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Digital Planning for Mini-Implant Supported Palatal Expander in Open-Bite Treatment

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Abstract

Open bite malocclusion, due to it's multifactorial etiology, has always been considered a difficult problem to treat. Often associated with transverse maxillary deficiency, this is a real challenge in the field of orthodontics. The traditional approach, for this type of anomaly, in adult patients, is orthognathic surgery and RME (rapid maxillary expansion). There are several approaches to the treatment of adult patients using digital technology. Mini-implant supported palatal expander limits the side effects of the conventional RME and is less invasive compared to orthognathic surgery. Precise and predictable mini-implant insertion, using a customized surgical guide, provides a safe therapeutic approach. This case report combines Cone-beam computed tomography (CBCT), laser scan superimposition, computer-aided design (CAD) and 3D printing in order to design and print a customized surgical guide for orthodontic mini-implant insertion. A CBCT scan was performed to determine the optimal site for mini-implants' placement. Using the 3Shape Trios Intraoral Scanner the maxilla and the mandible were laser-scanned. Blue Sky Plan 4 software was used to design the surgical guide, and RayWare software was used for printing it. 4 mini-implants were inserted using a safe and predictable technique. The 3D technology represents the future of orthodontics, reducing the risks, chair-side time while providing the best treatment plan for the patient.

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Introduction

Open bite is an anomaly with distinct characteristics that can be easily recognized in 25 to 38 % of the orthodontic patients [1]. Several etiological factors are responsible for this type of malocclusion such as: facial growth pattern, sucking habits, tongue-thrusting, mouth breathing, adenoid hypertrophy, syndromes, occlusal and eruptive forces, dental ankylosis, and postural mandibular imbalance. [2] Open bite is often associated with transverse maxillary deficiency, one of the most common malocclusions in orthodontics. [3]

Rapid maxillary expansion (RME) is the treatment of choice for the transverse maxillary deficiencies and it is achieved through the remodeling of the midpalatal and inter-maxillary sutures, in children and teenagers. [4,5]

Due to the increased inter-digitation of the maxillary sutures and the rigidity of adjacent structures, the prognosis is not that favorable for adult patients. [6] Root resorptions,damage to periodontal tissues,[7,8,9] technique failure or limitations,[10] reduced stability, [11] edemas and soft tissue lesions [12] have been reported as side effects for adult patients.

In order to minimize the side effects of classical RME and to optimize the potential for skeletal expansion in adult patients Lee et al proposed a mini-screw assisted rapid palatal expansion (MARPE) appliance. [13] Mini-screw insertion site is critical and requires careful consideration of the hard and soft tissue, biomechanics, accessibility and patients's comfort.

Digital technology plays a major role in contemporary orthodontics, changing the rules of conventional workflow. [14-18] Every procedure, from diagnosis and treatment outcome pre-visualization to the customization of the appliance design and customization of the therapy, is more predictable. [19,20]. The use of cone beam computer tomography (CBCT) allows for a more detailed diagnosis and selection for an insertion site with adequate bone quantity and quality. The placement of orthodontic mini-implants with a 3D method based on CBCT imaging has been described in recent years. [21,22].

Materials & Methods

This study presents the 3D planning for a surgical guide in order to place a mini-implant supported maxillary expander.

In the case presented below, a male patient aged 25 years, with the chief complaint of posterior, skeletal, bilateral cross-bite and anterior open bite, was referred for orthodontic treatment. A rapid palatal expansion appliance was proposed using a skeletal expander anchored on 4 BENEfit® mini-implants.

A CBCT scan was performed to determine the optimal site for mini-implants' placement. Using the 3Shape Trios Intraoral Scanner the maxilla and the mandible were laser-scanned (Fig.1). Blue Sky Plan 4 software was used to design the surgical guide, and RayWare software was used for printing it.

The digital model (stereolitography [STL] files) was superimposed on the CBCT scan (DICOM file [Digital Imaging and Communication in Medicine] file in order to facilitate the optimal positioning of the 4 mini-implants in the anterior hard palate.

Results

The most suitable antero-posterior mini-implant placement site is determined based on the width and thickness of the palatal vault. 4 self-drilling mini-implants (BENEfit®) were selected: 2 in the anterior palate (rugae area): 2.0 x 9 mm (ST-33-54209) and 2 in the posterior palate (para-midsagittal area): 2.0 x 7 mm (ST-33-54207). (Fig.2)

The precise position and angulation of the mini-implants is replicated by 4 cylindrical metallic guides taking into consideration the following parameters: bone thickness, soft tissue thickness and anatomical surrounding structures. The most appropriate site for the placement of mini-implants is: 3 mm lateral to the suture in the first premolar region. (Fig. 3,4)

A 3D positioning guide was designed on top of the virtual model with the final mini-implant position. (Fig.5)

The customized surgical template was 1.8 mm thick layer offset based on the teeth/mucosa/ bracket contour profiles and ranged from incisors to second premolar. The surgical template was designed to cover the entire occlusal surface. (Fig.6)

Patient's initials are engraved on the outer surface of the guide, as well as the dimensions of the mini-implants in order to provide more safety and not

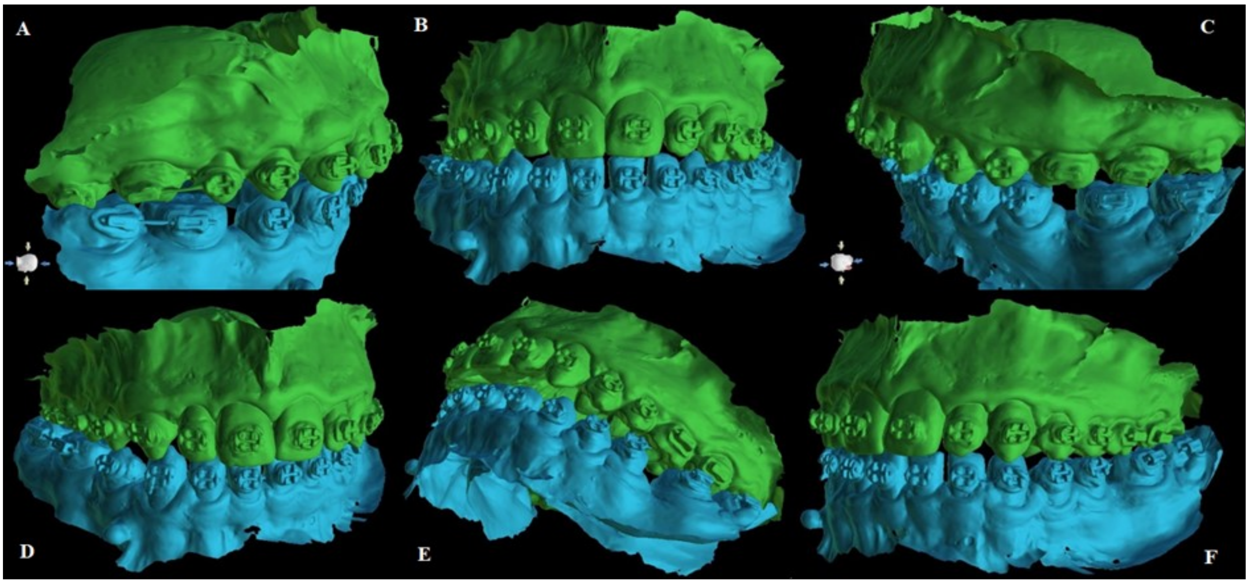

Figure 1. Digital models

A- Right lateral view; B- Frontal view; C- Leftlateral view;

D- Right semi-profile view; E- Sagittal view; F- Left semi-profile view

B.M.M, B, 25

Patient Name: B.M.M
Drill Kit: Blue Sky Bio Fully Guided Surgical Kit
Manufacturer: Blue Sky Bio

Implant/Tooth Number	Implant Part Number	Implant Diameter (mm)	Implant Height (mm)	Drill Type	Metal Cylinder Part Number	Drill Depth (mm)	Angle (°)
0		2	9	-	-	18	0.20
1		2	9	-	-	18	0.20
2		2	7	-	-	16	1.30
3		2	7	-	-	16	3.34

Implant/Tooth Number	Abutment Diameter (mm)	Abutment Height (mm)	Part ID	Angle (°)
0	3.00	20.00	-	0
1	3.00	20.00	-	0
2	3.00	20.00	-	-2.20957
3	3.00	20.00	-	-2.20957

The above metal cylinder and drill settings are based on the use of metal cylinders manufactured and sold by BlueSkyBio.com. The data will vary if the metal cylinders are sourced from a different supplier.

Figure 2. Mini-implant characteristics

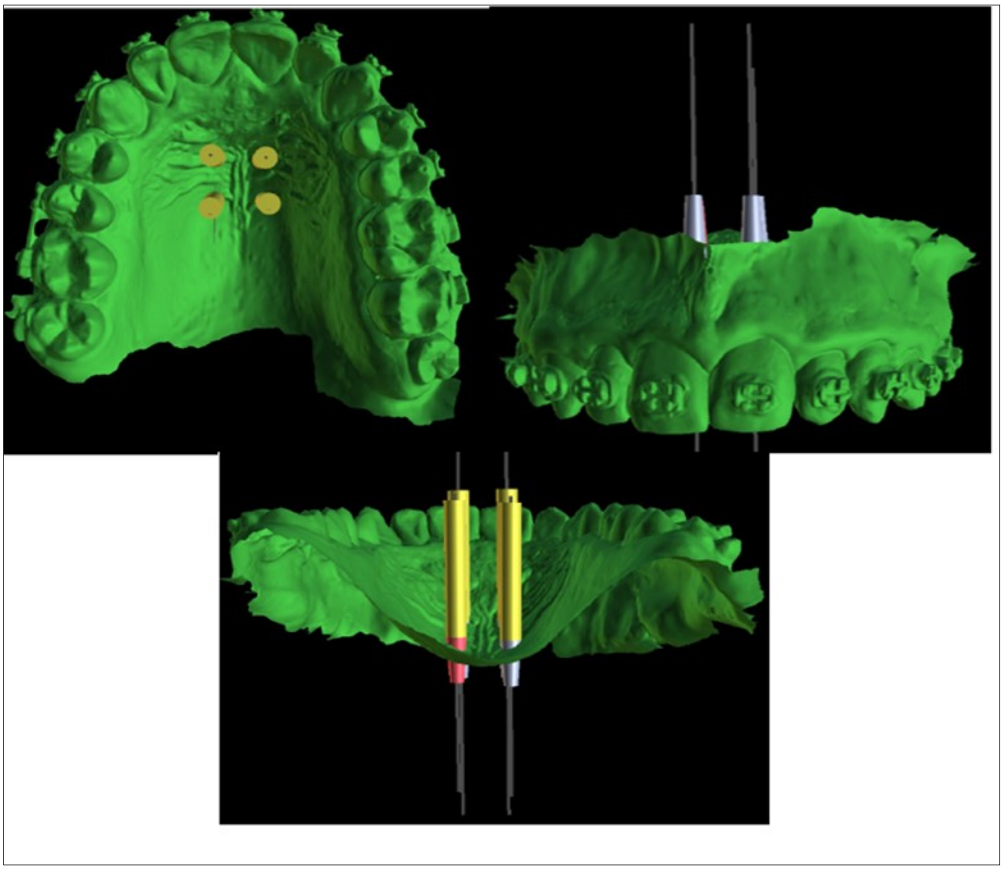

Figure 3. Positioning of the 4 mini-implants, visualized on the basis of the intraoral scan

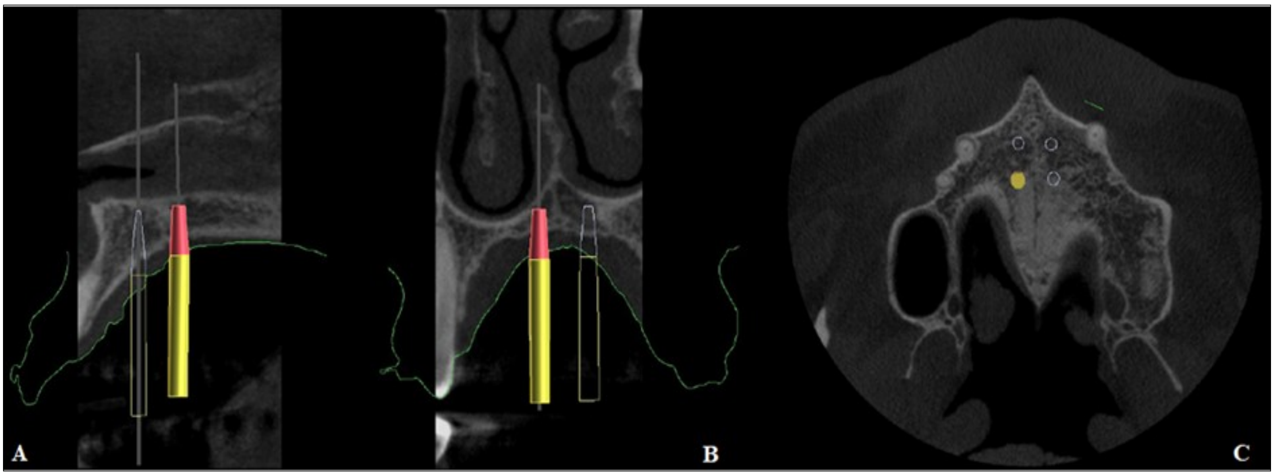

Figure 4. Positioning of the mini-implants on CBCT, A. Sagittal section, B. Coronal section, C. Axial section

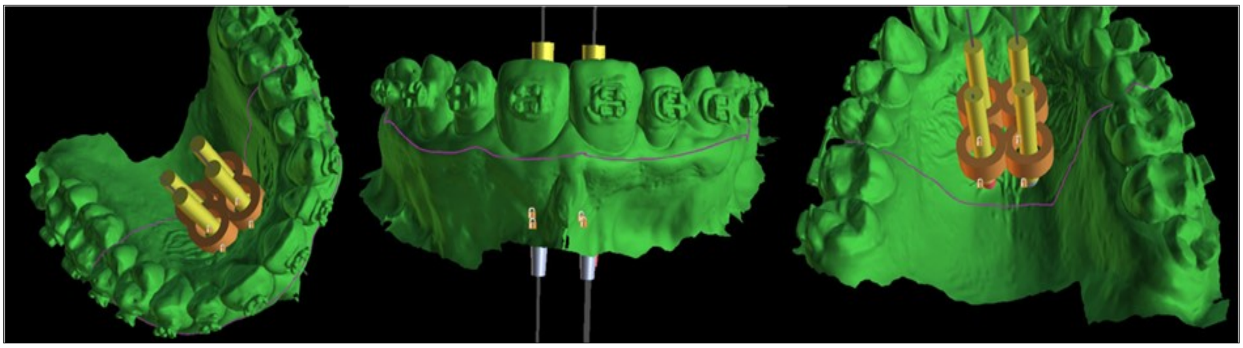

Figure 5. Designing the surgical guide

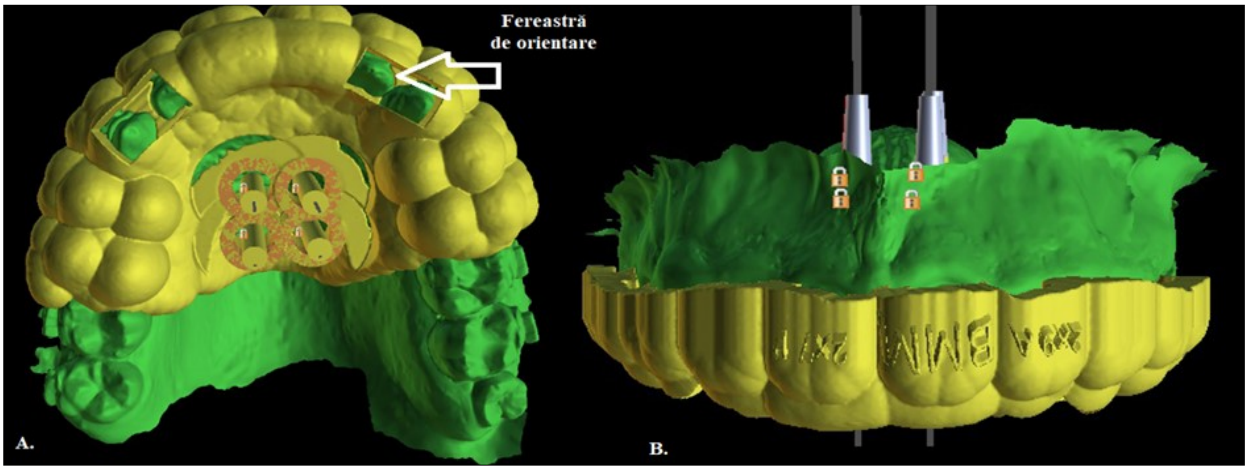

Figure 6. Custom made surgical guide with mini-implant analogs final design

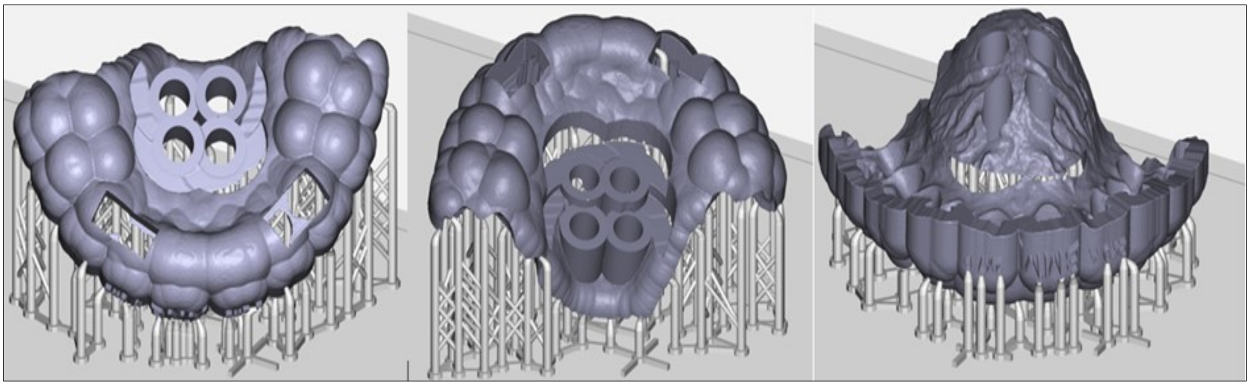

Figure 7. Final preview of the surgical guide before printing

cause confusion during the transfer from the printing office to the dental office (Fig. 6).

After this stage, this file was exported in RayWare software (Fig. 7) and printed using a auto-clavable resin (Surgical Guide-MoonRay).

Discussion

The digital workflow in orthodontics consists of a triad of digital models, orthodontic software and 3D printers and allows for faster digital case planning, improving communication between professionals and patients without the use of physical documents. In addition, the accessibility and ease of use of this technology enables its wide use in diagnostic and treatment planning. [23,24] Three-dimensional image processing allows for virtual planning using CAD (computer-aided design) software as well as CAM (computer-aided manufacturing), such as for the manufacture of surgical guides that were originally used in implantology. [25,26]. It is recommended to combine the knowledge of basic sciences and the evolution of new technologies in order to establish safer therapeutic approaches. [27]

Software-based digital orthodontic planning allows the simulation of the mini-implant placement, determining the ideal characteristics (shape, length, diameter and angulation). It also allows the precise and predictable mini-implant insertion.

Conclusion

The 3D technology represents the future of orthodontics, reducing the risks, chair-side time while providing the best treatment plan for the patient.

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