Avaliação radiográfica das alterações morfológicas na mandíbula decorrentes de perdas dentárias

Radiographic evaluation of morphological alterations of mandible resulting from tooth losss

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RESUMO

O objetivo deste trabalho foi correlacionar espessura da cortical mandibular na região de forame mentual e ângulo goníaco e, a altura do processo coronóide com antímeros direito e esquerdo, idade, gênero, tipos faciais e cefálicos, número e local das perdas dentárias em uma amostra populacional. Foram avaliadas 240 radiografias panorâmicas de ambos os gêneros, com idades entre 21 e 80 anos. Após as medidas faciais e cefálicas, as radiografias foram transferidas para Radiocef Studio 2®. As mensurações foram realizadas por um único avaliador em três momentos distintos nas seguintes regiões: base mandibular até a borda superior da imagem da cortical mandibular na região do forame mentual, altura dos processos coronóides e espessura da cortical na região do ponto goníaco, todos bilateralmente. As medidas foram submetidas à análise estatística Anova Two Way Analasys pelo software SigmaStat®. Observou-se diferença estatística significante em relação ao gênero, idade, tipo cefálico, número e local das perdas dentárias quando correlacionadas às mensurações avaliadas. Não houve diferença estatística quando correlacionados os diferentes tipos faciais e os lados direito e esquerdo de pacientes do mesmo gênero. Conclui-se que perdas dentárias provocam alterações na morfologia óssea mandibular. Além disso, fatores como idade, gênero e tipo cefálico também devem ser levados em consideração na análise da morfologia óssea mandibular.
Descritores: Mandíbula. Músculos da Mastigação. Radiografia Panorâmica. Perda de Dente.

ABSTRACT

The aim of this study was to correlate the mandibular cortical thickness in the region of the mental foramen and gonial angle and the height of the coronoid process with right and left sides, age, gender, cephalic and facial types and number and location of tooth loss. The study population comprised 240 patients of both genders, age ranged from 21-80 years. After the facial and cephalic measures, all panoramic were imported to the program Radiocef Studio 2®, and the measurements were carried out by a single examiner in three distinct moments in the following regions: the mandibular basis up to the top edge of the mandibular cortical in the region of the mental foramen on both sides, height of both coronoid process and cortical thickness in the region of gonial point bilaterally. All measures were statistically analyzed by two-way ANOVA using the SigmaStat® software. It was observed statistically significant differences in relation to gender, age, cephalic type, number and location of tooth loss as they were correlated to measurements assessed. There was no statistical difference by correlating different facial types and the right and left sides of the same gender patients. It was concluded that tooth loss causes changes in mandibular bone morphology. Furthermore, factors such as age, gender and cephalic type must also be taken into account in the analysis of mandibular bone morphology.
Key words: Mandible. Masticatory muscles. Panoramic radiography. Tooth loss.

INTRODUCTION

Recent studies have attributed lower masticatory effort to the changes in the jaw bone. The magnitude and the frequency of functional loads depend on many intrinsic and extrinsic factors, such as muscular efficiency (higher in men than in women, and decreasing with age[1] and the hardness of the diet (softer food and/or liquid diet versus hard food) [2-4]. The trabecular bone pattern changes according to the dissipation of masticatory load and causes alteration in the lamellar bone [5].

From a biomechanical point of view, it is known that the architectural arrangement of some bones facilitates the absorption and distribution of external forces that affect these structures. The bones of the stomatognathic system follow this structural pattern. In the specific case of the mandible, forces released at the tooth level are dispersed by an alveolar trajectory and follow in the direction of the head of the mandible. The tensile forces of the muscles, which are inserted close to the mandibular angle, form the marginal trajectory that occupies both the posterior edge of the mandibular ramus and the base of the jaw [6].

Optimal chewing is performed bilaterally, alternating and balancing the work, which favors the health of oral structures[7]. This bilateral pattern is beneficial for a harmonious craniofacial growth and development by activating the masticatory muscles on both sides, which cause bone remodeling in their insertion sites. Morphological changes suffered by the jaws occur throughout life and are influenced by patient's age and dental conditions. On the mandible, bone remodeling can occur in various regions, e.g. the gonial/antegonial region, condyle and mandibular ramus[8]. However, in cases of tooth loss, the mandible is also exposed to several types of atrophic alterations including: reduction of mandibular angle size, reabsorption of the medial surface of the condyles and decrease in size of the coronoid process[9, 10].

Another factor that can have great impact in the bone morphology of individuals is the wide spectrum of facial variations (facial patterns). In many cases, the facial pattern is considered the main etiologic factor of dental malocclusion and it is pointed as having a direct influence on the pattern of individual growth[11]. The cephalic index is an anthropometric parameter frequently used in the determination of phenotypic variations, often used to determine gender in individuals whose identity is unknown. Due to its validity and practicality, the cephalic index is advantageous to the study of the craniofacial skeleton[12, 13].

In a study conducted in 1998, the accuracy of horizontal and vertical linear measures in panoramic radiographs was evaluated by comparing its results with the physical measurement in 25 dried jaws. An accuracy of 95% was observed in horizontal distances in the posterior region and leads to the conclusion that it would be possible to use panoramic radiographs for performing some linear measurements. The method would be appropriate for assessing both sides, since no statistically significant differences in measures performed in mandibular medium line were found 14.

This study has clinical applicability once the knowledge of bone remodeling that occurs in regions of gonial angle, coronoid process and mental foramen can modify the treatment plan in various situations such as: placement of implants in areas with reduced bone height in the region the gonial angle may induce bone fractures; incorrect prosthetic planning due to unawareness of local greater bone resorption, as well as direct influence on orthodontic planning in relation to the cephalic and facial types.

Therefore, the current study aimed to evaluate the height of the mandible in the region of mental foramen (MF), gonial angle (GA), and the height of the coronoid process (CP) using panoramic radiographs. In addition, the region measured (MF, GA and CP) was correlated with right and left sides, age, gender, facial and cephalic types, tooth losses and their locations in a population sample.

MATERIAL AND METHODS

The study protocol was reviewed and approved by the Institutional Review Board of The Campinas University School of Dentistry at Piracicaba, São Paulo, Brazil (protocol 123/2011).

A prospective epidemiological research was performed, evaluating panoramic radiographs of 240 patients of both genders and age range from 21 to 80 years, who attended the Dental Radiology Clinic at the Piracicaba Dental School (University of Campinas, São Paulo, Brazil) in order to make radiographic exams for a variety of clinical indications.

Patients under 21 years old, foreigners, regular drug users, and users of removable or fixed dental prostheses were excluded from this study. Patients who met the criteria of this study were invited to participate as a volunteer and were requested to provide informed consent.

Measurements were performed on the face and skull to determine the facial and cephalic types. The facial type was obtained by the bizygomatic and fronto-nasal-mental measurements (Figure 1a and b), using a pachymeter of 24 cm (CESCORF, Brazil). The frontal-nasal-mental measure was multiplied by 100, and the value was divided by the bizygomatic value to obtain the facial index (Table 1).

Table 1. Facial types and reference values in centimeters (Avila, 1958).

Facial types	Reference values
Hypereuriprosopic	≤ 78.9
Euriprosopic	79 a 83.9
Mesoprosopic	84 a 87.9
Leptoprosopic	88 a 92.9
Hyperleptoprosopic	≥ 93.0

The antero-posterior and transversal diameters of the skull were measured using a compass of 260 mm (Figure 1c and d). The cephalic index was obtained from these measurements by multiplying the transverse diameter by 100 and dividing the value by the antero-posterior diameter (Table 2).

Table 2. Cephalic types and reference values in centimeters (Williams et al., 1995).

Cephalic types	Reference values
Dolicocephalic	DOL - 70 < IC < 74.9
Mesocephalic	MES - 75 < IC < 79.9
Braquicephalic	BRA - 80 < IC < 84.9

The volunteers were categorized according to age, gender, cephalic type, facial type, tooth loss and their locations, as follows: Age - group 1 (21-30 years), group 2 (31-50 years), group 3 (51-70 years), group 4 (71-80 years); Gender - male and female; Cephalic Type - dolichocephalic (70 < CT < 74.9), mesocephalic (75 < CT < 79.9), brachycephalic (80 < CT < 84.9); Facial Type - hypereuriprosopic (≤ 78.9), euriprosopic (79-83.9), mesoprosopic (84-87.9), leptoprosopic (88-92.9), hyperleptoprosopic (≥ 93.0); Presence of teeth - D1 (0-15 teeth present), D2 (16-32 teeth present); Location of tooth loss - L1 (all teeth present), L2 (anterior teeth missing), L3 (posterior teeth missing), L4 (absence of all teeth).

All panoramic radiographs were obtain on the same film-based device (Instrumentarium Orthopantomograph OP100, General Electric, Tuusula, Finland), modifying the exposure time to the characteristics and requirements of each patient in order to obtain a radiographic image with desired quality standards. For processing the films, an automatic processor (Macrotec MX-2, Macrotec, São Paulo, Brazil) was used.

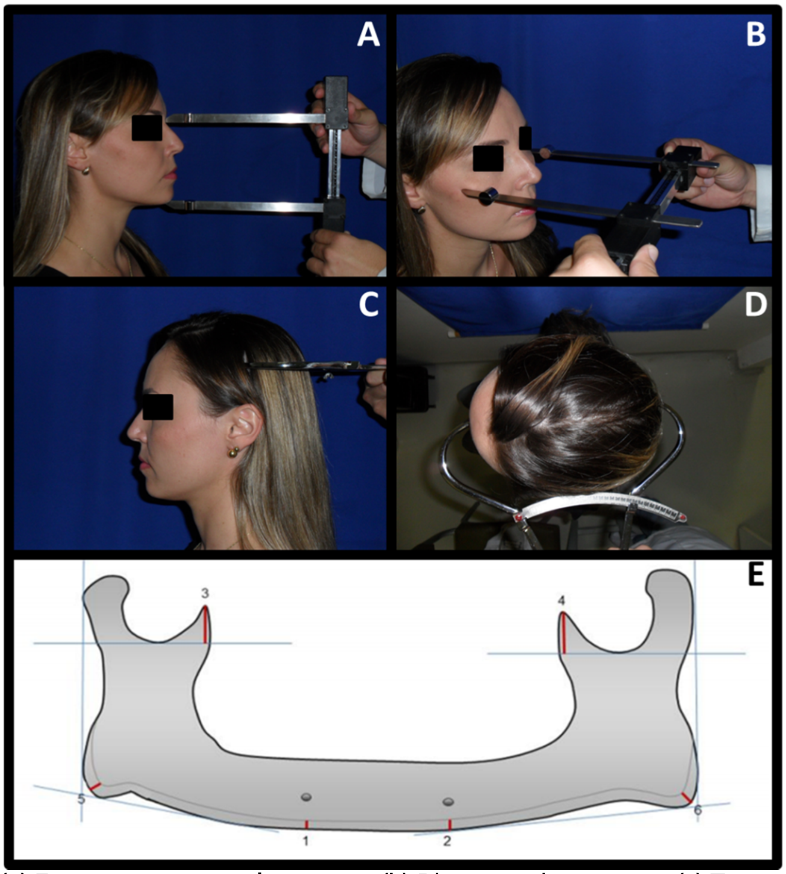

Figure 1: (a) Fronto-naso-mental measure; (b) Bizygomatic measure; (c) Transversal measure of skull; (d) Antero-posterior measure; (e) Schematic representation of the measurements performed.

After image quality approval, all radiographs were digitalized using a digital camera (Samsung ES68 12 Megapixel) and a stand (PF-4 ®, Nikon, Japan), with a distance of 42 cm from digital camera to panoramic radiograph. For subsequent calibration, a millimeter ruler (20 mm) was placed on the left side of the radiograph prior to the digital image acquisition. Images were exported to the computer and then imported into software for dental radiograph image processing and analysis (Radiocef Studio 2, Radio Memory, Minas Gerais, Brazil).

All panoramic radiographs were calibrated using two known points on the millimeter ruler and the measurements were performed in three different times by one previously calibrated examiner. After this calibration, the following linear measurements were performed on radiographic images: 1 – from the mandibular inferior cortical up to the upper edge of the mental foramen on the right side; 2 – from the mandibular inferior cortical up to the upper edge of the mental foramen on the left side; 3 - height of the coronoid process of the right side; 4 - height of the coronoid process of the left side (to obtain the height of coronoid process, a tangent to the mandibular incisures was traced and, from this reference line, a new line was traced to the highest point of the coronoid process); 5 – from the mandibular inferior cortical up to the superior edge of the cortical bone in the region of the gonial point on the right side; and 6 – from the mandibular inferior cortical up to the superior edge of the cortical bone in the region of gonial point on the left side (the gonial point was determined by the bisector of the angle formed by the tangent to the posterior edge of the ascending ramus of the mandible and the lower edge of the mandible body) (Figure 1e).

Intra-observer agreement was calculated using Cohen's kappa coefficient. It was observed an excellent reproducibility with the concordance variation of the examiners for the measurement of GA (k = 0.822), MF (k = 0.812) and CP (k = 0.808). The correlation between the measured points was analyzed using the Pearson correlation coefficient. Two way analysis of variance (ANOVA) and pairwise Tukey test comparisons between age, gender and facial and cephalic types were performed. Data analyses were performed using SigmaStat for Windows (Version 3.5, Systat Software Inc, Erkrath, Germany), considering a significance level of $p < 0.05$.

RESULTS

When the measurements were analyzed according to different age groups, it was noted that, in relation to the height in the region of the mental foramen, the highest average was found in group 2, whereas the lowest was obtained in group 4. There was a statistically significant difference between groups 1-4, 2-3 and 3-4 in this region of the mental foramen. On the other hand, the highest average at the gonial angle region was found in group 1, which showed statistically significant difference in relation to all other groups. The average of the height of the coronoid process was found to be highest in group 3, with statistically significant difference between the groups 1-3, 2-4 and 3-4 (Table 3).

There was a statistically significant difference between the mandibular measurements according to gender, with higher average for males than females (Table 3).

The radiomorphometric values comparing right and left sides in the same gender showed no statistically significant difference. However, by comparing the values among genders, there was statistically significant difference between sides for MF and GA, with higher average on the right side of males (Table 3).

Considering the cephalic types, there was a statistically significant difference between dolichocephalic (DOL) and two other types: mesocephalic (MES) and brachycephalic (BRA); with higher GA and MF average measures on DOL group. In relation to CP, the MES group presented higher values compared to BRA and DOL, but with no statistically significant differences (Table 3).

Among the different facial types, MF varied between 4.5 and 4.9 mm with no statistically significant difference. Considering GA, the mesoprosopic patients had the highest average, followed by euriprosopic, hypereuriprosopic, hyperleptoprosopic and leptoprosopic, however there was no statistical difference. Furthermore, it could be observed that the euriprosopic patients presented the highest CP values, although no statistically significant difference was found in relation to the other groups (Table 3).

The presence and location of teeth were also evaluated. In relation to MF and GA, group D2 showed higher values than group D1, with statistically significant difference. Regarding the CP, the mean values were higher in group D1, without statistically significant difference in relation to group D2 (Table 3). Regarding tooth loss, the absence of all teeth (L4) had lower average compared to other groups. The location of dental loss showed statistically significant difference only for the gonial angle region (Table 3).

DISCUSSION

The interaction between the masticatory muscles and the craniofacial skeleton has been studied as a parameter for the control of craniofacial growth[15, 16]. The present study measured regions of masseter and temporal muscles insertion to verify their influence in the jaw under different morpho-functional conditions. The low correlation of measurements obtained suggests that despite these locations suffer synergistic muscular tensions, it propagates differently, causing different reactions in the jaw.

Table 3. Radiomorphometric values in milimeters.

	MF		GA		CP	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
Age - Group 1	4.433[ab]	± 0.080	1.910[a]	± 0.038	9.266[ad]	± 0.214
Age - Group 2	4.525[a]	± 0.058	1.724[b]	± 0.027	9.697[ac]	± 0.156
Age - Group 3	4.278[b]	± 0.072	1.709[b]	± 0.034	10.086[bc]	± 0.193
Age - Group 4	3.601[c]	± 0.204	1.734[ab]	± 0.096	7.981[d]	± 0.543
Gender - Male	4.514[a]	± 0.063	1.830[a]	± 0.030	9.935[a]	± 0.165
Gender - Female	4.333[b]	± 0.049	1.704[b]	± 0.023	9.407[b]	± 0.128
Side - Male - Right	4.517[a]	± 0.089	1.846[a]	± 0.042	9.922	± 0.233
Side - Female - Right	4.294[b]	± 0.069	1.695[b]	± 0.042	9.408	± 0.181
Side - Male - Left	4.511	± 0.089	1.814	± 0.042	9.949	± 0.233
Side - Female - Left	4.373	± 0.069	1.713	± 0.033	9.406	± 0.181
Braquicephalic	4.340[a]	± 0.063	1.728[a]	± 0.031	9.301	± 0.170
Mesocephalic	4.488[a]	± 0.101	1.700[a]	± 0.049	9.826	± 0.269
Dolicocephalic	4.968[b]	± 0.151	1.945[b]	± 0.073	9.051	± 0.402
Hypereuriprosopic	4.572	± 0.206	1.776	± 0.101	9.347	± 0.550
Euriprosopic	4.439	± 0.161	1.830	± 0.078	10.083	± 0.428
Mesoprosopic	4.610	± 0.094	1.896	± 0.045	9.176	± 0.251
Leptoprosopic	4.865	± 0.144	1.701	± 0.070	8.810	± 0.384
Hyperleptoprosopic	4.508	± 0.069	1.752	± 0.034	9.547	± 0.186
Number of Teeth - D1	4.190[a]	± 0.101	1.623[a]	± 0.046	10.111	± 0.264
Number of Teeth - D2	4.457[b]	± 0.043	1.804[b]	± 0.020	9.604	± 0.114
Location of Teeth - L 1	4.419	± 0.072	1.866 [a]	± 0.028	9.621	± 0.177
Location of Teeth - L 2	4.099	± 0.082	1.731[a c]	± 0.085	10.030	± 0.512
Location of Teeth - L 3	4.468	± 0.061	1.712 [b c]	± 0.029	9.626	± 0.164
Location of Teeth - L 4	4.312	± 0.069	1.607 [b c]	± 0.043	9.453	± 0.193

One factor discussed in the literature in relation to patient's age is the mandibular bone architecture. Different authors have claimed that the greater the age of the patient, the thinner is the mandibular edge due to the reduction of muscle tonus that occurs with advancing of chronological age [17, 20, 21]. In this study, group 4 (71 to 80 years) had the lowest averages in the mental foramen and coronoid process measurements, and values close to other groups in the region of the gonial angle. These results confirm that age may influence the height of the cortical bone.

Regarding to gender, the literature states that males have higher mandibular edge than females, mostly due to their greater chewing force, which would contribute to an increase in tension and a higher bone remodeling in the region [20, 22]. Our results corroborate with the current literature, considering that the values measured in males were higher than those observed in females in all three regions analyzed.

Another correlation evaluated in this study was the one between right and left sides of the structures. No statistically significant difference was found between patient's sides in the same gender, but when comparing the measurements of the right side of both genders in the regions of mental and gonial foramens, a statistically significant difference was found, not corroborating with previous study[23].

Brachycephalic and mesocephalic were the most common cephalic types found in the sample studied, which is in accordance to the literature[24]. The measurements of the mental and gonial regions performed in this study showed significant higher values in dolichocephalic patients. The dental curvature defines the alveolar trajectory in the jaw and there is a greater dental inclination in dolichocephalic individuals, transferring more power to the bone[6]. In contrast, the coronoid height in these patients was smaller than the other groups, probably because this region suffers an inferior action of muscle strains, generating mild bone remodeling.

In relation to facial type, there was a predomination of mesoprosopic, leptoprosopic and hyperleptoprosopic patients, as reported in the literature[11]. When measurements were correlated to facial types, there was no statistically significant difference, presuming that the facial type would not interfere with local measurements.

Previous studies have reported that the number of present teeth in the oral cavity could make a difference in the jaw bone structure[14, 25, 26]. The two groups of volunteers in this study were divided according to Taguchi et al[17], who showed that women over 70 years of age who had 15 or more teeth presented with a greater width of mandibular cortices than those with fewer teeth. In the present study, it was found higher scores in the mental foramen and gonial angle in patients with more than 15 teeth. These values showed that the presence of teeth enables further dissipation of chewing forces, especially in the path of alveolar force, generating a higher cortical bone remodeling of the jaw.

Finally, the location of missing teeth was assessed to analyze whether this variable would influence the measurements performed. Statistically significant differences were found in the gonial angle region for the groups with absence of posterior teeth (L3 and L4). This result is important in that the posterior teeth present the highest rate of early loss, which is associated with a poor distribution of masticatory forces and leads to an instability in the dissipation of the alveolar trajectory[27]. Afterwards it would decrease alveolar bone remodeling in the gonial region and, consequently, increase the risk of bone fractures due to low height at the base of the mandible.

CONCLUSION

In conclusion, the tooth loss influenced in bone height in the regions of gonial angle, mental foramen and coronoid process, which shows the need for immediate oral rehabilitation in order to prevent future damage from unwanted bone remodeling. Knowledge of these changes is important for the dentist, once it can modify the treatment plan, either prosthetic orthodontic or surgery, improve the quality of patient treatment.

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