced, this study aimed to evaluate the chewing muscular dynamics and correlating the masticatory movement side that is more vertical and/or more horizontal established by the photomeasurement Masticatory Functional Angle (MFA) to the muscular activity behavior, showed in the surface electromyography and in the radiographic images.

MATERIAL AND METHODS

The materials for the research were used in accordance to the standards of the Health Ministry under the resolution number 196/96 of National Health Council and the study was approved by the Ethics Committee in Human Research of the Piracicaba Dental School, UNICAMP/Brazil(Process number 133/2005).

For this study were chosen seventeen subjects of both genders with an average age of 25 years, selected of a total of approximately 250 volunteers linked to the Piracicaba Dental School (UNICAMP). Some previous written authorization was asked to the volunteers evaluated by anamnesis and dental clinical examination. Data related to symptomatology, parafunctional habits, general health and psychological and emotional factors were taken into consideration. As far as symptomatology is concerned, the presence of pain in the right or/and left TMA, as well as the presence of noises or clicks, along with limitation in TMA during the masticatory movements were taken into account. When the frequency or persistency of these factors were observed, the person was excluded. Thereafter, followed the obtaining of the photomeasurement to appoint the predominant masticatory movement, more horizontal and /or vertical to obtain the Masticatory Functional Angle (MFA) based on to described by Posselt [12] in frontal plan (Figures 1, 2), followed by the acquisition of teleradiography in lateral norm with Hyoid bone cephalometric analysis (Figure 3) and electromyography of the masticatory muscles.

The electromyography data was obtained, bilaterally, of the masseter muscles, anterior portion of temporal and supra-hyoids in rest position and maximum bite. Surface passive electrodes for kids of Ag/AgCl, circular format, dischargeable of Meditrace® Kendall-LTP, model Chicopee MA01 were used and attached to a pre amplifier with gain of 20 times forming a differential circuit. The records of the electric signals were captured by the equipment EMG-8OOC of EMG System of Brazil Ltda of eight channels, frequency of 2KHz and 16 bits of resolution, digital filter with pass band of 20 to 500Hz.

The bite force was measured with a metallic transducer that was connected to a force sensor (Strain Gauge) to measure the deformation of the material model SF4 (EMG SYSTEM DO BRASIL). The data was submitted to statistical analysis by the program SPSS 11.0.4 to Mac OsX (Chicago, IL, EUA). It was adapted, clinically, the best value for the difference of the MFA in 5°, being the group classified in: altered vertical and horizontal masticatory movements and bilateral to MFA<5° and predominant vertical or horizontal masticatory movement to MFA>5°, through the ROC Curve (Figure 4). Establishing the Pearson's or Spearman's correlation between the differences of the variables and comparison among the groups with MFA>5° and MFA< 5° through the Student´s t test or Mann-Whitney test according to the distribution being normal or not, respectively.

RESULTS

The calculation error verified that there was no significance among the moments evaluated denoting reliability in the traces and cephalometric measurement.

It was adapted, clinically, the best value for the difference of MFA in 5°, being the group classified in: vertical and horizontal and bilateral altered masticatory movement to MFA<5° (41%) and predomi-

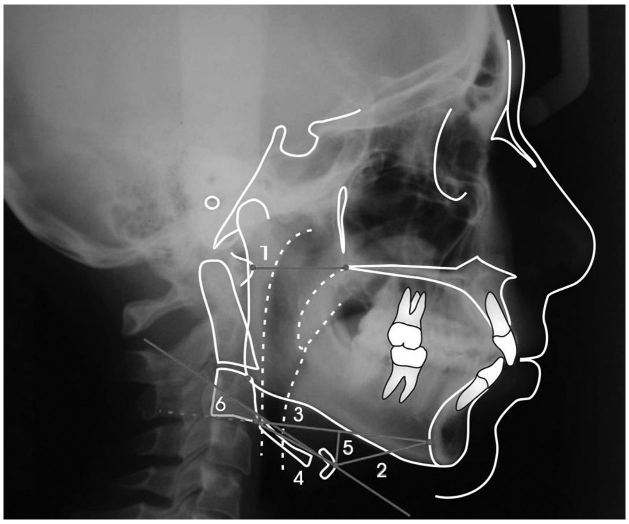

Fig. 3. Hyoid triangle:
1 – AA-PNS: distance between the atlas vertebrae to posterior nasal spine;
2 – H-RGn: distance between the hyoid bone to mandible;
3 – C3-RGn: distance between cervical spine to mandible;
4 – C3-H: distance between cervical spine to hyoid bone;
5 – H-H': vertical distance of hyoid bone;
6 – HPH: hyoid plan angle.

nant vertical or horizontal masticator movements to MFA>5° (59%).

The test "t" for independent samples was used to know if there is difference of the variable studied that presented normal distribution (parametric) among the individuals of female and male gender. The average differences were significant for the radiographic variables H-H' and C3-H with level of significance established in 5% (Table 1).

The Mann-Whitney test was used to compare, among the individuals of male and female gender, the average of those variables which presented non-parametric distribution with level of significance established of 5%, presenting a difference to the cephalometric variable C3-RGn (Table 2).

The test "t" for independent samples was utilized to know if there is a difference of the variables studied that presented normal distribution (parametric) among the individuals who had MFA>5 and MFA<5, presenting differences among the averages of the electromyography variables of the masseter muscle in the task of maximum bite with level of significance established of 5% (Table 3).

The test of Mann-Whitney was utilized to compare, among the individuals with MFA>5° and MFA<5°. The average of those variables which presented distribution non-parametric, without differences to the level of significance established of 5% (Table 4).

A strong correlation between the masseter muscles with the bite force (r=0.63, p= 0.0001) occurred for the group with MFA>5° (Table 5).

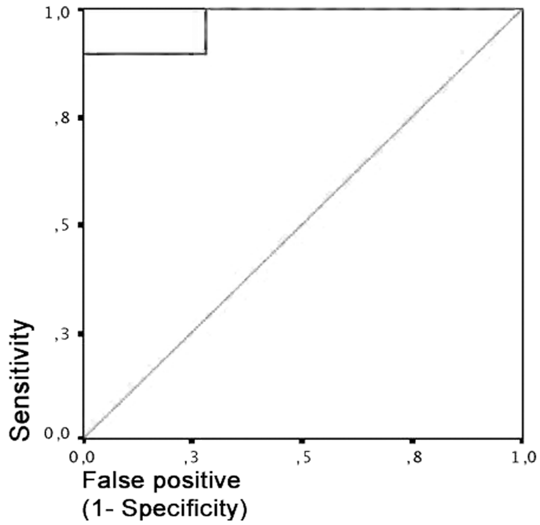

Fig. 4. ROC curve determining the rate of 4.66 (5°) is the best value to delineate the type of predominant masticatory movement

DISCUSSION

The option in this study was to evaluate the mandible biomechanics based on the study of the levers in individuals of both genders, with complete permanent dentition, with no Orthodontics or Maxillary Functional Orthopedic for the last ten years, with the aim of minimizing possible intercurrences of functional adaptation in the mandible dynamics.

Our study showed that the evaluation of the hyoid triangle, the vertical behavior of the hyoid bone was significantly more inferior in individuals of the male gender, confirming the findings of King [14] and Kollias & Krogstad [15]. The same occurred with the linear measure C3-RGn related to the morphology of the skeleton, agreeing with Coelho-Ferraz, et al. [1, 2], and disagreeing with Bibby & Preston [13] who didn't find sexual (dimorphism) differences.

At the time of the evaluation of the bite force, the results of this work showed that the group with MFA<5° (38,70±10,88) presented higher values and more significance related to the group with MFA>5° (27,28±11,40), showing not sexual dimorphism. A strong and significant correlation occurred only for the group with MFA<5° of the supra hyoid musculature in isometric with the bite force (r=0.70, p=0.05) and with the maximum opening (r=0.90, p=0.0001). Those differences could be explained by the feedback mechanism of the periodontal and by the balance of the muscular activity of both sides, being in accordance with several studies [16, 17]. Adjusting for this study, it is expected that the group with MFA<5°, that has the independent norm occlusion of the facial type, makes a balance in the condylar trajectories with the horizontal and vertical movements, ie, all of the teeth take part in mastication, altering the trajectories of balancing and work function. Those also corroborate the records of Bomjardim, et al. [18] and Lemos, et al. [19] who reported that the bite force is one of the components of the masticatory system, performed by elevator muscles and regulated by the nervous, muscular, bone and dental systems. Significant differences among the variables that define the electrical activity in maximum bite of the masseter muscle (174.16±49.67 and 116.41±51.11) and maximum intercuspation (40.04±11.82 and 26.86±11.70) for the group with MFA<5° and MFA>5°, respectively, are added to this mandibular dynamic.

A strong correlation between the masseter muscles with the force bite (r=0.63, p=0.0001) oc-

Table 1. Mean value and standard deviation (SD) of the electromyographic and cephalometric variables and Student´s t-test between the male and female subjects

Variables	Gender	Mean	SD	p-value*
RMS masseter in maximum bite	male	20.13	4.84	0.06
	female	16.44	4.94	
RMS temporal in maximum bite	male	110.95	60.41	0.27
	female	105.13	30.21	
Bite Force	male	36.81	9.89	0.78
	female	56.30	4.54	
C3-H	male	37.95	4.12	0.0001*
	female	33.15	2.48	
HRGn	male	34.75	2.53	0.47
	female	35.75	5.38	
H-H'	male	10.95	4.80	0.001*
	female	4.06	5.30	
HPA	male	14.95	6.13	0.09
	female	11.31	5.47	

* – p<0.05

Table 3. Mean and and standard deviation (SD) and Student´s t-test between MFA>5° and MFA<5° groups

Variables	MFA	Mean	SD	p-value*
RMS masseter in maximum bite	>5	116.41	51.11	0.002
	<5	174.16	49.67	
RMS temporal maximum bite	>5	96.66	32.61	0.17
	<5	115.89	45.37	
Bite Force	>5	27.28	11.40	0.005
	<5	38.70	10.88	
C3-H	>5	34.03	2.52	0.43
	<5	35.03	4.56	
H-RGn	>5	36.16	5.41	0.42
	<5	34.83	4.04	
H-H'	>5	5.97	6.18	0.92
	<5	6.19	6.02	
PHA	>5	11.97	4.47	0.70
	<5	12.75	6.93	

* – p<0.05

Table 2. Mean Rank and Mann-Whitney´s test between the male and female genders

Gender		Mean	SD	p-value*
RMS Supra-hyoid isometric	male	17.20	0.80	
	female	16.18		
RMS masseter rest	male	15.10	0.38	
	female	18.50		
RMS temporal rest	male	17.75	0.93	
	female	17.40		
RMS Supra-hyoid rest	male	12.40	0.06	
	female	19.63		
C3-RGN	male	23.10	0.034*	
	female	15.17		
AA-PNS	male	21.30	0.16	
	female	15.92		

* – p<0.05

Table 4. Mean Rank and Mann-Whitney´s test between the group with MFA>5° and MFA<5°

Variables	MFA	Mean Rank	p-value*
RMS Supra-Hyoid isometric	>5	13.38	0.06
	<5	19.63	
RMS masseter rest	>5	15.44	0.27
	<5	19.33	
RMS temporal rest	>5	20.28	0.13
	<5	15.03	
RMS Supra- Hyoid rest	>5	18.69	0.53
	<5	16.44	
C3-RGN	>5	17.50	1.00
	<5	17.50	
AA-PNS	>5	19.50	0.28
	<5	15.72	

* – p<0.05

Table 5. Correlations between electromyographic variables in MFA <5º and MFA 5º groups

Measures	MFA < 5°	MFA > 5°
supra-hyoid maximum bite x BF1	r=0.70 p=0.05	
masseter maximum bite x BF		R=0.63 p=0.0001

BF – Bite Force

curred for the group with MFA>5° that is in agreement with the discussion of Herring & Liu [10] whose ipsilateral electrical activity of the masseter muscle showed that the condylar tension is the result of the reaction force in the TMA and it acts as a lever of Class III, being the masseter muscle the main force responsible by the overload in opposed to other masticatory muscles or bite force. This is according with Christensen & Monhamed (1986) [9] that the masseter muscle was more active in work functional side.

In the Hyoid Triangle, for both groups, the vertical and angular behavior of the hyoid bone didn't present significant correlations. Those findings corroborate the data obtained by Coelho-Ferraz, et al. [1, 2, 13] and it was concluded that the craniofacial complex seeks for the most favorable position to perform its functions with the aim of keeping the dimensions of the superior airways.

Considering the number of volunteers of this research to get into conclusions in the population in general with the cephalometric and clinical characteristics of this sample, the results of this study suggest that even in individuals considered apparently healthy, they can present asymmetric masticatory movement. The tissues of the masticatory system are able of adapting to their environment, and the dentist must utilize extreme caution before the interruption of this balance.

CONCLUSION

Considering the characteristics of the sample utilized, the methodology used and complete analysis of the presented data, it was possible to suggest that the anatomic-physiological aspects of temporomandibular disorders are related to the asymmetrical mandible function.

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