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The anterior maxilla as a potential source of bone grafts: a morphometric cone beam computed tomography analysis of different anatomical areas

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Abstract. The aim of this research was to use cone beam computed tomography (CBCT) to analyze the volume, density, and morphology of the bone available in the anterior region of the maxilla, in order to investigate its potential as a source of bone grafts. Three independent zones were evaluated: the palatine process of the maxilla (PPM), anterior nasal spine (ANS), and subnasal bone (SN). The latter was analyzed bilaterally (SN_R, SN_L). One hundred CBCT scans were evaluated. The morphometric analysis comprised volumetric and subsequent automatic density calculations, as well as linear measurements. Potential correlations among these parameters, including demographic characteristics, were investigated. The study comprised 52 women and 48 men (mean age 49.6 ± 14.5 years). The calculated bone volume averaged 2.41 ± 0.72 cm^3 for PPM, 0.46 ± 0.16 cm^3 for ANS, 0.58 ± 0.2 cm^3 for SN_R, and 0.57 ± 0.21 cm^3 for SN_L. The anterior region of the maxilla can provide a considerable amount of bone volume from different anatomical zones and should be regarded as a potential donor site for the regeneration of maxillary atrophic bones. Further investigation is required before these findings can be applied in the routine clinical setting.

Key words: bone graft; palatine process of the maxilla; anterior nasal spine; subnasal bone; CBCT; i-CAT; SIMPLANT; donor site.

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The search for reliable bone graft donor sites is a constant aim of clinicians dedicated to oral and maxillofacial reconstruction. Although substantial investigation has resulted in the incorporation of several allografts, xenografts, and alloplastic materials into the routine armamentarium, autologous bone grafting is still considered, in most cases, the gold standard option.[1–4]

The reconstruction of certain maxillofacial defects requires clinicians to obtain autologous grafts from extraoral sites such as the iliac crest, tibia, and parietal bone. Alternatively, intraoral donor sites may be

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preferable for certain indications in order to reduce morbidity, time, and costs.[5] The disadvantage of these is that they often provide limited bone volume.[5–7] In addition, the great variability that exists between individuals has been highlighted.[8,9] Hence, an individualized analysis of each case is crucial.

Used in conjunction with the appropriate software, computed tomography (CT) provides the most powerful and reliable technique for pre- and postoperative assessment.[10] However, the advent of cone beam computed tomography (CBCT) has provided a very convenient tool for the evaluation of the hard tissues in the dentomaxillofacial area. Advantages of CBCT include its wide accessibility, easy handling, and low radiation doses compared to conventional CT.[11]

Unexpectedly, the number of studies assessing intraoral donor sites – even with conventional radiological techniques – is quite low.[5,6,12,13] In fact, only one recent publication reports the combined use of CBCT and accurate volumetric measurements with a structured and reproducible method.[14]

Traditionally, the anterior region of the maxilla has been considered a recipient site for bone grafts. Very few studies have considered it as a donor site.[15–18] To date, three different zones have been described for this purpose: the palatine process of the maxilla (PPM), anterior nasal spine (ANS), and subnasal bone (SN).

The present study investigators have recently described a specific methodology for the morphometric evaluation of the PPM using CBCT technology and a related third-party software.[14] Based on the favourable preliminary results, the aim of this study was to assess the available bone volume, density, and morphology of the anterior region of the maxilla in a structured, precise, and reproducible way, and thereby to demonstrate its potential application as an alternative source of intraoral grafts.

Materials and methods

A retrospective analysis of the CBCT scans of 100 patients who had been referred to a university dental clinic for routine dental evaluation was performed. Patients were selected from the centre database according to the following inclusion criteria: CBCT imaging of the entire maxillary bone, complete physical growth (age ≥20 years), and dentate (from tooth 14 to 24). Patients with developmental malformations of the maxilla, tumours or cysts of the hard palate, severe periodontitis involving the region from tooth 14 to 24, and impacted teeth in the area of study were excluded from further evaluation.

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki (first adopted at the 18th World Medical Association General Assembly, Helsinki, Finland, June 1964). Ethical approval was obtained from the local ethics committee of clinical research. Written informed consent for CBCT analysis was obtained for each case. Patient confidentiality was safeguarded in compliance with the 15/1999 Organic Law. There was no direct or indirect contact with any of the study subjects, and their personal information was appropriately separated from the study database and filed for any possible audits, inspections, or confirmation of information veracity. Accordingly, each patient was assigned a number (consecutive from 1 to 100).

CBCT scans were obtained with an i-CAT device version 17–19 (Imaging Sciences International, Hatfield, PA, USA). The radiological parameters used were 120 kV and 5 mA; the axial slice default distance was 0.300 mm and the voxel size was 0.3 mm^3. The facial mode with 23-cm field of view (FOV) was used. Primary images were stored as DICOM (Digital Imaging and Communication in Medicine) files.

The metric analysis was performed as described in a previous publication.[14] This methodology was applied to each of the three anatomical regions studied: PPM, ANS, and SN. The patient's dataset was opened in SIMPLANT Pro 16.0 software (Materialise, Leuven, Belgium). The region of interest was defined in a sagittal slice view, eliminating all unnecessary areas. By default, the slice thickness was 0.3 mm. In order to obtain a thickness per slice of 0.9 mm, two segments from each slice were omitted. In 'segmentation mode', a mask was created marking the starting point of the bone. All areas irrelevant to the study were again eliminated. Then, maximum quality was set for the three-dimensional (3D) analysis. Once in 'planning preparation mode', a panoramic curve was created to facilitate the readings on the different spatial planes. A ±0.1 mm error deviation was established for all calculations. All measurements were taken from the axial plane in a caudal–cranial direction. Three references were set for each slice (anterior, posterior, and lateral margins). Once this protocol was implemented, a surface was created for each slice.

For the purpose of quantitative volumetric analysis, a 3D image of the delimited zone was constructed. Each of the three volumes of interest was defined as outlined below.

For the PPM, the starting slice was the base of the hard palate. The ending slice was the nasal floor. The anterior margin was the palatine area from tooth 14 to 24. This limit was defined by marking a point in the medial/palatine area of each tooth (Fig. 1). The same procedure was followed for the mesial and distal views wherever an adjacent tooth was not observed (usually in the longest canine roots) (Fig. 2). A 2-mm safety margin was established around the incisive canal. In this case, three peripheral points were marked (one on either side of the paramedials and one middle posterior). Similarly, a 2-mm safety margin was also set wherever the maxillary sinus appeared in the most cranial slices (Fig. 3). Wherever any of these teeth were no longer observed (usually in the most cranial slices), the anterior margin was delimited by the facial buccal plate. The posterior margin was the palatal

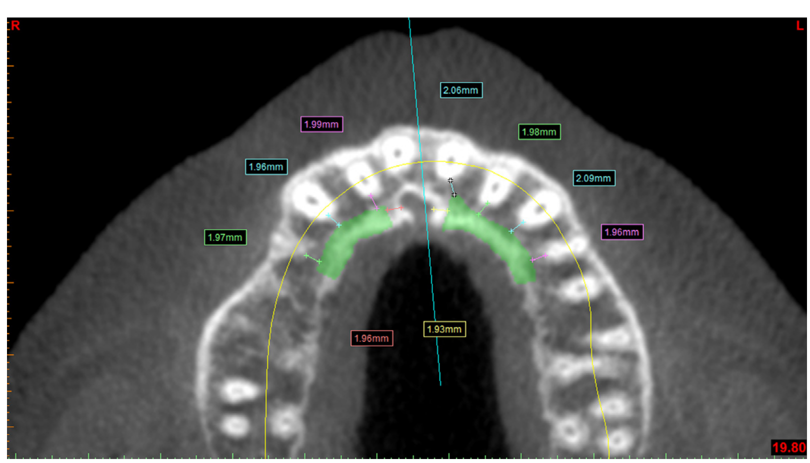

Fig. 1. Palatine process of the maxilla: axial caudal slice.