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Transverse dimension of the alveolar bone in different masticatory patterns

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Aim: The aim of this study was to evaluate, through cone beam computed tomography (CBCT), the transverse dimension of the alveolar bone in the posterior region of the maxilla and mandible in subjects with different patterns of mastication, comparing both sides of the arches according to the performance of the masticatory function. Methods: 39 subjects not orthodontically treated, with normal occlusion or symmetrical malocclusion, and normal periodontal condition were selected. Twenty-one subjects (54%) were identified as having preferential unilateral mastication, 11 subjects (28%) had bilateral mastication and 7 (18%) had exclusive unilateral mastication. All participants were submitted to CBCT and the buccolingual dimension of the posterior regions was evaluated at a height of 2, 4, 6, 8, and 10mm from the alveolar crest. Results and Conclusion: Subjects with bilateral mastication showed statistically significant difference between the right and left sides at the heights of 6 (p=0.030) and 8mm (p=0.023) between the first and second maxillary premolars. There was no difference in the transverse dimension of the alveolar bone in the posterior regions of maxilla and mandible between preferred and non-preferred sides in subjects with preferred unilateral mastication and between right and left sides in subjects with bilateral mastication.

Keywords: Alveolar process. Bone. Cone-beam computed tomography. Mastication.

Introduction

Mastication is one of the most important functions of the stomatognathic system because it is related to nutrition, maturation of the orofacial musculature, occlusal stability, temporomandibular joints and growth and development of the craniofacial complex, as well as a necessary factor for a perfect homeostasis of the human being[1].

When considering the health of the stomatognathic system, a desirable pattern of mastication is required, which is characterized by unilateral cycles with periodic alternation of food between the right and left sides, distributing the force of mastication on the teeth and structures of support on both sides of the dental arches[2,3], what results in greater masticatory efficiency[4-6]. However, this bilateral pattern of distribution of food is not present in most of the population, where a preferred chewing side is more common[7,8]. The choice for a preferred chewing side is a voluntary decision that becomes involuntary with function performance[9] and may be associated with the control of the central nervous system[10] or related to peripheral factors[9].

Since teeth are supported by the alveolar process, this bone structure is directly exposed to mechanical loads created by the functional performance of the maxilla and mandible[11]. Bone tissue is in a constant process of functional adaptation through modeling and remodeling mechanisms, which are significantly influenced by mechanical stimuli[12]. Thus, the masticatory function provides mechanical stimuli capable of influencing the formation, maintenance and remodeling of the craniofacial skeleton, exerting an important function in the regulation of the mass and bone architecture of this region[13].

Changes in intensity and/or frequency of functional load may be accompanied by changes in the alveolar bone[12,14-16]. In studies with rats, implementation of soft diet[14,17] or placement of anterior[18] and posterior[12] occlusal build-ups produced changes in the occlusal force applied to the teeth and distributed in the alveolar process, resulting in significant qualitative and quantitative alterations in the alveolar bone tissue. However, the hypothesis that the dimension of the alveolar bone can be influenced by functional loading was not tested.

The purpose of this study was to evaluate, through cone beam computed tomography (CBCT), the transverse dimension of the alveolar bone in the posterior regions of the maxilla and mandible in subjects with different patterns of mastication, comparing both sides of the arches according to the performance of the masticatory function.

The hypothesis of this study is that the transverse dimension of the alveolar bone in the posterior regions of the maxilla and mandible is greater in the preferred side than in the non-preferred side in subjects with preferred and exclusive unilateral mastication. Such difference does not exist between the right and left sides in subjects with bilateral mastication.

Material and methods

The sample consisted of 39 subjects, not orthodontically treated, between 19.2 and 44.6 years (mean: 24,3 years) with complete permanent dentition (except

third molars), normal occlusion or symmetrical malocclusion, and normal periodontal condition, as assessed by visual evaluation. This study was approved by the Research Ethics Committee of the of the Juiz de Fora Federal University, and all participants signed an informed consent form.

Determination of the preferred chewing side

The first phase of this research consisted in determining the masticatory pattern of the subject by means of a visual method[19,20] where the participant was seated in an upright position in a chair with their backs towards a white background, their hands resting on their legs, and looking fixedly at the digital video camera (Sony MHS-PM5), which was placed on a fixed tripod one meter away from the chair back at the height of their mandible. Each subject was filmed chewing on a piece of French bread in their habitual manner for approximately 90 seconds.

The videos were analyzed by 3 speech therapists who counted the masticatory cycles in each hemi-arch and determined, unanimously, the masticatory pattern of each participant, classifying it as bilateral (occurrence of up to 60% of the cycles in one side), preferred unilateral (occurrence from 61% to 77% of the cycles in one side) or exclusive unilateral (occurrence from 78% to 94% of the cycles in one side)[21].

From the total of 39 subjects, 21 (54%) were identified as having preferred unilateral chewing (13 right and 8 left), 11 (28%) bilateral chewing, and 7 (18%) exclusive unilateral chewing (2 right and 5 left).

Evaluation of the transverse dimension of the alveolar bone

All participants were submitted to cone-beam computed tomography (CBCT) (i-CAT-Imaging Sciences International, Hatfield, PA – USA), operated at 120kV and 3-8 mmA, voxel of 0.25 mm, rotation time of 26.9s, and field of view with a diameter of 160 mm and height of 100 mm.

For image acquisition, each subject was seated with the chin on the chin rest, with the Frankfort plane parallel to the floor, the midsagittal plane perpendicular to the floor and with the participant in maximum intercuspation position. The field of view was positioned in a way that the occlusal plane occupied its vertical center and the anterior nasal spine was at 35 mm from its anterior border.

Images were analyzed with the i-CAT Vision (Imaging Sciences International Inc., Hatfield, USA) software, on MPR visualization mode (multiplanar reconstruction), with 0.5 mm-thick slices.

Initially, for the definition of the images of the posterior interdental regions, the line corresponding to the coronal slice was centrically positioned in the posterior interdental areas (vertical line – figure 1b) and perpendicular to the alveolar process buccolingually (horizontal line – figure 1a). The line corresponding to the sagittal slice was positioned in the long axis of the alveolar process (vertical line – figure 1c). The posterior interdental regions between maxillary and mandibular canine and first premolar, first and second premolar, second premolar and first molar and first and second molars of both sides were evaluated (figure 1b).

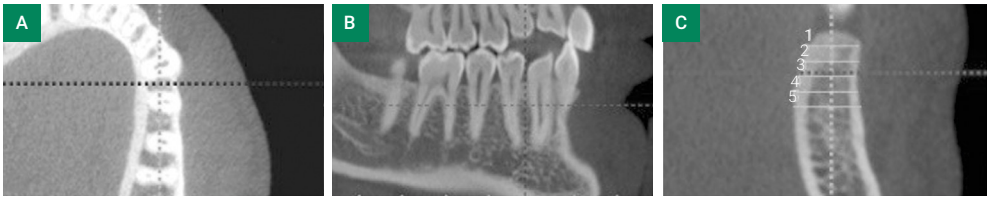

Figure 1. Definition of the interdental image and determination of the transverse dimension of the alveolar process on axial (a), sagittal (b), and coronal (c) cuts.

Buccolingual dimensions of the posterior interdental regions were determined at the heights of 2, 4, 6, 8 and 10 mm from the alveolar bone crest (figure 1c), including the bone height where the roots of the posterior teeth were located. Measurements were performed by two examiners in a blind manner, where examiner 1 measured teeth quadrants 1 and 3 and examiner 2 measured teeth quadrants 2 and 4.

Statistics

Intra- and inter-examiner agreement was determined by intraclass correlation coefficient, which was calculated on the basis of the values of the buccolingual dimensions of 3 (240 measurements) randomly chosen participants and measured twice by the examiners with a 20-day interval.

The distribution pattern of the values of the buccolingual dimensions was evaluated by the Shapiro-Wilk test, where the variable showed normal distribution.

The comparison between the preferred chewing side and the opposite side for the participants with preferred and exclusive unilateral mastication and between the right and left sides for the subjects with bilateral mastication was performed with the Student t test for paired samples. Statistical analysis used a level of significance of a = 0.05 and the data were processed with the SPSS Statistics 17.0.0 software (SPSS, Chicago, IL, USA).

Results

Intra- and inter-examiner agreement for the buccolingual dimensions were 0.959 ($p<0.001$) and 0.979 ($p<0.001$) respectively, demonstrating excellent agreement.

The mean values for the maxillary and mandibular buccolingual dimensions of the alveolar process in subjects with preferred unilateral, bilateral and exclusive unilateral masticatory patterns, as well as the comparison between comparable sides (the preferred and non-preferred sides, right and left sides, and mastication and balancing sides) are shown in tables 1 to 3.

Subjects with preferred unilateral and exclusive unilateral mastication did not show statistically significant difference between the preferred and non-preferred sides and the chewing and balancing sides, respectively, for both the maxilla and mandible.

Subjects with bilateral mastication showed statistically significant difference between the right and left sides at the heights of 6 mm ($p=0.030$) and 8 mm ($p=0.023$) between the first and second maxillary premolars.

Table 1. Mean values of the buccolingual dimensions of the alveolar bone in subjects with preferred unilateral mastication.

Interdental region	Height	Maxilla					Mandible				
		Preferred side		Non-preferred side		P Value	Preferred side		Non-preferred side		P Value
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Canine X 1rst Premolar	2mm	7.89	0.75	7.92	1.00	0.892	7.47	1.18	7.40	1.07	0.758
	4mm	8.67	0.94	8.83	0.98	0.332	8.58	1.39	8.55	1.55	0.929
	6mm	9.15	1.22	9.11	1.33	0.841	8.90	1.37	8.76	1.41	0.432
	8mm	9.45	1.62	9.28	1.52	0.509	9.14	1.47	9.05	1.53	0.685
	10mm	9.88	1.96	9.77	2.03	0.765	9.47	1.66	9.53	1.80	0.843
1rst Premolar X 2nd Premolar	2mm	9.38	0.96	9.19	0.86	0.239	8.16	1.83	8.02	1.27	0.681
	4mm	9.83	1.09	9.89	1.17	0.680	9.35	1.79	8.98	1.34	0.201
	6mm	9.95	1.34	10.02	1.20	0.722	9.67	1.70	9.53	1.51	0.528
	8mm	10.05	1.38	10.02	1.40	0.852	9.94	1.59	9.76	1.59	0.380
	10mm	10.31	1.69	10.20	1.78	0.535	10.08	1.55	10.15	1.55	0.702
2nd Premolar X 1rst Molar	2mm	10.34	1.16	10.34	1.22	1.000	9.65	1.29	9.50	1.04	0.539
	4mm	11.15	1.11	11.22	1.07	0.562	10.80	1.34	10.58	1.22	0.303
	6mm	11.38	1.62	11.30	1.59	0.577	11.08	1.40	11.15	1.53	0.705
	8mm	11.38	1.88	11.40	1.81	0.942	11.20	1.64	11.41	1.65	0.314
	10mm	12.13	2.00	12.13	1.98	1.000	11.25	1.60	11.52	1.88	0.237
1rst Molar X 2nd Molar	2mm	13.01	1.09	13.11	0.90	0.597	11.19	1.19	11.04	1.33	0.219
	4mm	13.67	1.02	13.92	0.81	0.165	12.40	1.43	12.34	1.38	0.717
	6mm	14.33	1.14	14.36	1.14	0.900	13.32	1.65	13.21	1.58	0.623
	8mm	14.18	0.85	14.45	1.13	0.355	13.43	1.62	13.33	1.46	0.565
	10mm	15.80	2.01	16.45	2.98	0.552	13.22	1.81	13.34	1.58	0.521

Table 2. Mean values of the buccolingual dimensions of the alveolar bone in subjects with bilateral mastication.

Interdental region	Height	Maxilla					Mandible				
		Right side		Left side		P Value	Right side		Left side		P Value
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Canine X 1rst Premolar	2mm	8.00	1.31	8.02	1.11	0.952	7.09	0.91	7.40	1.31	0.358
	4mm	8.93	1.28	9.15	1.10	0.447	8.50	1.30	8.75	1.27	0.345
	6mm	9.22	1.30	9.27	1.19	0.896	8.97	1.55	8.93	1.41	0.829
	8mm	9.36	1.50	9.31	1.33	0.899	9.04	1.77	9.13	1.65	0.777
	10mm	9.56	1.46	9.34	1.03	0.615	9.18	1.83	9.43	2.00	0.448
1rst Premolar X 2nd Premolar	2mm	9.15	1.08	9.09	0.11	0.732	7.88	1.48	8.20	1.71	0.322
	4mm	9.90	1.63	9.38	1.02	0.118	9.15	1.91	9.29	1.81	0.523
	6mm	9.97	1.45	9.45	1.16	0.030*	9.72	1.74	9.61	1.45	0.598
	8mm	9.79	1.53	9.27	1.32	0.023*	10.13	1.49	10.13	1.26	1.000
	10mm	9.77	0.80	9.50	1.31	0.323	10.50	1.46	10.38	1.46	0.450
2nd Premolar X 1rst Molar	2mm	10.31	1.37	10.77	1.10	0.064	9.61	1.24	9.50	1.58	0.742
	4mm	11.40	1.24	11.20	0.07	0.455	10.75	1.46	10.72	1.57	0.921
	6mm	11.56	0.61	11.22	1.43	0.151	11.36	1.69	11.40	1.51	0.835
	8mm	11.57	2.09	11.25	1.64	0.231	11.61	1.81	11.47	1.55	0.628
	10mm	11.17	3.04	11.28	2.22	0.807	11.65	1.91	11.63	1.76	0.918
1rst Molar X 2nd Molar	2mm	12.88	1.01	13.13	1.37	0.490	11.18	1.30	11.15	1.28	0.884
	4mm	14.22	1.00	14.34	1.16	0.713	12.34	1.46	12.18	1.40	0.396
	6mm	14.38	0.71	14.11	1.23	0.263	13.25	1.72	13.09	1.60	0.494
	8mm	14.33	1.19	14.02	1.29	0.179	13.77	1.88	13.54	1.97	0.331
	10mm	13.50	1.62	13.81	1.14	0.504	13.77	2.03	13.43	2.28	0.180

* - statistically significant difference according to Student t test for paired samples.

Table 3. Mean values of the buccolingual dimensions of the alveolar bone in subjects with exclusive unilateral mastication.

Interdental region	Height	Maxilla					Mandible				
		Chewing side		Balancing side		P Value	Chewing side		Balancing side		P Value
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Canine X 1rst Premolar	2mm	7.67	0.64	7.92	0.97	0.533	7.67	1.54	7.92	1.51	0.356
	4mm	8.39	0.92	8.46	1.36	0.875	9.17	2.03	9.07	2.12	0.573
	6mm	8.57	1.37	8.85	1.67	0.493	9.67	2.17	9.64	2.14	0.818
	8mm	8.25	1.58	8.85	2.16	0.222	9.35	2.78	9.92	2.50	0.388
	10mm	8.57	1.61	9.17	3.06	0.422	10.17	2.88	10.07	2.79	0.695
1rst Premolar X 2nd Premolar	2mm	9.28	1.43	9.07	1.24	0.585	8.67	1.68	8.25	1.43	0.111
	4mm	9.82	1.59	9.71	1.12	0.815	9.67	2.26	9.60	1.88	0.778
	6mm	9.92	1.71	9.92	1.79	1.000	10.28	2.33	10.03	1.91	0.403
	8mm	10.39	1.95	10.35	1.74	0.945	10.42	2.46	10.60	2.11	0.499
	10mm	10.60	2.51	10.60	2.27	1.000	10.46	2.95	10.92	2.35	0.308
2nd Premolar X 1rst Molar	2mm	10.25	1.02	10.39	0.80	0.558	9.39	1.48	9.96	2.37	0.403
	4mm	11.16	0.58	11.75	0.93	0.052	10.39	2.02	10.89	1.36	0.197
	6mm	11.79	1.02	11.91	1.47	0.832	10.96	2.00	11.53	1.53	0.084
	8mm	12.10	1.52	12.40	1.85	0.485	11.17	2.12	12.00	1.53	0.054
	10mm	13.00	2.88	13.18	3.27	0.547	11.60	2.56	12.07	1.85	0.239
1rst Molar X 2nd Molar	2mm	12.25	0.76	12.82	1.37	0.306	10.96	1.26	11.00	1.02	0.864
	4mm	13.85	1.00	13.75	1.10	0.448	12.28	1.04	12.28	1.30	1.000
	6mm	14.25	0.88	14.54	1.27	0.384	13.60	1.12	13.10	1.26	0.221
	8mm	14.50	0.90	15.12	1.49	0.098	14.14	1.42	14.03	1.29	0.796
	10mm	15.37	1.45	16.12	2.21	0.223	14.32	1.95	14.28	1.79	0.890

Statistical power was calculated based on the group of subjects with exclusive unilateral mastication where, hypothetically, a greater difference between both sides was expected. Besides, this group represents the weakest statistical condition, because it has a fewer amount of patients. Alveolar dimensions of 1mm were considered as of clinical relevance. The power of statistical significance was found to be 0.78, which corresponds to a 78% chance of having a real effect.

Discussion

The ideal masticatory pattern presents a similar number of masticatory cycles on both sides of the arches[2]. However, most people show preference for one chewing side during the masticatory function[7-9], which may be due to an adaptive process to problems such as tooth loss, occlusal interferences, morphology of the craniofacial bones and muscular and temporomandibular joint problems[9]. In the present study, the occlusal and dental characteristics that might interfere asymmetrically in the alveolar bone structure were controlled, and from the total of 39 participants, 72% had unilateral mastication (54% preferred and 18% exclusive) and 28% had bilateral mastication. This distribution reflects what can be found in the general population where 73% to 77% have a preferred chewing side[22].

Besides being an adaptive process to the occlusal pattern, the choice for a preferred chewing side may be associated with the type of food and its texture[3]. In this study, the type of food was standardized for all analyses. Each participant received a portion of French bread sufficient to perform the filming of approximately 90 seconds. French bread was used in other research concerning the masticatory system with good acceptance from the population studied[19]. The filming technique and subsequent speech therapy evaluation are recommended strategies for the analysis of the masticatory pattern[8,20,22]. The video and the evaluations made by 3 speech therapists permitted a careful analysis by means of repeated visualizations and discussion of each case.

Cone beam computed tomography was used to evaluate the buccolingual dimension of the alveolar bone because it provides images without superimposition of structures with resolution and reliability sufficient to analyze the amount of bone and allow tridimensional manipulation of the structures under study[23].

Research have evidenced the relationship between the preference for a chewing side and facial anthropometric measurements, demonstrating that unilateral masticatory function results in asymmetric changes of the maxilla and mandible[24]. Studies with rats have correlated masticatory hypofunction with reduction of the alveolar bone[11,12,17]. In the present study, however, subjects with preferred or exclusive unilateral mastication pattern did not show statistically significant differences in the buccolingual dimension of the alveolar bone between the preferred and non-preferred sides in the interdental regions evaluated in the maxilla and mandible.

Statistically significant differences were found at the heights of 6 mm and 8 mm between the first and second premolars on the right and left sides of the maxilla in patients with bilateral chewing. Since from a total of 40 comparisons made for these subjects (5 heights x 4 interdental regions in maxilla and mandible), only 2 showed such variation, this result seems to reflect an isolated difference in the sample and it does not allow to infer that the masticatory pattern was responsible for the alterations found.

Conclusions

There was no difference in the transverse dimension of the alveolar bone in the posterior regions of maxilla and mandible between preferred and non-preferred sides in subjects with preferred unilateral mastication and between right and left sides in subjects with bilateral mastication.

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