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Technical Note
Dental Implants

Palatal orthodontic miniscrew insertion using a CAD-CAM surgical guide: description of a technique

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Abstract. The aim of this report was to describe a new computer-guided technique for a controlled site preparation and palatal orthodontic miniscrew insertion using a dedicated software. A surgical guide was designed after planning the appropriate insertion sites on three-dimensional images created by the fusion of cone-beam computed tomography (CBCT) and digital dental model images. Pre- and postoperative CBCT images were compared and the angular, coronal, and apical deviations between the planned and the placed miniscrews were calculated. The mean coronal and apical deviations were 1.38 mm (range: 3.48–0.15 mm; standard deviation (SD): 0.65) and 1.73 mm (range: 5.41–0.10 mm; SD: 1.03), respectively, while the mean angular deviation was 4.60° (range: 15.23–0.54°; SD: 2.54). The present surgical guide allows a controlled and accurate palatal miniscrew placement in three dimensions.

Key words: orthodontics; CAD-CAM; minimally invasive surgical procedures orthodontic anchorage procedures dental implants; surgery; computer-assisted; temporary anchorage device (TAD).

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The orthodontic miniscrews that provide a skeletal anchorage have allowed the simplification of many orthodontic procedures conventionally employed for the control of anchorage, and a reduction in the undesirable effects of many orthodontic appliances[1]. The temporary anchorage devices (TADs) have the advantages of being relatively inexpensive, easy to insert and remove, versatile (they can be installed in many places in the maxilla and mandible), and predictable enough to be used routinely in dental practice[1]. The stability of miniscrews needs a good bone thickness either in the labial or palatal regions[2–4]. The anterior midpalatal and paramedian palate regions are potential sites of miniscrew placement because these areas are devoid of major blood vessels and nerves[2–4]. Therefore, these regions are relatively safe for orthodontic treatments requiring miniscrew placement.

The palatal thickness, varying from individual to individual[4,5], needs an accurate analysis to estimate where to insert the miniscrew and to ensure a reliable anchorage.

Recent improvements in three-dimensional (3D) imaging techniques have provided a means to overcome the limitations of two-dimensional (2D) images. Cone-beam computed tomography (CBCT) technology provides highly accurate and detailed information for a broad spectrum of clinical and research applications[6,7]. The current technological innovations mean that the insertion of orthodontic

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miniscrews would be within the reach of any orthodontist, although this is usually a strictly surgical technique.

The aim of the present technical note is to show a new computer-aided design and computer-aided manufacturing (CAD-CAM) surgical guide which is designed for palatal orthodontic appliances. This ensures a minimally invasive and accurate site preparation and miniscrew insertion. The present surgical guide was created using a dedicated software. The appropriate miniscrew insertion sites were planned on 3D images created by the fusion of CBCT and dental digital model images. The surgical guide was manufactured using a 3D printer. The accuracy of miniscrew insertion was finally evaluated comparing pre- and postoperative CBCT.

Technique

At the Department of Oral and Maxillo-Facial Sciences of ''Sapienza'' University of Rome, five patients were treated with an intraosseous screw-supported maxillary molar distalization appliance. A total of 10 palatal miniscrews were inserted. The digital model of the dental cast was acquired through a 3D scanner (Easy Optical 3D Scanner, Open Technologies, Rezzato, BS, Italy). The cast scanner images were saved as stereolithography (STL) files and stored.

A CBCT examination was perfomed. During the CBCT exam the patient wore a personalized radiological tray (Universal Stent, Bionova, Follo, La Spezia, Italy) with radiopaque landmarks; this radiological tray was properly positioned in the mouth with a transparent vinyl polysiloxane (Elite Transparent, Zhermack, Badia Polesine, Rovigo, Italy) and allowed a perfect overlap of the jaw and cast STL files (Fig. 1A). Furthermore, the radiological tray made it possible to maintain the correct occlusal position during the scan. DICOM (Digital Imaging and Communications in Medicine) images were acquired using a software (Vector 3D, WHITEK, Lodi, Italy), which allowed the segmentation of 3D medical images. Images of the jaws were transformed into 3D models and saved as STL files. With the same software and using the radiological matching tray as reference, the STL files of the jaw and cast were matched. This software permitted a view of the 3D model from different perspectives and planes with a perfect rendering. On the STL 3D model file the ideal points for miniscrew insertion were identified, usually placed in the anterior region of palate between the distal area of canines and the distal area of second premolars. The placement site and angle were determined on the basis of the width and thickness of the palatal vault. A software application (Guide Design) permitted the design of the surgical guide (Vector Guide, WHITEK, Lodi, Italy). The 3D STL model of the surgical guide was printed using a 3D printer (Fig. 1B–D).

Before starting the surgery, the patient's mouth was rendered aseptic by rinsing with a 0.2% chlorhexidine solution. Local anaesthesia was performed with 2% carbocain containing adrenaline in the ratio of 1:100,000. The surgical template was held in place by a tooth-borne shape to ensure stable retention (Fig. 2A). The same guide

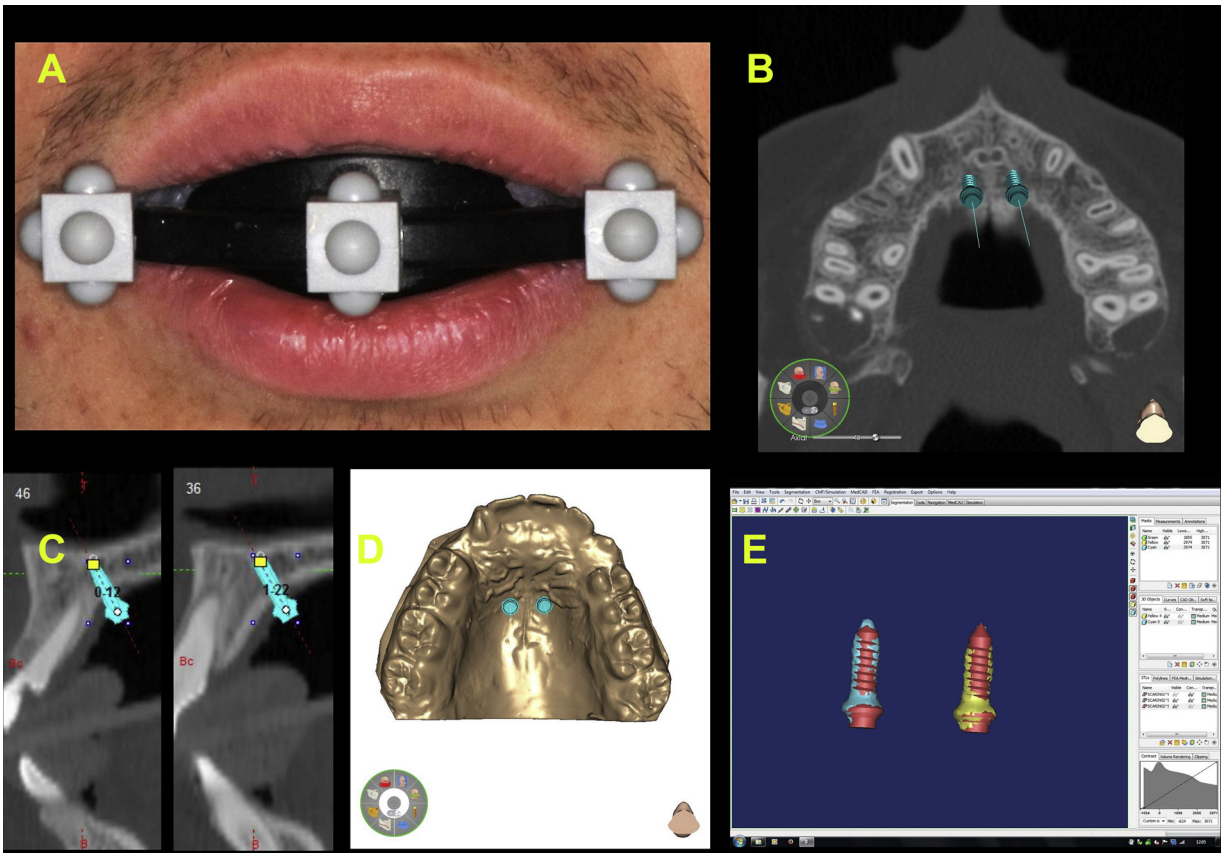

Fig. 1. (A) The radiological tray used to obtain a perfect overlap of the jaw and virtual dental cast stereolithography files. (B, C) Virtual miniscrew placement using the three-dimensional computer simulation software. Axial, three-dimensional, panoramic, and cross-sectional images of the jaw are visible at the same time on a computer monitor. (D) Using the planning software it is also possible to evaluate the position of miniscrews on the virtual dental cast. (E) The matching procedure with Mimics software is used to evaluate the accuracy. Planned implants are represented in red and placed miniscrews are represented by various colors.

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