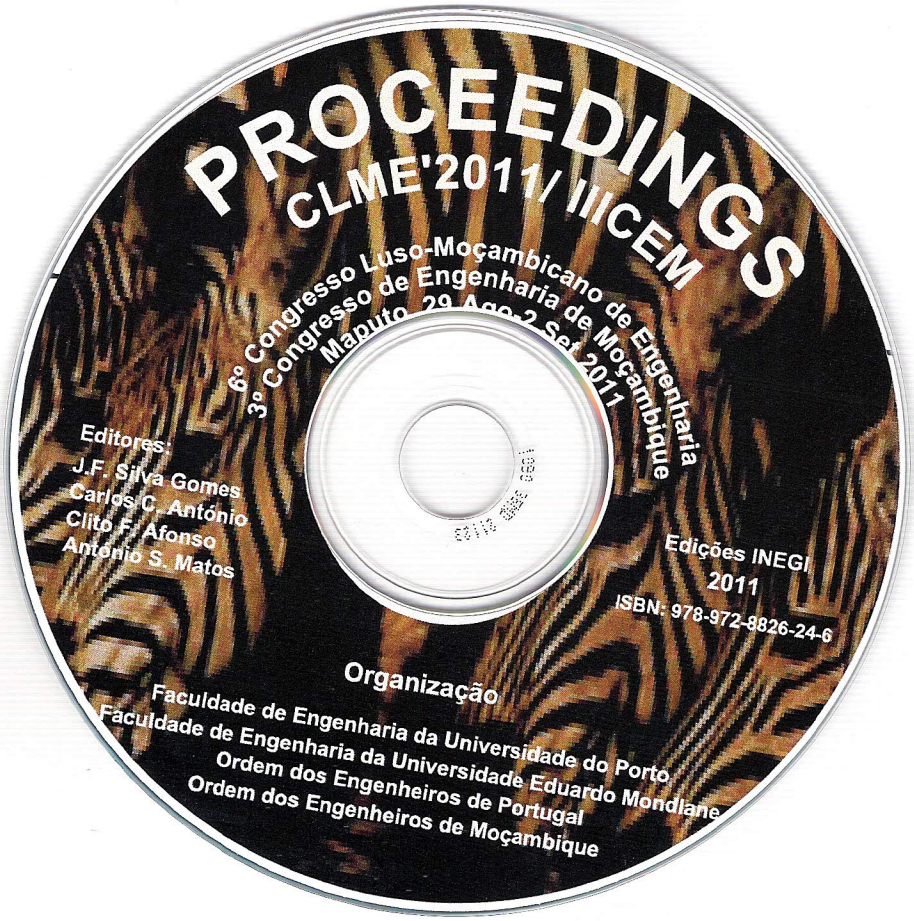
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EVALUATION OF THE CORTICAL BONE THICKNESS IN EIGHT DIFFERENT HUMAN MANDIBLES

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ABSTRACT

The main objective of this study was to investigate if there is a relation between the cortical bone thickness of human mandibles, with age and patient gender. In this work, the measure of the cortical bone thickness was obtained using different medical images.

Different human mandibles were obtained, with high resolution, through computed tomography. The cortical thickness was measured using image processing software (Sante DICOM Viewer FREE, Santesoft). The three dimensional visualization of the medical images was obtained using InVesalius 3.0 (FREE Beta 2 Software, C. T. I. Renato Archer). An initial work with this purpose was produced by [Fonseca, et al 2010] using other software.

A total of eight medical images were analysed in two different groups. One group was characterized with four female mandibles, from different ages (26-79 years old). Other group with four male mandibles has similar age (42-57 years old). The cortical thickness value was obtained for each studied case. A comparison between gender patients was obtained.

Conclusions about the cortical bone thickness of the mandible affected by tooth extraction, age and gender patient will be produced. The use of this type of information could be useful for complementary diagnostic information and clinical treatment planning.

Key words: Cortical bone; mandible; computed tomography

INTRODUCTION

Computed tomography (CT) is the most common technique used for examination of maxillofacial, because it permits the visualization of soft tissues and bone structures in the same medical image [Cavalcanti, *et al* 2001]. This technique is used in several clinical dentistry applications even by axial slices, in two (2D) and three-dimensional (3D) reconstructed images [Rocha, *et al* 2003], [Fonseca, *et al* 2010]. In some regions of the maxilla or mandible is very difficult to distinguish between cortical and trabecular bone [Natali, 2003]. Therefore, with thresholding, segmentation operations and to built separate models, the modelling procedure is possible using dedicated software package.

Many researchers have studied the relation between CT values and the bone material properties and using the results in finite element analysis. The cortical bone at the alveolar bone ridge is in general much thinner than the basal bone [Natali, 2003], and generally much lower than CT values of cortical bone at other locations. Tooth extraction causes continuous and irreversible bone reduction at the mandible [Polat, *et al* 2001]. A number of factors affect the bone and cortical thickness, hormonal, metabolic, endocrinology and dietary factors. The measure control of bone density in jaw bone structures has very important in different applications [Zlatarié, *et al* 2002]. Analyse of changes after tooth extraction or during full or removable partial denture wearing, permits a planning during a clinical intervention. Authors [Dabney & Dechow, 2002] refer studies from other researches about the consequences of tooth loss and associated residual ridge resorption. The material properties of mandibular cortical bone are essential for understand the bone quality in the edentulous mandible [Dabney & Dechow, 2002], and little study has been performed in individual bone organs. An interesting study was realized by [Miyamoto, *et al* 2005] for determine the cortical bone thickness influence and implant length, on implant stability at the surgery time in human patients. The thickness of cortical bone increases dental implant stability in humans [Miyamoto, *et al* 2005]. The changes of the human mandible during lifetime stimulated a lot of medical and biomechanical research [Kober, *et al* 2004]. The organ geometry representation, an appropriate material properties and the load conditions, are essentials for these type of research.

With this work conclusions about cortical bone thickness will be produced through the analysis of eight different human mandibles.

METHODS

Eight different CT with high resolution were analysed. Different layers from each human mandible were selected to measure the number of pixels values in mm. Pixel by pixel for each slice and using image processing software (Sante DICOM Viewer FREE, Santesoft), different layers were selected. The measure was made since bottom of the mandible until above.

Figure 1 represents one mandible with the visualization of the cortical and trabecular bone. Different axial planes scan are represented through the mandible, considering the outer and inner side for all measured points used in this work.

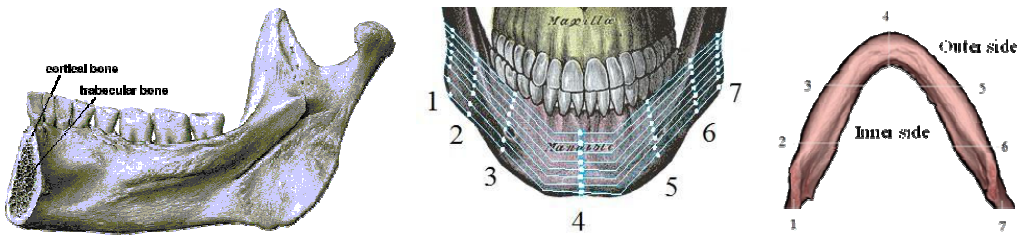

Figure 1. Layers and seven measured points (Courtesy of ADAM).

Two groups were studied with different mandibles; female F and male M group. M patients have between 57 and 42 years old (M57, M53, M43, M42). F patients have different ages,

between 26 and 79 years old (F79, F59, F57, F26). The cortical bone thickness was calculated in seven different positions for each layer, and between symmetric planes, for outer and inner side of mandible, measuring the number of pixels.

All studied cases are represented in figures 2 and 3. A 3D scan of each case was represented, using the software InVesalius 3.0 (FREE Beta 2 Software, C. T. I. Renato Archer) for visualisation. The numbers of teeth in F mandibles are 8, 10 and 13. The old F mandible has no teeth or is edentulous.

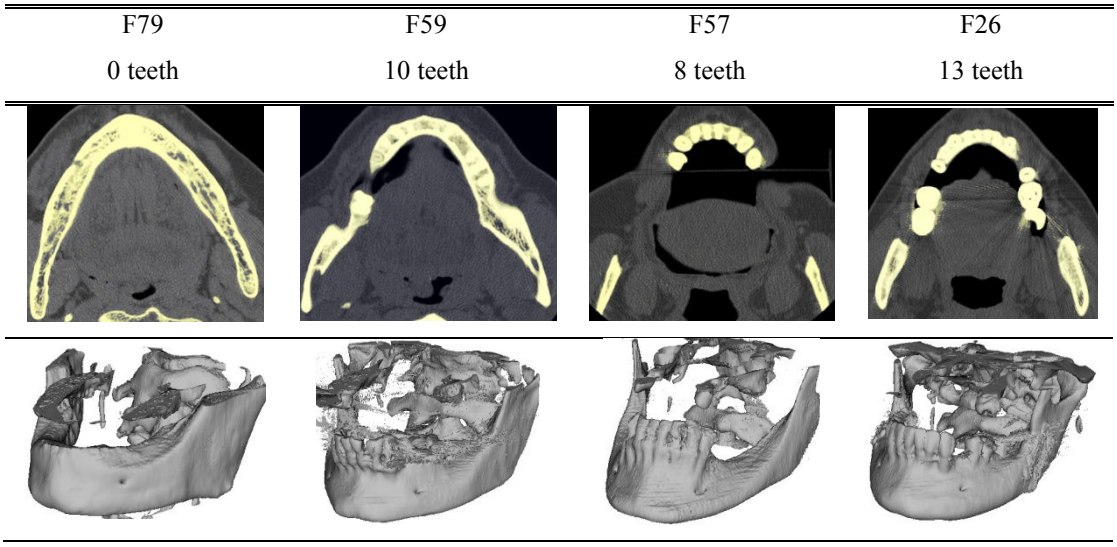

Figure 2. Number of teeth, 2D and 3D scan of F mandibles.

Figure 3 represents all images for M mandibles. As shown, the number of teeth is similar between all images, 12 or 13.

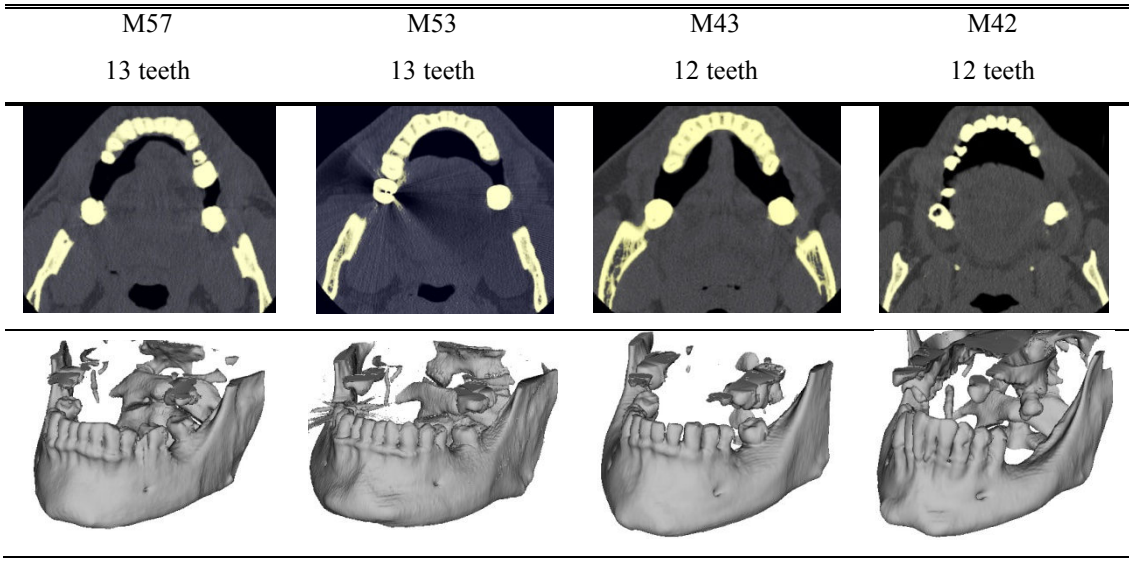

Figure 3. Number of teeth, 2D and 3D scan of M mandibles.

RESULTS

In this work eight mandibles (four for each gender) were studied. Different axial slices were selected and seven measurements were made for each other. The estimated value of cortical thickness was the mean of these calculations.

Tables 1 and 2 give the mean values of cortical thickness, according the age and patient gender for each measured point. Cortical thickness of mandible (CTM) is also represented in these tables. CTM is the mean of all collected values from the measured points for outer and inner side of each mandible.

Table 1. Mean values of cortical thickness for outer side, mm.

Measured Points	F79 0 teeth	F59 10 teeth	F57 8 teeth	F26 13 teeth	M57 12 teeth	M53 13 teeth	M43 12 teeth	M42 12 teeth
1	0.977	2.638	2.230	1.816	1.488	2.141	1.168	2.366
2	1.715	2.895	1.688	2.520	2.426	3.233	3.264	3.658
3	1.348	2.247	1.242	2.460	2.894	3.016	2.036	1.685
4	1.579	2.000	1.786	1.559	1.857	2.010	1.201	1.583
5	1.572	1.998	1.390	2.220	2.748	2.338	1.563	1.482
6	1.572	3.290	1.425	2.050	2.363	2.517	2.931	2.426
7	0.931	2.008	3.370	2.726	0.523	1.400	0.988	1.707
CTM	1.39	2.44	1.88	2.19	2.04	2.38	1.88	2.13

Table 2. Mean values of cortical thickness for inner side, mm.

Measured Points	F79 0 teeth	F59 10 teeth	F57 8 teeth	F26 13 teeth	M57 13 teeth	M53 13 teeth	M43 12 teeth	M42 12 teeth
1	0.977	2.638	2.230	1.824	1.488	2.141	1.168	2.366
2	0.809	1.215	1.408	2.473	2.112	2.117	1.954	2.641
3	1.348	1.714	1.848	3.203	3.604	3.278	2.336	2.325
4	3.157	2.808	2.704	2.319	3.026	3.081	2.867	2.628
5	1.168	1.758	1.934	2.768	3.635	3.725	1.941	1.853
6	0.786	1.026	1.522	1.531	1.643	2.430	1.502	1.725
7	0.931	2.008	3.370	2.170	0.360	1.400	0.988	1.707
CTM	1.31	1.88	2.15	2.327	2.267	2.60	1.82	2.18

DISCUSSION

The CTM measurements in tables 1 and 2 show significant differences between the age, tooth extraction and patient gender. Through tables 1 and 2 a comparison of cortical bone thickness between different ages and groups, for outer and inner side, were represented.

According table 1, the values of cortical thickness for F79 patient is the smaller. The teeth extraction results in a decrease of the mandible strength. M group has a range of cortical thickness values between 1.88 and 2.60mm. The measured points 2 and 6 present higher values and always in M patients.

Table 2 represent the same conclusion about F patient. Cortical thickness for F79 patient is smaller. Between M and F mandibles there are differences and a different behaviour. For point nº4, in the middle of measure, the values are similar in all patients and present the higher values.

The most difference in edentulous patient is the tendency for cortical thickness to be lesser in positions 1 and 7, when compared with other patients with teeth. This conclusion is also presented by [Dabney & Dechow, 2002].

Figures 4 and 5 represent the CTM values for outer and inner side of mandibles in all patients.

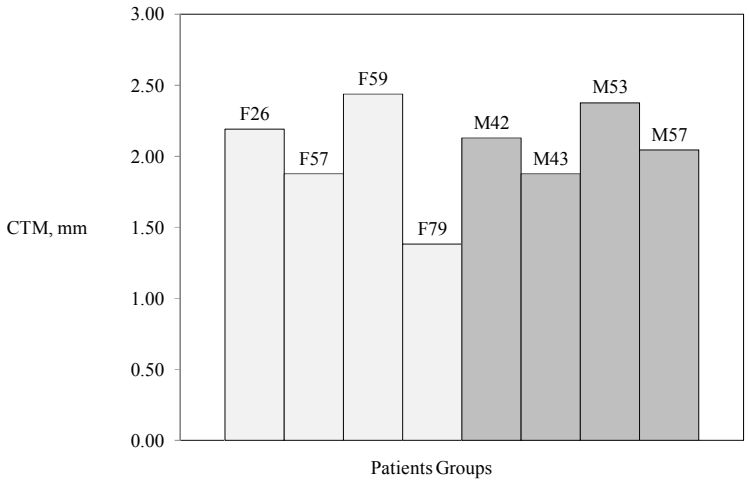

Figure 4. CTM values for F and M patients, (outer side).

As can see in figures 4 and 5, F79 patient has always the smaller CTM value. F59 present higher values for outer side and a relative difference between the inner side. F26 present the thickness value more constant between all different sides (2.19-2.32). This mandible presents the higher value of teeth (13) in F mandibles. M patients have more similar values, around 1.82-2.6mm for outer and inner side of mandible. All M patients have similar value of teeth (12-13). The thickness behaviour of F26 is similar with M patients, although the age was the smaller. F patients have a different behaviour and are possible to verify the cortical bone reduction more pronounced when compared with M mandibles.

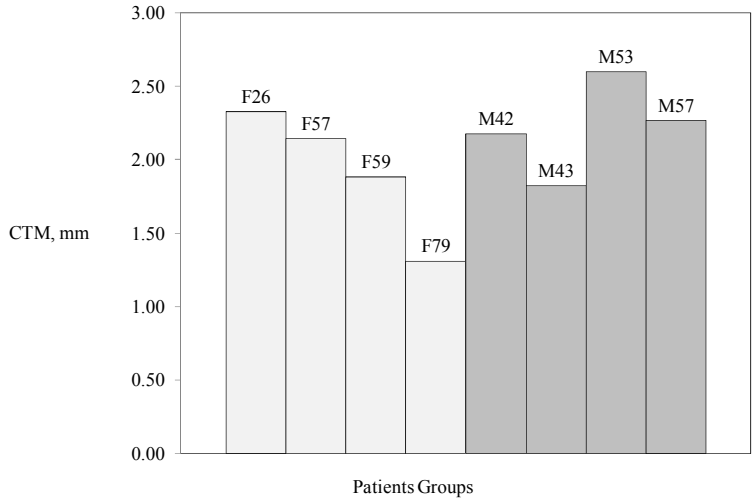

Figure 5. CTM values for F and M patients, (inner side).

CONCLUSION

The cortical bone thickness of the human maxilla/mandible may be affected by tooth extraction, age and patient gender. Edentulous mandible causes a bone reduction and a decrease in the strength. The use of this information is useful for complementary diagnostic and clinical treatment planning. Nevertheless, for continue to obtain a better correlation between different ages groups and gender, more CT should be analysed. The use of CT method is an excellent way to distinguish different tissues, as verified in this work. With this capability was possible to determine the cortical mean thickness value in different human mandibles.

REFERENCES

Cavalcanti, M.G.P.; Ruprecht, A.; Vannier, M.W., 3D-CT vascular setting protocol using computer graphics for the evaluation of maxillofacial lesions, Pesqui. Odontol. Bras., 15(3) (2001) 229-236.

Dabney, C.L.S; Dechow, P.C., Edentulation Alters Material Properties of cortical Bone in the Human Mandible, Journal of Dental Research, 81(9) (2002) 613-617.

Fonseca, E.M.M.; Lima, M.J.; Noronha, J.K.; Vaz, M.A.P., The thickness of the cortical bone in different maxillae using medical images, Proceedings of the I International Conference on Biodental Engineering, Portugal, R.M. Natal Jorge et al (Eds), CRC PRESS, Taylor & Francis Group, (2010) 109-112.

Kober, C.; Erdmann, B.; Lang, J.; Sader, R.; Zeilhofer, H.F., Adaptative Finite Element Simulation of the Human Mandible Using a New Physiological Model of the Masticatory Muscles, (2004) ZIB-report 04-16, Germany.

Miyamoto, I.; Tsuboi, Y.; Wada, E.; Suwa, H.; Iizuka, T., Influence of cortical bone thickness and implant length on implant stability at the time of sugery – clinical, prospective, biomechanical, and imaging study, Bone, 37 (2005) 776-780.

Natali, A.N., Dental biomechanics, Taylor & Francis (2003).

Polat, P.; Ceylan, G.; Suma, S.; Yanikoglu, N., The effects of tooth extraction on cortical thickness and bone mineral density of the mandible: evaluation with computerized tomography, Turk J Med Sci. 31 (2001) 271-274.

Rocha, S.S.; Ramos, D.L.P.; Cavalcanti, M.G.P., Applicability of 3D-CT facial reconstruction for forensic individual identification, Pesqui. Odontol. Bras. 17(1) (2003), ISSN1517-7491.

Zlatarié, D.K.; Celebié, A.; Milat, O., Bone Densitometric Study of Mandibular Density Using Dental Panoramic Radiographs, Acta Stomatol Croat. 36 (2002) 35-37.

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