Original Article

Method standardization of buccal and palatal arch bone plate measurement using Cone Beam Computed Tomography

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Abstracts

Introduction: The thickness of the bone plates that cover teeth in buccal and palatal aspects represents one of the limiting factors of tooth movement. Technological advances in imaging have made it possible to evaluate these anatomical areas in detail, using cone beam computed tomography (CBCT). **Objective:** to describe and standardize, in details, a method for measuring buccal and palatal bone plates of the maxilla and mandible using cone beam computed tomography images. **Methods:** Digital standardization of the facial image position should be the first step before selecting the CBCT slices. Two axial sections of upper and lower maxillae were employed to measure the thickness of the buccal and palatal aspects of the alveolar bone. The cemento-enamel junction of the permanent molars was used as reference, for both the maxillary and mandibular arches. **Results:** Axial sections parallel to the palatal plane were indicated for quantitative evaluation of the maxillary alveolar bone. In the mandibular plane, the axial sections should be parallel to the functional occlusal plane. **Conclusion:** The method described herein is reproducible for use in research as well as for clinical evaluation of periodontal effects of tooth movement, by allowing the comparison of pre- and post-treatment images.

Keywords: Tomography. Spiral Cone Beam Computed Tomography. Diagnosis. Alveolar process.

INTRODUCTION

The relationship between orthodontic treatment and periodontal health has always been a reason for concern among orthodontists and periodontists, either because of the levels of force applied or the concern with initial and final periodontal tissue.[1,8,9,10,13]

The periodontal effects caused by tooth movement on bone plates, either in buccal or palatal aspects, still present limited scientific evidence.

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Studies conducted with that objective, in monkeys and dogs, demonstrated that buccal movements lead to bone dehiscences and, in a smaller degree, to gingival retraction. Palatal tooth repositioning may lead to partial regeneration of the buccal bone plate, with coronal migration of the buccal bone crest.[3,12,14]

Most of the literature on periodontal effects of orthodontic treatments has dealt with evaluating interproximal bone crests, especially in extraction areas. In general, studies have reported greater alveolar bone loss in groups who underwent orthodontic treatment, especially in extraction areas, but in clinically non-significant magnitudes. Furthermore, there is ample evidence that the effect of induced tooth movement may compound inflammation caused by bacteria, accelerating the rate of periodontal decay. However, works that evaluate gum tissues in buccal or palatal aspect are scarcer, perhaps due to the fact that these areas cannot be viewed in two-dimensional radiographs.[7] Nevertheless, with the advent of computed tomography, and particularly with cone beam computed tomography,[6] which allows exams with significantly lower doses of radiation, it is currently possible to perform quantitative and qualitative evaluations of buccal and palatal bone plates. Studies using computed tomography have shown that the thinner the bone plate is at the beginning of treatment, the greater the chances of dehiscences during rotation or buccal movements.[4,5,11]

Thus, the presence and thickness of the buccal and palatal bone plates becomes a limiting factor of tooth movement, and should be taken into account for orthodontic planning. Moreover, it becomes necessary, for research purposes, to develop a detailed standardization of the method of measuring the buccal and palatal bone plates of the maxillae using cone beam computed tomography, which is the main objective of this work.

MATERIAL AND METHODS

A methodology proposal will be described, step by step and in detail, for the quantitative evaluation of the buccal and palatal bone plates of maxillary and mandibular teeth. The steps of the methodology were adjusted for the i-CAT scanner (www.imagingsciences.com) and Nemoscan software (Madrid, Spain, www.nemotec.org).

Image collection

Prior to the exam, the tomography scanner should be configured to work under the following specifications: 120KvP, 8mA, 20-second exposure time. Patients should be instructed to remain seated in the device, with their head placed so that the Frankfurt plane is parallel to the floor and the midsagittal plane is perpendicular to the floor (Fig 1).

In order to encompass the dentoalveolar area of the maxilla and mandible, as well as the reference planes used in this methodology, the image collection protocol used was the "face" exam with a 13 cm cephalocaudal extension or "extended face" with 22 cm for patients with larger faces. Voxel width, and consequently the thickness of the axial sections, can be 0.3 or 0.4 mm.

The images obtained from cone bean computed tomography are generated in DICOM (Digital Imaging and Communication in Medicine) format. In DICOM, images acquired in any CT scanner, regardless of the imaging process (single, multislice, cone beam), can be viewed using different volumetric imaging software programs. The original DICOM format images feature a security key or number, which prevents alterations and has legal value (Fig 2).

Standardization of image placement

After copying the exam file to a conventional computer using Nemoscan software, image placement is standardized prior to selecting the sections to be used for measurement. The visualization of sections in the three spatial dimensions (axial, sagittal and coronal sections), as shown in figure 3, is known as multiplane reconstruction.

FIGURE 1 - **A**) i-Cat cone beam computed tomography scanner used in this work. **B**) Patient's head positioned with the Frankfurt plane parallel to the floor and the midsagittal plane perpendicular to the floor.

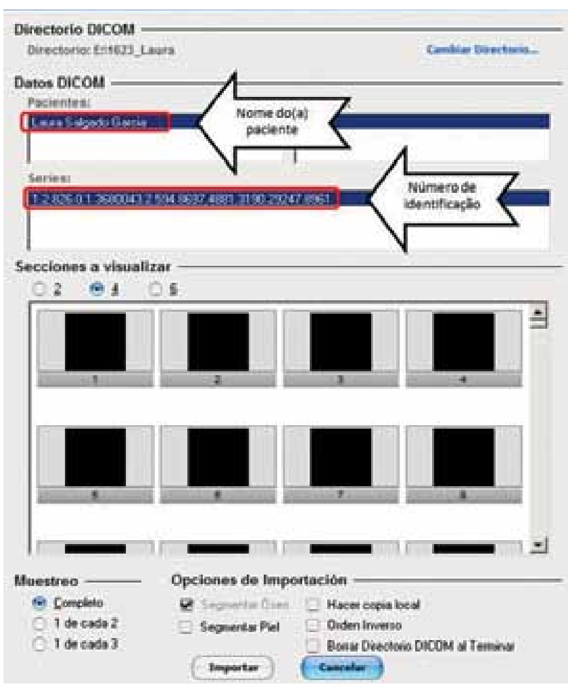

FIGURE 2 - Window of the Nemoscan software in which each of the original axial sections from the CT scan can be viewed, so they can be imported and manipulated using the software.

On that screen, it is possible to select the sections—in other words, the depth or structure to be visualized—as well as rotate the images so they can match the reference lines, as demonstrated in figures 4 and 5.

The references to standardize the image positions should be chosen for all three planes. The reference chosen to standardize the axial and sagittal planes was the bispinal line, coinciding with the vertical and horizontal planes, respectively. (Figs 6 and 7). The reference employed to standardize the coronal plane was the line between the infraorbital points, named the infraorbital line (Fig 8), thus concluding the positioning of images over the three spatial planes (Fig 9). When head position standardization is done using a 3D image—such as with Dolphin 3D software (Dolphin Imaging and Management Solutions, Chatsworth, CA, USA)—the Frankfurt plane can be used as a horizontal reference for the left and right lateral views, and the infraorbital point can be used for the frontal facial view, thus replacing the use of multiplane slices.

Image selection for measurement

For the maxilla, the first step was to select, among the axial sections parallel to the palatal plane (Fig 10), the section that shows the cemento-enamel junction of the distal-labial portion of the right maxillary first molar (Fig 11). From this

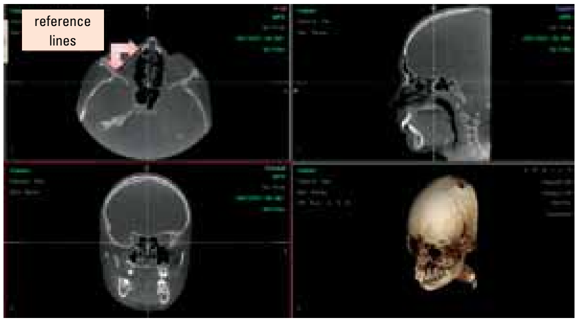

FIGURE 3 - Multiplane reconstruction showing the vertical and horizontal reference lines present in the three planes: axial, sagittal, and coronal.

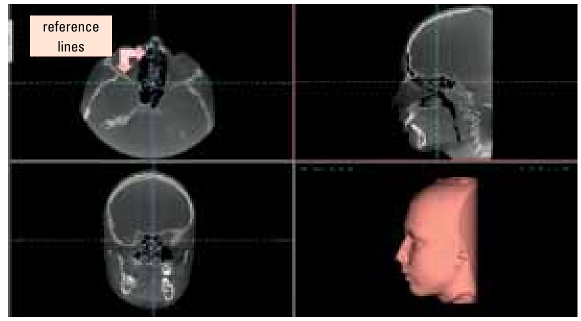

FIGURE 4 - After clicking on the “volume reformat” icon, the three reference lines can still be seen, but now with the possibility of rotating the images to make them coincide with the selected anatomical structures.

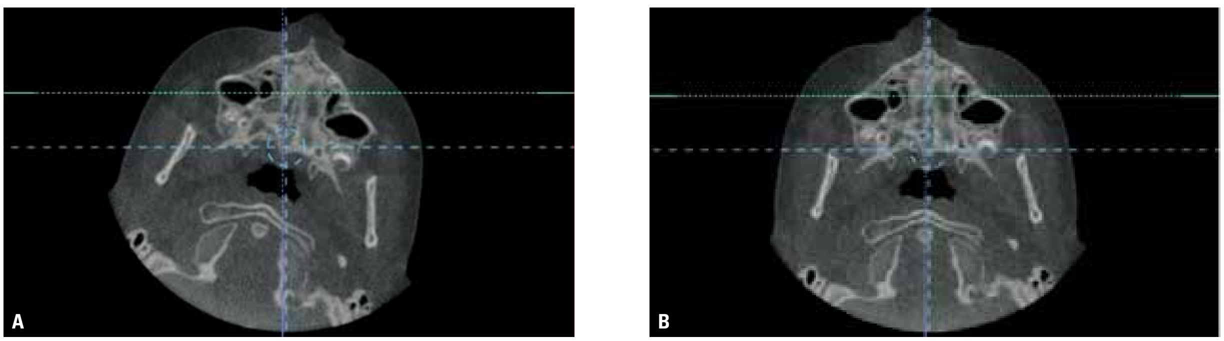

FIGURE 5 - Rotation of the axial image, making the bispinal line coincide with the vertical reference line. Note that in case of error in the positioning of the patient’s head during the scan, the discrepancy can be corrected in this stage.

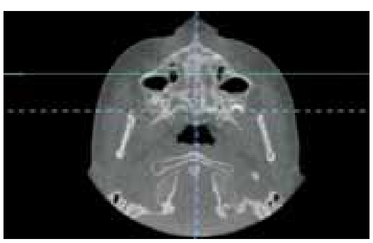

FIGURE 6 - Standardization of the axial section, making the bispinal line coincide with the vertical reference line.

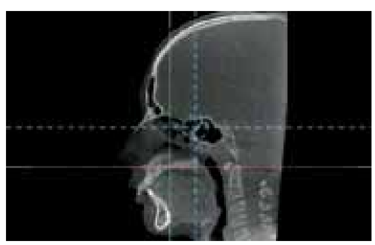

FIGURE 7 - Sagittal section, making the bispinal line coincide with the horizontal reference line.

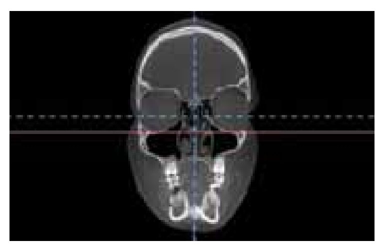

FIGURE 8 - Coronal section, making the infraorbital line coincide with the horizontal reference line (in pink).

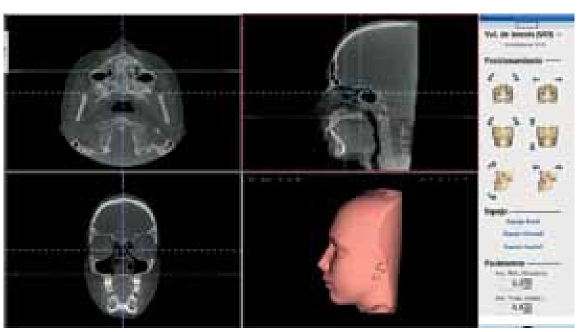

FIGURE 9 - Final view of the three-dimensional positioning of the patient’s images.

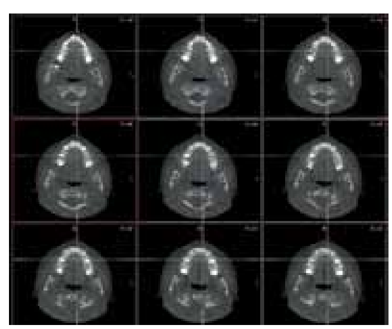

FIGURE 10 - Axial sections of the maxilla.

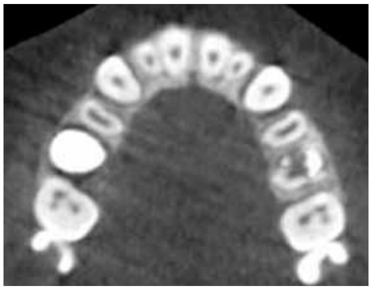

FIGURE 11 - Maxillary section selected as reference, passing through the cemento-enamel junction of the distal-labial portion of the right maxillary first molar.

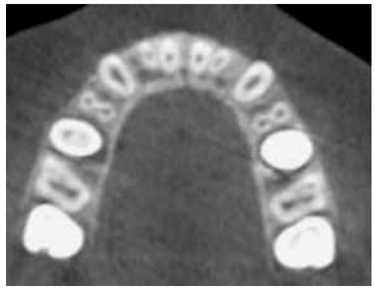

FIGURE 12 - Axial section passing 3.0 mm from the cemento-enamel junction of the right maxillary first molar.

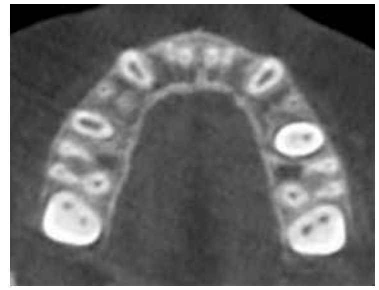

FIGURE 13 - Axial section passing 6.0 mm from the cemento-enamel junction of the right maxillary first molar.

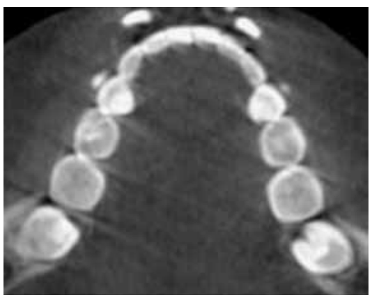

FIGURE 14 - Mandibular section selected as reference, through the cemento-enamel junction of the distal-labial portion of the right maxillary first molar.

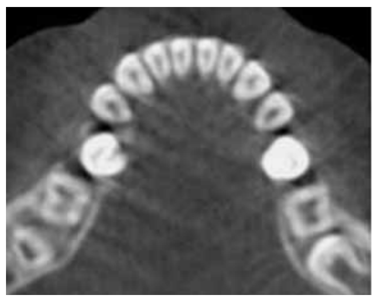

FIGURE 15 - Axial section passing 4.0 mm from the cemento-enamel junction of the right mandibular first molar.

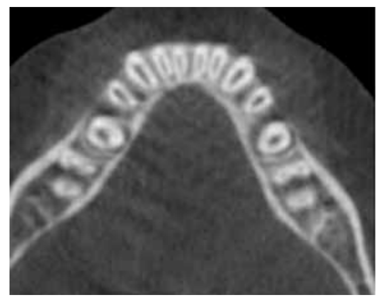

FIGURE 16 - Axial section passing 8.0 mm from the cemento-enamel junction of the right maxillary first molar.

axial section, two axial sections were selected, passing 3.0 and 6.0 mm apical to the cemento-enamel junction, respectively illustrated in Figures 12 and 13.

For the mandible, axial sections parallel to the functional occlusal plane were selected. To that end, the image of the head was repositioned using the software, tilting it backwards equivalent to the angle formed between the palatal plane (ENA-ENP) and the functional occlusal plane. The occlusal plane is a line that passes through the interocclusal contact point most distal from the first molars and through the mean overbite point of the canines. The PP.PO angle assumes different values for the various facial types (hypodivergent, normodivergent and hyperdivergent).[3] After this angle has been measured in the lateral cephalometric radiograph, reconstructed from the CBCT, the image of the head should be tilted backwards the equivalent to the correction value of the PP.PO angle, so that the functional occlusal plane is parallel to the plane of the axial sections. An axial section is then executed, passing through the cemento-enamel junction of the distal-labial portion of the right maxillary first molar (Fig 14). Using that section as reference, two axial sections are selected, passing 4.0 and 8.0 mm from the aforementioned cemento-enamel junction, respectively illustrated in Figures 15 and 16.

Image measurement

Measurements can be taken in either buccal or palatal aspect using the digital method. From the selected axial section, the image is zoomed in for easier visualization of the desired area (Fig 17). The measurements of the buccal bone plate are

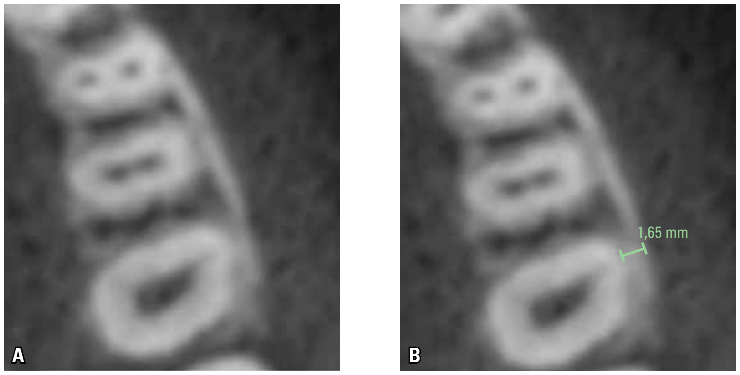

FIGURE 17 - Image zoomed in to facilitate the measurement (**A**) and with the measurement already executed (**B**).

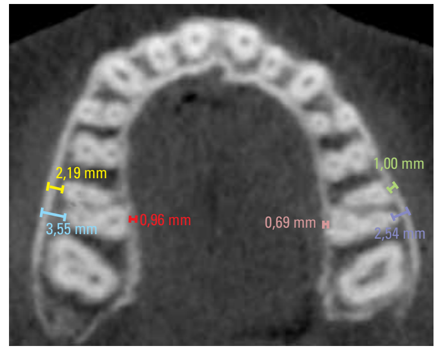

FIGURE 18 - Measurements taken using the software, indicating the thickness (in mm) of the buccal and palatal bone plates.

made in millimeters from the buccal limit of the radicular contour up to the outermost section of the cortical bone, perpendicular to the contour of the dental arch. Palatal bone plate measurement extends from the palatal limit of the radicular contour to the external surface of the palatal bone plate (Fig. 18).

CONCLUSION

Thus, based on a standardized methodology, a detailed evaluation is possible of the buccal and palatal bone plates. Studies using this methodology can evaluate the risks assumed when tooth movements are made in palatal or buccal aspect, and make possible an evaluation of the limits of orthodontic movement. Tooth movement in atrophic bone areas can also be evaluated using this methodology. It should be emphasized that the evaluation method proposed in this work is geared mainly towards research. With the objective of evaluating buccal and palatal bone plates, visual analysis of the axial and parasagittal sections is sufficient to expose areas with critical alveolar bone thickness. However, a numeric evaluation should be conducted, comparing the pre- and post-treatment exams in specific clinical cases with the aid of this method.

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