Bone density assessment for mini-implants position

Marlon Sampaio Borges*, José Nelson Mucha**

Abstract

Introduction: The cortical thickness the interradicular spaces width and bone density are the key factor for the efficiency of mini-implants as anchor of resources. The objective was to assess the alveolar and basal bone density in maxilla and mandible in Hounsfield units (HU). **Method:** Eleven files from adults computed tomography images, were obtained 660 measurements of bone density: alveolar(buccal and lingual cortical),cancellous bone and basal(maxilla and mandible). Values were obtained through the Mimics software version 10.0(Materialise, Belgium). **Results:** Maxilla: The density of buccal cortical alveolar ranged from 438 to 948 HU, and the lingual from 680 to 950 HU, and the cancellous bone ranged from 207 to 488 HU. The basal bone in buccal showed a variation from 672 to 1380 HU and cancellous bone from 186 to 402 HU. In the mandible: a variation in alveolar bone in the buccal cortical was 782 to 1610 HU, in the lingual cortical alveolar from 610 to 1301 HU, and cancellous bone from 224 to 538. The density in the basal area was from 1145 to 1363 in the buccal cortical and 184 to 485 in the cancellous bone. **Conclusions:** The greater bone density in the maxilla in the area was observed between the pre-molars in the buccal alveolar cortical. The maxillary tuberosity is the region with lower bone density. The bone density in the mandible was higher than in the maxilla and there was a progressive increase from anterior to posterior and from alveolar to basal bone.

Keywords: Bone Density. Orthodontic Anchorage Procedures. Orthodontics.

INTRODUCTION

The mini-implants have been objects of study today, and have achieved great popularity in the community orthodontic.[1,2,6] The reasons are due to these devices promote adequate anchorage in orthodontic mechanics.

All appliances or intraoral devices show some loss anchorage and headgear depend on the cooperation of patients about the proper use of orthodontic appliances. When using an endosseous anchorage by means of temporary anchorage devices, as is the case for mini plates, mini-implants or dental implants, can be an anchorage without the need of cooperation from patients.

Compared with other anchoring devices, the mini-implants have excelled in the preference of professionals, the ease of insertion and removal, the possibility of immediate loading, small size and low cost.[8,11,16,20]

* Private practice, Orthodontic Specialist, Universidade Federal Fluminense, Niterói, RJ, Brazil
** Professor and chairman, Department of Orthodontics, School of Dentistry, Universidade Federal Fluminense, Niterói, RJ, Brazil.

Regarding the location for its implementation, several sites have been proposed for the installation of mini-implants, which can be inserted in different regions of the basal bone and alveolar maxillary and mandibular. In the maxilla, between second premolar and first molar and mandible between the first and second molars are commonly used as a resource for anchoring in cases of retraction of anterior teeth after extractions of premolars.[7,12,19]

The choice of the insertion site of mini-implant should be based on appropriate regions of soft tissues such as the presence of attached gingiva, adequate amounts of cortical bone, the angulation and the size of mini-implant and foremost, the type of tooth movement that is claiming, intrusion, extrusion, or space closure with both drive for mesial to distal.[10.17]

Consequently, for that mini-implants are effective as anchorage, there must be adequate thickness of cortical bone, enough spaces between the roots for their deployment, without damaging the dental roots, and also the quality of this bone should be such that favors the retention of mechanical device in a predetermined location. It is considered that bone density is a key factor for the efficiency of mini-implants as an anchorage. This aspect of the assessment or mapping of characteristics related to bone density is still a subject little discussed and emphasized in the literature.

It was intended, therefore, with this study to evaluate the maxillary and mandibular bone density in various sites, both in the alveolar bone and basal bone by computed tomography (cone beam), quantitatively in Hounsfield units (HU).

MATERIAL AND METHODS

The study sample consisted of 11 files of computerized tomography (CT) in DICOM format (Digital Imaging and Communication in Medicine), obtained from two men and nine women, Brazilians, aged between 20 and 30 years, holders of Class I malocclusion with biprotrusion and all permanent teeth present except third molars, from the database of tomographic images of the post graduate course in orthodontics, Universidade Federal Fluminense - UFF (Niterói, RJ, Brazil).

The same measurements were performed for the left and right sides of the dental arches and do not present statistically significant differences between them, were grouped, the total sample consists of measurements of the study.

660 measurements were performed, evaluating the region of the alveolar bone, the density of buccal cortical, lingual cortical, cancellous bone and in the basal bone region, the densities of buccal cortical and cancellous bone in both maxilla and mandible.

The bone densities were calculated using the Mimics software version 10.01 (http://www.materialise.com/materialise/view/en/65854 - Materialise, Begic) from images obtained from CT scans. The densities were measured in Hounsfield units (HU).

With help of the software Mimics 10.01, CT cuts were made in the alveolar bone height in the range of 3 to 5mm from the bone crest and to the basal bone height in the range of 5 to 7 mm from the apex of the teeth, as illustrated in Figure 1.

In certain areas of alveolar bone and basal bone sites evaluated between teeth were among the central and lateral incisors (1 and 2) between cuspids and first premolars (3 and 4) between the first and second premolars (4 and 5), between the second premolar and first molar (5 and 6), between first and second molars (6 and 7) and the region distal to second molars (7D) for both the jaw and to the mandible (Fig 2).

In areas between the teeth was measured the alveolar bone density of buccal cortical, lingual cortical and cancellous bone. In the section of basal bone was measured using the density of buccal cortical and cancellous bone.

FIGURE 1 - Tranversal section computerized tomography, illustrating the location of the crest, and root apices, as well as determining the areas measured, corresponding to the alveolar bone (3 to 5 mm of bone crest) and the basal bone (5 to 7 mm of root apices).

FIGURE 3 - Magnified view of CT section in the region between 1 and 2 in the mandible with the illustration of the measurement of bone density in the section of basal bone, both buccal cortical vestibular and cancellous bone area. The section shows the area represented the alveolar bone.

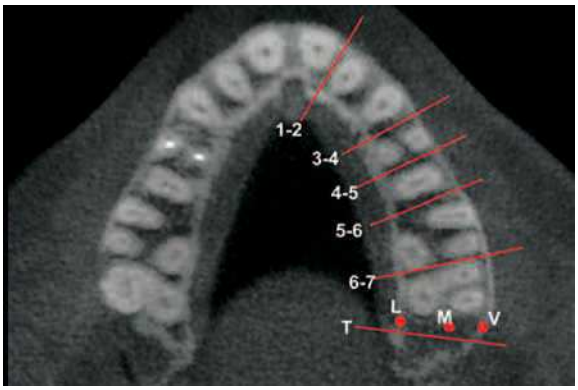

FIGURE 2 - Sites reviewed: 1 and 2, between the central incisor and lateral incisor, 3 and 4, between cuspid and first premolar, 4 and 5, between first and second premolar, 5 and 6, between the second premolar and first molar; 6 and 7, between first and second molar; T, tuberosity; V buccal cortical ; M, cancellous bone; L, lingual cortical.

Measurements of the thickness of cortical bone met the limits of the buccal and lingual cortical and cancellous bone was measured in the section between cortical, corresponding to the cancellous bone with trabecular aspect, as illustrated in Figure 3.

Data were organized in tables and proceeded to obtain measures of central tendency and statistical tests.

Analise Estatística Statistical Analysis

The analysis of differences between the sites was evaluated through analysis of variance (ANOVA), complemented with subsequent examination (Tukey test) for multiple comparisons of differences between sample means.

For this purpose, multiple comparisons, we used the BioStat 5.0 software, which is distributed free (freeware), by site (http://www.mamiraua.org.br/download/download.php?fname=./BioEstat 5 Portugues/BioEstat5_Portugues.zip).

RESULTS

The means, standard deviations and statistical significance between the areas assessed values for bone density, and basal alveolar jaw are shown in Table 1.

The values obtained for the averages, standard deviations and statistical significance between the areas assessed, bone density, and basal alveolar jaw are shown in Table 2.

The maxillary alveolar bone density, measured from the buccal aspect showed a variation 438-

948 HU, and the lingual side ranging 680-950 HU, and cancellous bone in this region has varied between 207-488 HU.

When observed values without the data obtained for the maxillary tuberosity, the density of cortical alveolar bone of the jaw, both in evaluating the buccal and lingual ranged between 802 and 950 Hounsfield units (HU). The maxillary tuberosity shows, therefore, one with poor bone density when compared to other sites analyzed in this study. A média da densidade óssea para a tuberosidade maxilar foi de 438 HU para a cortical vestibular e 680 HU para a cortical lingual. The average bone density for the maxillary tuberosity was 438 HU for buccal cortical and 680 HU for lingual cortical.

The area with greater bone density in the buccal cortical, was found in the region between the premolars, with 948 HU (± 220), as shown in Table 1.

The maxillary basal bone showed a variation in buccal cortical vestibular 672-1380 HU, and cancellous bone 186-402 HU. The values of standard deviations were also high for all areas assessed. In the basal bone, again, the exception was the maxillary tuberosity, which presented as average of the lowest bone density, with 672 HU for cortical vestibular and 186 HU for the can-

TABLE 1 - Means, Standard Deviations and Statistical Significance of maxillary bone densities in Hounsfield units (HU) in regions evaluated between teeth, lateral incisor and central incisor (1 and 2) between cuspid and first premolar (3 and 4); first and second premolars (4 and 5), second premolar and first molar (5 and 6) first and second molars (6 and 7), and the maxillary tuberosity (7D).

		Region (between teeth)												
		1 and 2		3 and 4		4 and 5		5 and 6		6 and 7		7D		Valor de P
		Mean	SD	Mean	SD	Mean	SD	Mean	DP	Mean	SD	Mean	SD	
Alveolar Bone	Buccal cortical	802.67^{A}	170.95	876.67^{B}	190.15	948.40^{B}	220.42	840.33^{C}	100.54	886.00^{C}	185.14	438.76^{F}	211.08	<.0001
	Cancellous bone	488.30^{A}	168.54	365.82^{C}	190.15	281.67^{A}	167.94	207.51^{B}	159.03	230.93^{F}	212.92	207.89^{E}	158.04	<.0001
	Lingual cortical	802.46^{A}	130.45	912.88^{A}	196.61	930.18^{A}	175.35	873.35^{C}	177.33	950.24^{A}	210.05	680.05^{D}	281.10	<.0001
Basal bone	Buccal cortical	832.44^{A}	230.79	1043.68^{D}	211.78	1181.45^{D}	256.90	951.00^{A}	168.01	1380.90^{E}	236.32	672.20^{F}	208.65	<.0001
	Cancellous boné	370.84^{A}	170.60	290.80^{C}	121.08	301.16^{A}	174.42	247.76^{E}	68.94	402.79^{A}	244.61	186.42^{D}	168.09	.0005

Means followed by the same letter do not differ statistically significant (P> 0.05) by Tukey test.

cellous bone region, indicating low density, statistically significant.

According to the analysis of Table 1 and Figure 4, it can be seen in the maxilla, the buccal cortical was more dense in the section of basal bone than in the section of alveolar bone in all regions analyzed.

In the evaluation of mandibular bone density, there was a variation of the alveolar bone in the buccal cortical (782-1610 HU), and lingual cortical (610-1301 HU), and in the alveolar cancellous bone area was 224-538 HU. The density in the basal area of the buccal cortical ranged from 1145 to 1363 HU and 184-485 in cancellous bone.

Was observed, in general, a progressive increase in bone density in the anterior mandible (lower density) to the posterior region (higher density). In the mandible the buccal cortical basal compared to buccal alveolar cortical, showed statistically significant higher density evaluated areas, except in the retromolar region (Table 2 and Fig 5).

The alveolar bone density of buccal cortical region of the mandible was statistically higher than in the maxilla, except as between central and lateral incisor (1 and 2) and between second premolar and first molar (5 and 6) as illustrated in Figure 6.

TABLE 2 - Means, Standard Deviations and Statistical Significance of mandible bone densities in Hounsfield units (HU) in regions evaluated between teeth, lateral incisor and central incisor (1 and 2) between cuspid and first premolar (3 and 4); first and second premolars (4 and 5), second premolar and first molar (5 and 6) first and second molars (6 and 7), and retromolar mandibular (7D)

		Region (between teeth)												
		1 and 2		3 and 4		4 and 5		5 and 6		6 and 7		7D		Valor de P
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Alveolar Bone	Buccal cortical	782.75^{A}	172.73	1010.34^{D}	105.98	1098.33^{E}	164.39	801.76^{A}	221.60	1320.08^{E}	139.17	1610.42B^{C}	145.25	<.0001
	Cancellous bone	505.70^{A}	210.80	538.63^{F}	178.87	474.58^{A}	124.51	224.31^{F}	220.38	358.00^{B}	130.54	324.78^{F}	81.81	<.0001
	Lingual cortical	707.18^{A}	198.00	1108.55^{D}	135.14	1250.20^{D}	188.95	610.27^{F}	109.72	1290.71^{E}	139.11	1301.20^{B}	203.68	<.0001
Basal bone	Buccal cortical	1285.12^{A}	230.50	1145.57^{D}	312.99	1339.06^{B}	80.99	1363.44^{B}	244.14	1299.70^{E}	108.94	1166.70^{B}	149.06	<.0001
	Cancellous boné	435.50^{B}	262.40	485.78^{A}	320.24	274.97^{F}	201.48	413.38^{C}	305.16	223.76^{B}	180.04	184.52^{E}	105.74	<.0001

Means followed by the same letter do not differ statistically significant (P> 0.05) by Tukey test.

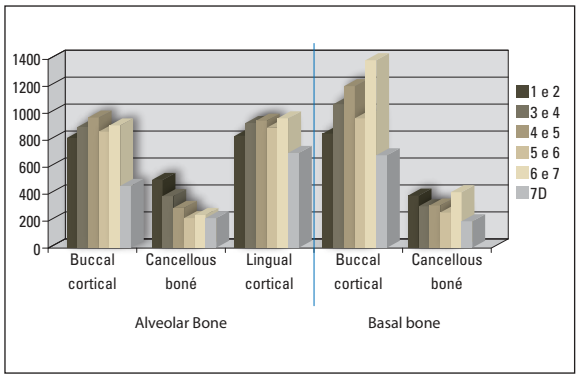

FIGURE 4 - Averages of the maxilla bone densities in Hounsfield units (HU) between the regions: central incisor and lateral incisor (1 and 2), cuspid and first premolar (3 and 4); first and second premolars (4 and 5), second premolar and first molar (5 and 6) first and second molars (6 and 7), and the region of the maxillary tuberosity (7D).

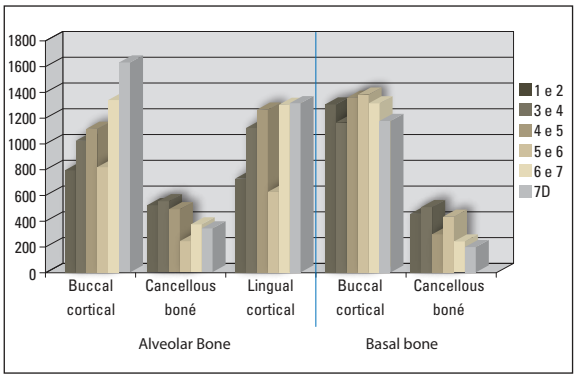

FIGURE 5 - Averages of mnadible bone densities in Hounsfield units (HU) between regions: central incisor and lateral incisor (1 and 2), cuspid and first premolar (3 and 4); first and second premolars (4 and 5), second premolar and first molar (5 and 6) first and second molars (6 and 7), and retromolar mandibular (7D).

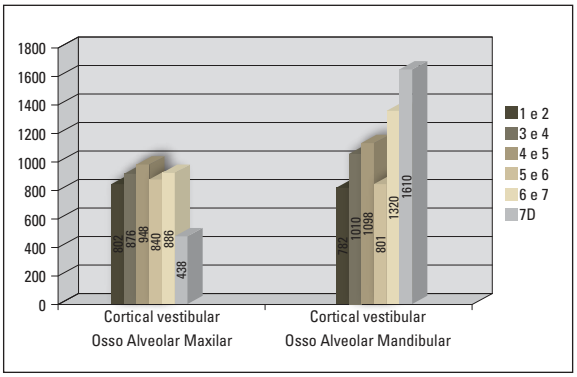

FIGURE 6 - Comparison between the mean bone density measurements (HU) areas of alveolar bone, the buccal cortical maxillary and mandibular.

Comparing the cancellous bone of the alveolar region, the locations between cuspid and first premolar (3 and 4) and between first and second premolars (4 and 5) were most dense in the mandible compared to the maxilla, which is statistically significant.

In the alveolar bone, the values obtained for the lingual cortical were very similar with average values for the vestibular cortical, as both the maxilla to the mandible.

DISCUSSION

The study of bone density in the maxilla and mandible, using images obtained from CT (Cone Beam), and using the software Mimics, to read images in DICOM format, allowing the section of the slices in the regions between the teeth, and evaluating the sections on both alveolar bone in certain areas such as basal 3-5 mm of bone crest and from 5 to 7 mm of root apices, as possible locations for the installation of mini-implants, was appropriate to this study.

The results may be used as additional information when selecting and electing the most suitable places to receive the anchoring devices, such as mini-implants.

The sample consisted of digital images obtained from adults, generating a total of 330 measurements on each side of the dental arches, and do not present statistically significant differences were grouped, resulting on 22 representative measures of each area evaluated, in a grand total of 660 measures. The sampling strategy adopted, with many measures and in several sites, generating results as averages in millimeters of cortical thickness, can be considered a point of emphasis of work in comparison with other studies.[4,9,10,16,17,18]

It was found that specific areas of the maxil-

la, as the buccal cortical alveolar bone between the premolars, as one of the sites with greater bone density and the maxillary tuberosity area as lower bone density.

There are many reasons for the failure of mini-implants as an anchorage, and among these may be cited as the loss or unscrew. This fact is not only bone density, but the knowledge of the values of bone density, both alveolar and basal constitutes yet another important factor for selection of suitable sites for deployment.

The uppermost in the maxilla, the basal bone in this study represented by the regions located 5 to 7 mm of root apices showed higher density in comparison with those located in the alveolar bone. The application of forces supported by mini-implants should be based on the type of tooth movement desired,[7,14,20] but when intrusion movements are expected and there is no impairment of efficacy of mechanical placement of mini-implants more superiorly ally interradicular a little space, can be considered uppermost, since they have greater bone density.[16,18]

Another factor that provides the stability of mini-implants is the thickness of cortical bone.[9,10,16] This study verified that the values of cortical bone density of the area are larger, generally in the same region, to double or up to 3-4 times the density of the cancellous bone area. This observation reinforces the need to insert mini-implants with an angled 10-20 degrees to the long axis of the teeth, to make the most of small thickness and higher density of cortical, either by buccal lingual as per.[10]

With the aesthetic concerns of the appliances, and for greater control mechanical anchorage devices can be installed by the lingual side.[9,10] There was this study that bone density in maxillary alveolar region is similar to the density at the buccal side, with even slightly higher.

The placement of mini-implants in the mandible, considering only the highest bone density as a factor for success will be more interesting in the more posterior and inferior. But this fact does not always occur, because other factors may contribute to loss or unscrew of the mini-implants. In some situations in areas of basal bone, and without attached gingiva alveolar mucosa may be one of the causes of failures, coupled with the difficulty of hygiene at.[3,11]

However, despite the greater mandibular bone density, the heating caused by the drilling process of the cortical thick through drills, could cause bone necrosis at temperatures above 47 ° C, causing the loss of the anchoring device.[11]

Stand out as most interesting places of election to receive the mini-implants in clinical cases of retraction of anterior teeth for space closure after extraction of premolars, the region between second premolar and first molar in the maxilla and between first and second molars in the mandible. These sites appear to be interesting, because together with the good quality of bone density, there is a safe space for mini-implants between the roots of the teeth.[12,15]

In the range of basal bone was not analyzed the density of lingual cortical, difficulty and even impossibility of clinical application of mini-implants in this anatomical region. Also, was not evaluated bone density in this region to be extremely thin and usually not be enough space for its placement.

The data will serve as guides for procedures for choosing the most suitable places for the placement of mini implants. It should be emphasized that in all measurements, the standard deviations found were very high, representing a wide variation of behavior of bone densities, requiring special consideration by the clinician for each case specifically.

Studies with larger samples and more specific, involving the resources of digital images, must be performed to qualify and quantify the characteristics most suitable sites for installation of mini-implants.

CONCLUSIONS

In the buccal cortical vestibular maxillary alveolar bone, the greater bone density was observed in the area between the premolars.

Higher density was observed in the buccal cortical basal of the maxilla between the premolars and molars between.

The density of lingual alveolar cortical maxillary showed slightly higher than in the buccal cortical.

The maxillary tuberosity was the region with lower bone density.

Bone density in the mandible was higher than in the maxilla in practically all areas assessed.

We observed in the mandible a gradual trend of increase in bone density from anterior to posterior and superior to inferior.

The mandibular alveolar cortical density was higher in the retromolar region, both by the buccal and lingual.

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Enviado em:
Revisado e aceito:

Contact address
Marlon Sampaio Borges
Rua Conde de Bonfim 255 - sala 612
CEP: 20.520-051 - Tijuca - Rio de Janeiro - Brasil
E-mail: borges.marlon@gmail.com