

Noriyuki Kitai, DDS, PhD
Senior Lecturer

Yoshitaka Yasuda, DDS, PhD
Associate Professor

Kenji Takada, DDS, PhD
Professor and Chairman

Department of Orthodontics and
Dentofacial Orthopedics
Graduate School of Dentistry
Osaka University
Osaka, Japan

Reprint requests:

Dr Noriyuki Kitai
Department of Orthodontics and
Dentofacial Orthopedics
Graduate School of Dentistry
Osaka University
1-8 Yamadaoka, Suita
Osaka, 565-0871 Japan
Fax: +81 6 6879 2960
E-mail: nkitai@dent.osaka-u.ac.jp

A stent fabricated on a selectively colored stereolithographic model for placement of orthodontic mini-implants

The purpose of this report is to present a new method for placing orthodontic mini-implants using a stent fabricated on a selectively colored stereolithographic model. A stent was fabricated that incorporated a guide groove drilled in accordance with the planned direction of the mini-implant. Tooth crowns, gingiva, tooth roots, and the maxillary sinuses were clearly identified in the stereolithographic model. As a result, the stent could be fabricated while taking into account the anatomic characteristics of both the bone interior and the dental surface. A stent fabricated on the selectively colored stereolithographic model is suggested to be a promising device for guiding placement of orthodontic mini-implants adjacent to the tooth roots and the maxillary sinuses. (Int J Adult Orthod Orthognath Surg 2002;17:264–266)

Although computerized tomography (CT) has frequently been used for planning treatment involving dental implants,^{1–8} the direct transfer of preoperative planning data to the intraoperative site is difficult. Resin stents with guide grooves directing the implant to the planned position have often been used^{1,4,5,8} to solve the problem. The stents have been fabricated on the dental cast^{1,5,8} or on a stereolithographic model created from the CT data.⁴ It is difficult to combine the images of tooth roots and maxillary sinus into a stent fabricated on the dental cast. However, it is also impossible to ascertain morphology of tooth crowns and gingiva accurately using the CT stereolithographic model. To fabricate a stent that takes into account the anatomic characteristics of both the bone interior and the dental surface, it is necessary to integrate data from the dental cast and CT.

Mini-implants with microscrews have recently been used as anchorage for orthodontic tooth movement.⁹ Placement of the mini-implant must be carefully implemented, because the implants are often placed between tooth roots and occasion-

ally close to the maxillary sinuses. No previous reports have documented a method for accurate placement of the mini-implants.

The purpose of this report is to present a new method for placing orthodontic mini-implants using a stent fabricated on a selectively colored stereolithographic model.

Materials and methods

Before CT examination, a bite plate with 5 ceramic marker balls was set into the patient's oral cavity: 1 ball was positioned on the labial surface in front of the maxillary central incisors, 2 were placed in front of the canines, and 2 were set in front of the first molars (Fig 1). Scanning of the area between the inferior ridge of the orbit and the tip of maxillary tooth crowns was performed using a helical type CT scanner (General Electric). Slice thickness was 1.0 mm with no slice gap. Field of view (FOV) was 25 cm and the number of matrices was 512 to provide a pixel size of 0.49 mm.

The ceramic marker balls attached to the bite plate used in the CT scanning

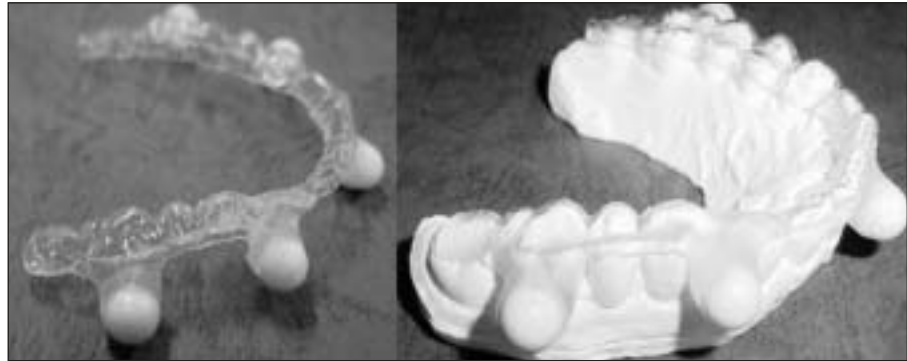


Fig 1 (left) Bite plate with 5 ceramic marker balls built in. (right) Dental cast model with the bite plate.

process were set on the dental cast. The 3D surface image of the dental cast model, including the ceramic marker balls, was digitized using a non-contact 3D measuring system (Surflacer, VMS150R-D, Unisn).

Tooth roots and the maxillary sinuses were segmented in the CT dataset using the software package Mvox (Anamedic). The CT and dental-surface images were registered and integrated according to the ceramic marker balls,¹⁰ and the 3D reconstruction of the integrated image was performed using the software package Surfacr (Structural Dynamic Research).

The stereolithographic model, in which the tooth roots were stained with red dye, was created using a rapid prototyping machine. The superior surface was the inferior border of the maxillary sinuses. The placement direction of the mini-implants (1.2 mm in diameter and 6 mm in length; Ortho Anchor K1 System, Dentsply-Sankin K.K.) was planned in the stereolithographic model so that the implants would not be in contact with the tooth roots or the maxillary sinus.

A stent was fabricated that incorporated a guide groove drilled in accordance with the planned direction of the mini-implant.

Results

Images of tooth roots and the maxillary sinuses from CT and images of tooth crowns and gingiva derived from the dental cast were integrated (Fig 2). Tooth crowns, gingiva, tooth roots, and maxillary sinuses were clearly identified in the

stereolithographic model (Fig 3). The stent with guide grooves was fitted on the stereolithographic model (Fig 4). An orthodontic mini-implant was placed using the stent (Fig 5).

Discussion

For placement of dental implants, the direct transfer of preoperative planning data to the intraoperative site has frequently been carried out using stents.^{1,4,5,8} The present report, for the first time, documents the use of a stent for the placement of mini-implants that has been fabricated on a stereolithographic model, including tooth crowns, tooth roots, gingiva, and maxillary sinuses. The absence of reports documenting this kind of stent may result from the fact that it is difficult to integrate CT data with dental cast data. Because CT is not superior for visualization of tooth crowns and gingiva, and dental casts cannot depict the anatomic characteristics in the bone, there are no common landmarks for the registration between the CT and dental cast images. In the present report, we used ceramic balls for the registration according to a previously reported method.¹⁰

The integrated image data from CT and dental casts were reproduced as a stereolithographic model in this study. The stereolithographic model facilitates the visualization of tooth crowns, gingiva, tooth roots, and maxillary sinuses. As a result, we could fabricate the stent taking into account the anatomic characteristics of both the bone interior and dental surface.

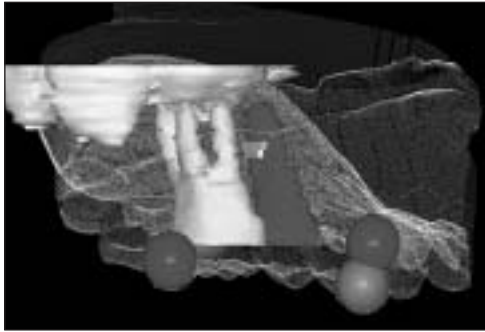


Fig 2 The 3D integrated image of CT and dental cast with the 5 ceramic marker balls.



Fig 3 The stereolithographic model, in which the tooth roots are stained with red dye. The superior surface is the inferior border of the maxillary sinus.

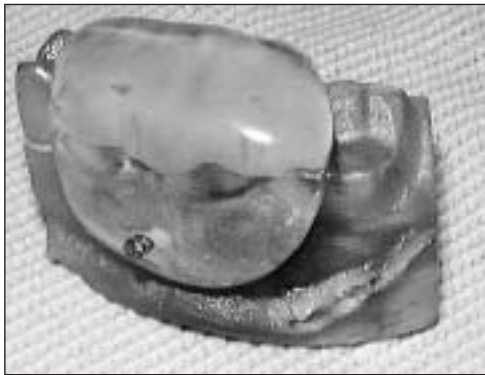


Fig 4 A stent including the guide groove is drilled according to the direction of the mini-implant planned in the stereolithographic model.



Fig 5 An orthodontic mini-implant is placed using the stent.

Conclusion

A stent fabricated on a selectively colored stereolithographic model is suggested to be a promising device for guiding placement of orthodontic mini-implants adjacent to the tooth roots and the maxillary sinus.

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References

- Fortin T, Coudert JL, Champlébourg G, Sautot P, Lavalée S. Computer-assisted dental implant surgery using computed tomography. *J Image Guid Surg* 1995;1:53–58.
- Amet EM. Computerized tomography with CT models for contemporary ramus frame implant planning and construction. *J Oral Implantol* 1998;24:152–158.
- Borrow JW, Smith JP. Stent marker materials for computerized tomograph-assisted implant planning. *Int J Periodontics Restorative Dent* 1996; 16:60–67.
- Hagiwara Y, Koizumi M, Igarashi T. Application of CT imaging for dental implant simulation. *J Oral Sci* 1999;41:157–161.
- Iritani O, Shiota M, Tachikawa N, Enomoto S. Diagnosis for dental implant using computed tomography and precise implantation using modified stent. *Kokobyō Gakkai Zasshi* 1998;65:380–386.
- McAllister ML. Application of stereolithography to subperiosteal implant manufacture. *J Oral Implantol* 1998;24:89–92.
- Urquiola J, Toothaker RW. Using lead foil as a radiopaque marker for computerized tomography imaging when implant treatment planning. *J Prosthet Dent* 1997;77:227–228.
- Verde MA, Morgano SM. A dual-purpose stent for the implant-supported prosthesis. *J Prosthet Dent* 1993;69:276–280.
- Kanomi R. Mini-implant for orthodontic anchorage. *J Clin Orthod* 1997;31:763–767.
- Nishii Y, Nojima K, Takane Y, Isshiki Y. Integration of the maxillofacial three-dimensional CT image and the three-dimensional dental surface image. *Orthod Wave* 1998;57:189–194.