DENTAL TECHNIQUE

A digital implant custom tray fabrication method using the design process for simulating the position of the impression copings and 3D printing technology

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For accurate fabrication of implant-supported prostheses, the exact relationship between the implant and surrounding teeth and soft tissues must be accurately recorded.[1,2] Nonuniformity of the impression material can lead to an inaccurate definitive cast because of polymerization shrinkage.[3,4] A uniform thickness in the impression material can be achieved with the use of a custom tray, controlling polymerization shrinkage[5] and improving accuracy.[6]

Traditional handmade custom trays have the disadvantage of inconsistent quality.[7] It is difficult to control the amount of space in the intaglio surface, and it is also difficult to control the quantity of acrylic resin used to fabricate the tray. Consequently, the trays may require considerable adjustment. Moreover, as custom trays for implant impression making must be fabricated without knowing the exact location of the implant, it is difficult to leave sufficient space for a consistent amount of impression material around the impression copings, and the trays must be fabricated with excess space. Moreover, because the final positions of the guide pins that fix the impression copings are also difficult to predict, situations arise in which the custom tray cannot fully cover the impression coping. This can result in exposure of the retention grooves of the copings, which may not be covered with sufficient

ABSTRACT

The technique described allowed an implant custom tray to be fabricated referencing the location of connected impression copings. The technique uses dental computer-aided design (CAD) software and 3D printing technology. The method controls the thickness of the impression material around the impression copings, improving the impression-making process. (J Prosthet Dent 2019;121:566-70)

material or covering of the top of the coping pin with impression material, because too much material is used.

A method of manufacturing custom trays which uses dental computer-aided design (CAD) software and 3D printing technology to predict the position of the implant impression copings and to ensure even space around the copings is presented.

TECHNIQUE

1. After connecting the implant healing abutment (Healing abutment; Dentium) and the laboratory analog (Fixture analog; Dentium), generate the healing abutment library data using a tabletop scanner (Identica Blue; Medit) (Fig. 1A).
2. Connect the implant impression coping (Impression Coping Pick-up; Dentium) and the laboratory analog (Coping-lab) and scan the assembly.
3. Construct a library by scanning the healing abutments and impression copings that have varying diameters and heights (Fig. 1B).
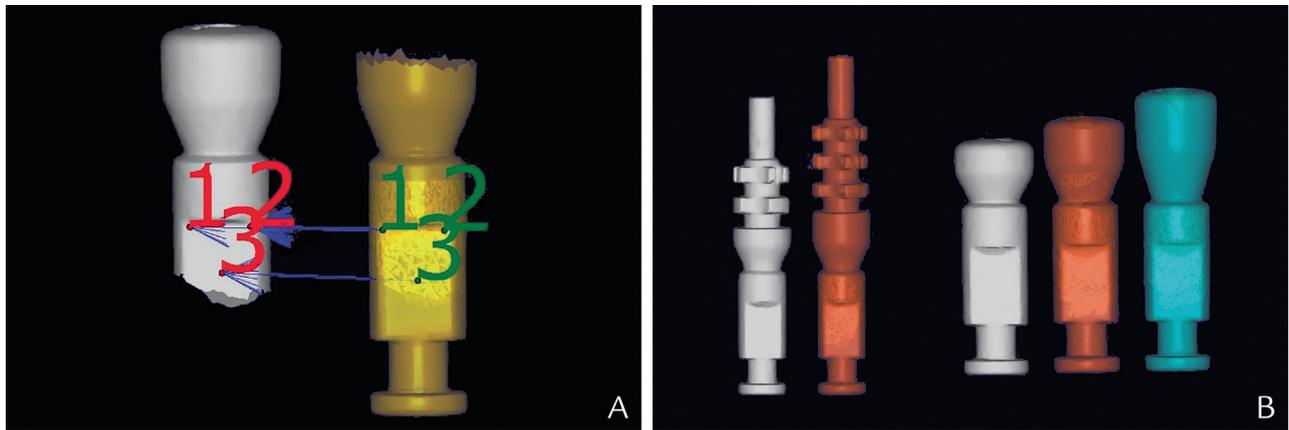
Figure 1. A, Image of scanning after connecting healing abutment and laboratory analog and generating library data. B, Range of library data generated according to diameter and height of impression coping and healing abutment.
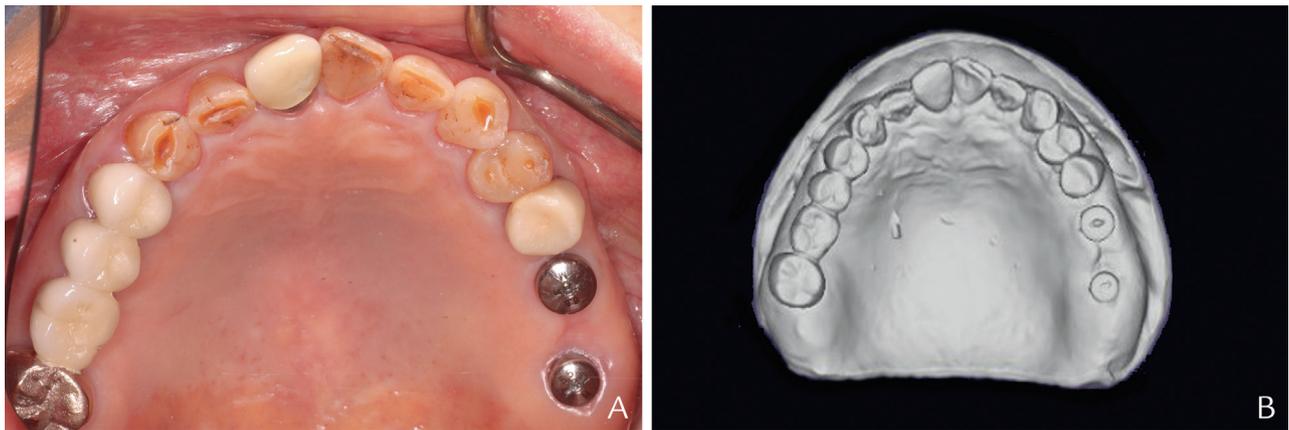

Figure 2. A, Implants placed in maxillary molar position. Healing abutments installed. B, Diagnostic cast before scanning and conversion to digital data.

4. Save the generated files in standard tessellation language (STL) file format and under different file names that allow identification of the implant manufacturer and the diameter and length of the component.

5. After the implant site has healed, make a preliminary intraoral impression with the healing abutment installed; then, fabricate a gypsum cast and scan the cast. Alternatively, make an intraoral image with an intraoral scanner (Fig. 2).

6. Record the diameter and length of the installed healing abutment.

7. Select the impression coping to be used in the definitive impression-recording process by considering the amount of mandibular opening and ease of intraoral access.

8. Retrieve the library data for the same diameter and height as the healing abutment in the scanned data obtained from the diagnostic cast and superimpose on the healing abutment area of the diagnostic cast (Fig. 3A).

9. Retrieve the connection data with the diameter and height to be used on the patient and superimpose on the data of the laboratory analog (Fig. 3B). In this way, mesh data similar to the impression coping can be obtained, and the tray can be fabricated on the basis of these data.

10. Indicate the area where space should be included and the thickness of the spacer (about 2 mm) using the occlusal splint module of the design software (Exocad DentalCAD; Exocad GmbH) (Fig. 4A).

11. Add stops on the nonfunctional cusps of the remaining teeth using the attachment subtraction function in the CAD software (Fig. 4B).

12. Design the external surface of the tray along the entire tray boundary based on the corresponding mesh data; fabricate the tray handle by making the appropriate choice from a prefabricated tray handle library. For rigidity, the tray should be designed to have sufficient thickness and width for each situation.
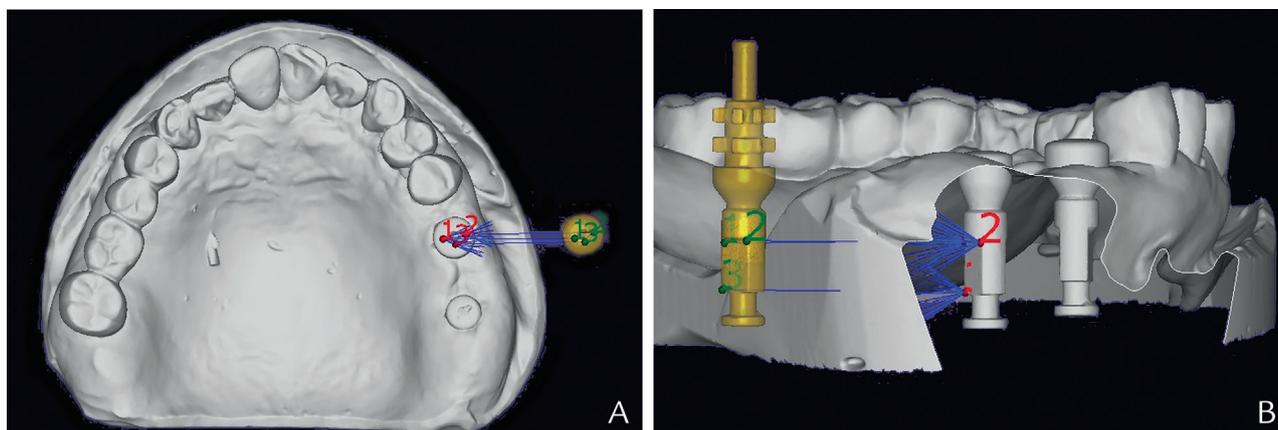
Figure 3. A, Healing abutment library data retrieved and superimposed on scanned data of diagnostic cast. B, Healing abutment and laboratory analog data superimposed. Library data of laboratory analogs selected and superimposed.
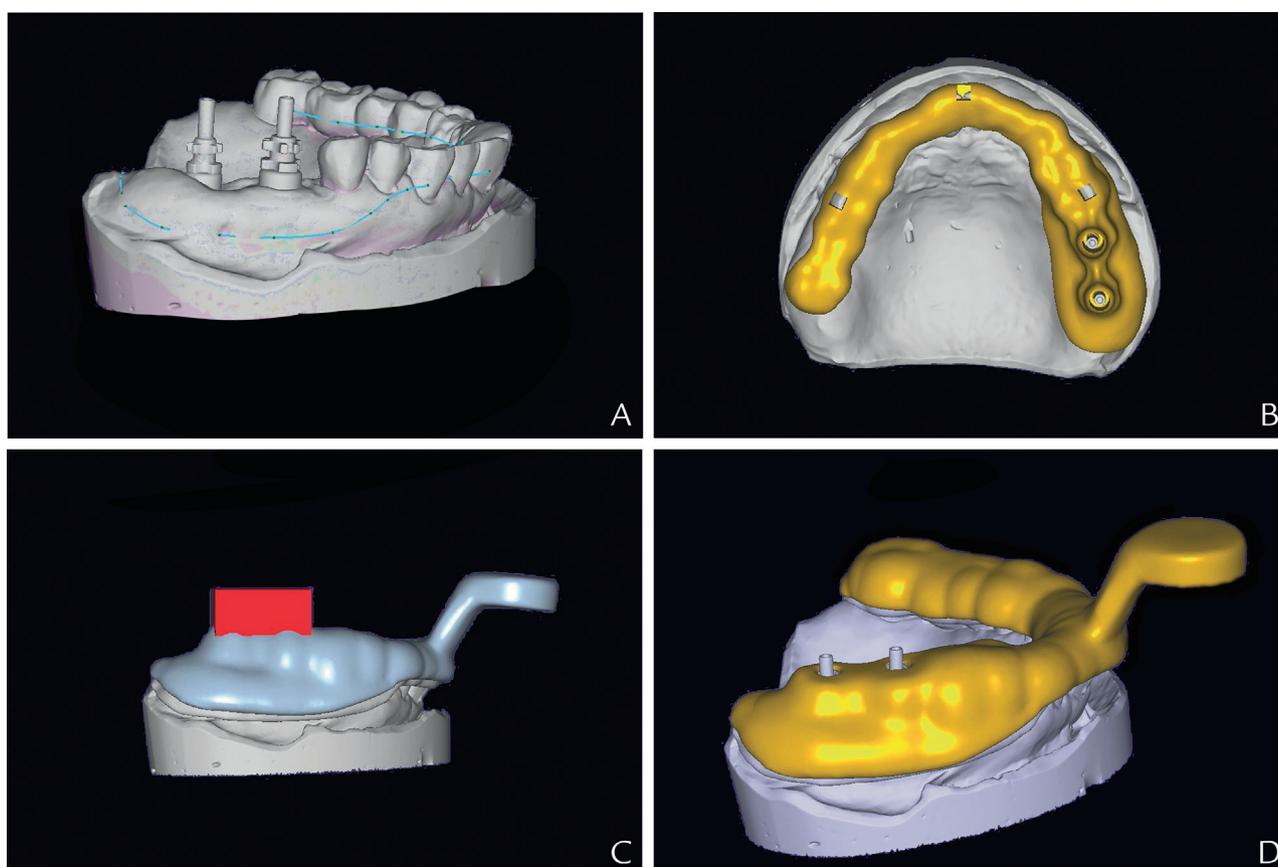
Figure 4. A, Position of impression copings reproduced on digital cast confirmed and area designated where space with consistent thickness should be provided around teeth and impression coping. B, Placement of stops in three nonfunctional cusps. C, Shape of tray completed, and prefabricated handle from handle library attached. Guide pin of impression coping should be exposed by about 2 to 3 mm. Cuboid-shaped mesh (*red*) retrieved for subtraction process. D, Confirmation that impression coping guide pins penetrate tray.

13. Expose the guide pin of the impression coping outside of the tray by about 2 to 3 mm by subtracting the corresponding area using a cuboid-shaped mesh (Fig. 4C, D).
14. Print the custom tray and support in different colors using a 3D printer such that the thickness of the tray does not vary across sites even after removing the support structure and smoothing rough surfaces (Fig. 5).
15. Connect the impression coping to the antirotation structure. Ensure that the tray is correctly seated and that the guide pin of the
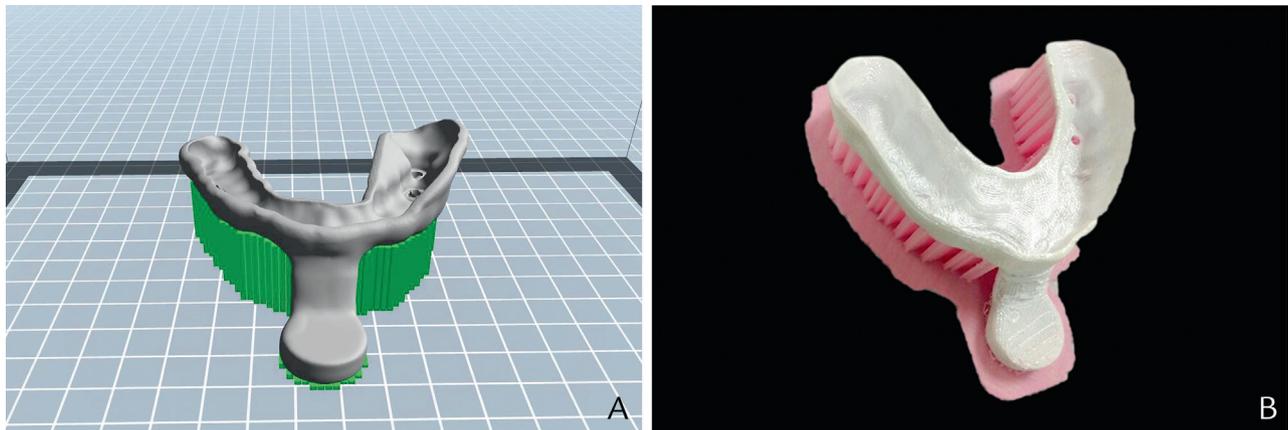
Figure 5. A, Support for fabricating completed implant custom tray by 3D printing. B, 3D-printed tray, completed by removing support.

impression coping is exposed through the opening area.

16. Apply tray adhesive to the tray and make the impression.

DISCUSSION

Healing abutments and impression copings of varying diameters and heights were connected to laboratory analogs and scanned to construct the library, which was then used to fabricate implant custom trays. When making a preliminary impression with only the intraoral healing abutment connected, it is possible to simulate the connection of the coping to the implant fixture. Therefore, the CAD software can be used to control the area and amount of impression material so that it can evenly cover not only the remaining teeth but also the entire impression coping area. If a consistent amount of space can be provided, the inaccuracy caused by shrinkage of the impression material can be reduced, and a more accurate implant prosthesis can be fabricated.[7,8] Additional advantages include that the time required for fabrication can be reduced, and a consistent quality can be achieved by using a standardized tray fabrication process.[9,10]

Impression copings must be firmly fixed with impression material to produce consistent impression outcomes, but when the retention features of the impression coping contact the intaglio of the tray or are not embedded in the impression material, accuracy will be affected.[11,12] Liu et al[12] reported that when custom trays are designed to cover the entire area around the implant impression coping, more accurate impressions result than when using custom trays when parts of the impression coping are not well covered by impression material or by implant splinting.

This technique has some limitations. If the healing abutment is too short and does not extend sufficiently beyond the soft tissue, the accuracy of the location of the simulated impression coping on the CAD will be reduced because the library data cannot be accurately matched. In such a situation, it would be helpful to install a longer healing abutment. Moreover, unless the library data have already been created, additional processing will be required.

To facilitate clinical application of this technique, studies should quantify the accuracy of the impression recording by using a tray design method as compared with that using the existing handmade custom tray. In addition, whether there are differences depending on the 3D printing material (such as photopolymerizing resin or thermoplastic filament) used should be investigated. Studies on rigidity, volume stability, and compatibility with tray adhesives when printing custom trays from these materials are also necessary.

SUMMARY

The technique presented allows an implant custom tray to be manufactured based on the prediction of impression copings already installed. The manufacturing method allows control over the even covering of impression material around the impression copings.

REFERENCES

1. Örtorp A, Jemt T, Bäck T, Jälevik T. Comparisons of precision of fit between cast and CNC-milled titanium implant frameworks for the edentulous mandible. Int J Prosthodont 2003;16:194-200.
2. Waskewicz GA, Ostrowski JS, Parks VJ. Photoelastic analysis of stress distribution transmitted from a fixed prosthesis attached to osseointegrated implants. Int J Oral Maxillofac Implants 1994;9:405-11.
3. Ciesco JN, Malone WFP, Sandrik JL, Mazur B. Comparison of elastomeric impression materials used in fixed prosthodontics. J Prosthet Dent 1981;45:89-94.
4. McCabe JF, Storer R. Elastomeric impression materials. The measurement of some properties relevant to clinical practice. Br Dent J 1980;149:73-9.
5. Millstein P, Maya A, Segura C. Determining the accuracy of stock and custom tray impression/casts. J Oral Rehabil 1998;25:645-8.
6. Christensen GJ. Now is the time to change to custom impression trays. J Am Dent Assoc 1994;125:619-20.

7. Gordon GE, Johnson GH, Drennon DG. The effect of tray selection on the accuracy of elastomeric impression materials. J Prosthet Dent 1990;63: 12-5.
8. Rueda LJ, Sy-Munoz JT, Naylor WP, Goodacre CJ, Swartz ML. The effect of using custom or stock trays on the accuracy of gypsum casts. Int J Prosthodont 1996;9:367-73.
9. Chen H, Yang X, Chen L, Wang Y, Sun Y. Application of FDM three-dimensional printing technology in the digital manufacture of custom edentulous mandible trays. Sci Rep 2016;6:19207.
10. Sun Y, Chen H, Li H, Deng K, Zhao T, Wang Y, et al. Clinical evaluation of final impressions from three-dimensional printed custom trays. Sci Rep 2017;7:14958.
11. Burns J, Palmer R, Howe L, Wilson R. Accuracy of open tray implant impressions: an in vitro comparison of stock versus custom trays. J Prosthet Dent 2003;89:250-5.
12. Liu DY, Cader FN, Abduo J, Palamara J. Accuracy of different implant impression techniques: evaluation of new tray design concept. J Prosthodont 2019;28:e682-7.

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Noteworthy Abstracts of the Current Literature

Private practice of prosthodontists in the United States: Results from the 2017 survey of prosthodontists and trends since 2001

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Purpose. To review data and results from past surveys of prosthodontists sponsored and conducted by the American College of Prosthodontists (ACP). Specifically, results are examined and presented from the most recently conducted survey in 2017. Trends and changes in characteristics impacting the private practice of prosthodontists over time are discussed using results from six surveys completed in 2002, 2005, 2008, 2011, 2014, and 2017.

Material and methods. Results from the past surveys of prosthodontists are statistically examined and used to estimate several characteristics of the current population of practicing prosthodontists. The selected characteristics include age, gender, hours in the practice, employment of staff, referral sources, and financial conditions (e.g., gross receipts, expenses in the practice, and net income of prosthodontists). While the most recent survey was conducted during the year 2017, the respondents reported survey data for the previous year of 2016.

Results. The average age of private practice respondents in 2016 was 50 years; 23 years since graduation from dental school and 18 years since completion of residency; an average of 18 years since starting practice as a prosthodontist, with 52% in solo practice. The mean number of hours per week in the practice was 33.9 hours and the mean number of hours treating patients averaged 28.3 hours per week. The single largest source of referrals is the prosthodontist's patients (24.8%), while general practitioners are a close second source of referrals (21.8%). Salaries paid by prosthodontic practices reached 55% of total practice expenses. The mean nominal net income in 2016 of prosthodontists in private practice was $231,140 while the mean total net income from all prosthodontic sources was $263,850.

Conclusions. Changes have continued to take place in the private practice of prosthodontics during most of the last decade. The average age of prosthodontists has declined since 2010. Hours in practice and hours treating patients have declined at a rate of about 1% per year since 2001. Mean net earnings of prosthodontists have declined at a rate of 1.6% since 2001 and 3.1% per year since 2007. The prosthodontist private practice industry, not unlike dentistry as a whole, has undergone economic and practice challenges that have affected the conditions of private practice during the last decade.

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