ACP AMERICAN COLLEGE OF PROSTHODONTISTS
Your smile. Our specialty.®

A Digital Technique to Fabricate Segmental Individual Tooth Trays for Making an Impression of Multiple Crown Preparations

Xiaoxiang Xu, DDS,[1] Qiufei Xie, DDS,[1] Lei Zhang, DDS,[1] Yijiao Zhao, ME,[2] & Ye Cao, DDS[1]

[1]Department of Prosthodontics, Peking University School and Hospital of Stomatology & National Center of Stomatology & National Clinical Research Center for Oral Diseases & National Engineering Laboratory for Digital and Material Technology of Stomatology & Beijing Key Laboratory of Digital Stomatology & Research Center of Engineering and Technology for Computerized Dentistry Ministry of Health & NMPA key Laboratory for Dental Materials, Beijing, PR China
[2]Center of Digital Dentistry, Peking University School and Hospital of Stomatology & National Center of Stomatology & National Clinical Research Center for Oral Diseases & National Engineering Laboratory for Digital and Material Technology of Stomatology & Beijing Key Laboratory of Digital Stomatology & Research Center of Engineering and Technology for Computerized Dentistry Ministry of Health & NMPA key Laboratory for Dental Materials, Beijing, PR China

Keywords
Computer-aided design; 3D printing; segmental tray; impression; fixed prosthodontics.

Correspondence
Dr. Ye Cao, DDS, Department of Prosthodontics, Peking University School and Hospital of Stomatology, No.22 Zhong Guan Cun South Avenue, Haidian District, Beijing 100081, PR China.
E-mail: ye.cao@bjmu.edu.cn

Funding
National Natural Science Foundation of China (81800998) and Program for New Clinical Techniques and Therapies of Peking University School and Hospital of Stomatology (PKUSSNCT-19B14 and PKUSSNCT-14B04)

Conflict of interest
The authors deny any conflicts of interest in regards to this study.

Accepted October 26, 2021

doi: 10.1111/jopr.13445

Abstract

A digital technique is described for designing and fabricating segmental individual tooth trays that can be used to make an impression of multiple preparations with high accuracy and efficiency. A digital model of prepared dentition was acquired. The segmental individual tooth trays with retention attachments and tissue stops were designed and 3D printed with light-polymerizing resin. The segmental impression of each section of the prepared dentition was made with the corresponding individual tooth tray loaded with the impression material. A final overall impression was made to pick up the segmental individual tooth trays with a full arch tray.

An accurate and void-free impression is essential for the long-term success of fixed prosthodontics.[1] The difficulty of making an ideal impression increases significantly with the greater number of crown preparations, like in cases of full arch rehabilitation. Generally, the one-step or two-step overall impression technique is adopted to make an impression for all the prepared teeth at one time. However, even for an experienced practitioner, it's a challenging task to obtain an acceptable impression of a full arch rehabilitation case at the first attempt, since it's difficult to accomplish all the steps including eliminating body fluid, injecting impression material for individual tooth, and inserting the impression tray with high precision within the very limited working time of impression materials. This frequently leads to repetition of impression taking which increases material cost, prolongs chairside time, and compromises patient's comfort and trust in the clinician. The digital technique to directly obtain the surface configuration of oral structures has been successfully used in fixed

Figure 1 Maxillary crown preparations.

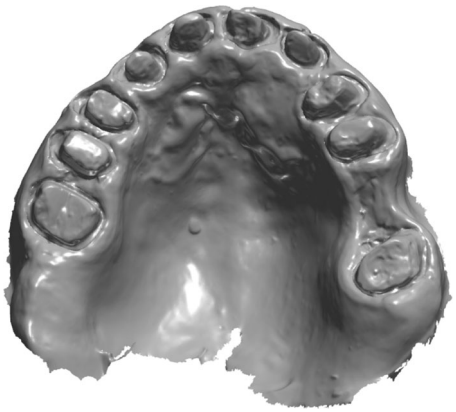

Figure 2 Digital model of the maxillary dentition.

restoration for single unit or limited units. However, it is still controversial to apply the intraoral scanning in cross-arch extensive rehabilitation.[2,3]

Several special techniques have been described for making the impression of multiple prepared teeth, such as segmental trays,[4–6] individual copings,[7–9] and matrix system.[10] These techniques share a common principle that converts the overall impression at one time to sectional impressions for limited preparation in stages, followed by the pick-up impression in the end. In this way, the entire procedure can be simplified and the success rate can be improved.[11] However, these techniques require additional technical and chairside procedures for preparing and adjusting these special instruments, which is time-consuming and arduous. With the popularity of digital technology, the application of computer-aided design and computer-aided manufacturing (CAD-CAM) has made the prosthodontic process more convenient, accurate, and efficient. This paper describes a digital technique to design and fabricate segmental individual tooth trays, which can be used to make an impression for multiple crown preparations in a simple and reliable way.

Technique

1. Perform the crown preparation (Fig 1). Acquire the digital model of the dentition including the prepared teeth and the associated soft tissue region (Fig 2). Fabricate and insert the provisional restorations.
2. Import the digital model to dental CAD software (Dental system; 3shape, Copenhagen, Denmark). Determine the segmentation way for the dentition containing the prepared teeth. Choose the design module of the temporary crown for each preparation. Select the design module of the bridge connector between the neighboring abutments within each section (Fig 3).
3. Place the margin line along with each prepared tooth, within the range from the cervical boundary to the gingiva crest (Fig 4A). Set the insertion direction for each section. Form the contour of the main body of the individual tooth tray by importing the preinstalled morphology data in the software. Enlarge the imported contour for sufficient inner space for impression material. Ensure the proximal surface has no contact with the adjacent tooth or tray. Set the margin thickness with 0.15 mm and the body thickness with 0.4 mm. Design the connector area. Add retention attachments at the labial and palatal surface (Fig 4B).
4. Import the designed data to industrial CAD software (Geomagic Studio; 3D Systems, Rock Hill, SC). Establish the cylinder object with suitable size at the inside of the attachment part and form the inner retention structure by Boolean subtraction algorithm (Fig 5A). Design tissue stops at the inner occlusal surface of the individual tooth tray through the following steps. Select part of the incisal or occlusal surface of the prepared teeth at each end of the section. Thicken the chosen area until it exceeds the corresponding tray body. Subtract the exceeding part and combine the rest with the tray body (Fig 5B). Add a connector between the separate tray bodies within the same section where there is a missing tooth (Fig 5C). Export the finalized data as standard tessellation language (STL) files (Fig 5D).
5. Design a traditional full arch individual tray for the pick-up impression using the corresponding module of the dental CAD software based on the combined data of the dentition with individual tooth trays in place (Fig 6A and B).
6. Send the STL files to a 3D printer (Objet 260; Stratasys, Eden Prairie, MN) and print them with light-polymerizing resin (MED 690; Stratasys) (Fig 7).
7. Try-in these segmental individual tooth trays on the prepared abutments (Fig 8). Try-in the full arch tray and ensure no interference between individual tooth trays and the full arch tray.
8. Perform the classic segmental impression procedure. Displace the gingiva around prepared teeth with retraction cords. Remove the cords and clean the surface of the teeth within one section. Inject the impression material around the prepared teeth. Place the individual tray filled with impression material on the abutment teeth. Stabilize the individual tooth tray until the impression sets. Perform the same procedure for the other sections. Pick up all segmental impressions with a full arch tray.
9. Alternatively, use a modified segmental impression technique when the soft tissue around the prepared teeth are conditioned well with provisional restorations (Fig 9A). Insert the individual tooth tray loaded with low-viscosity

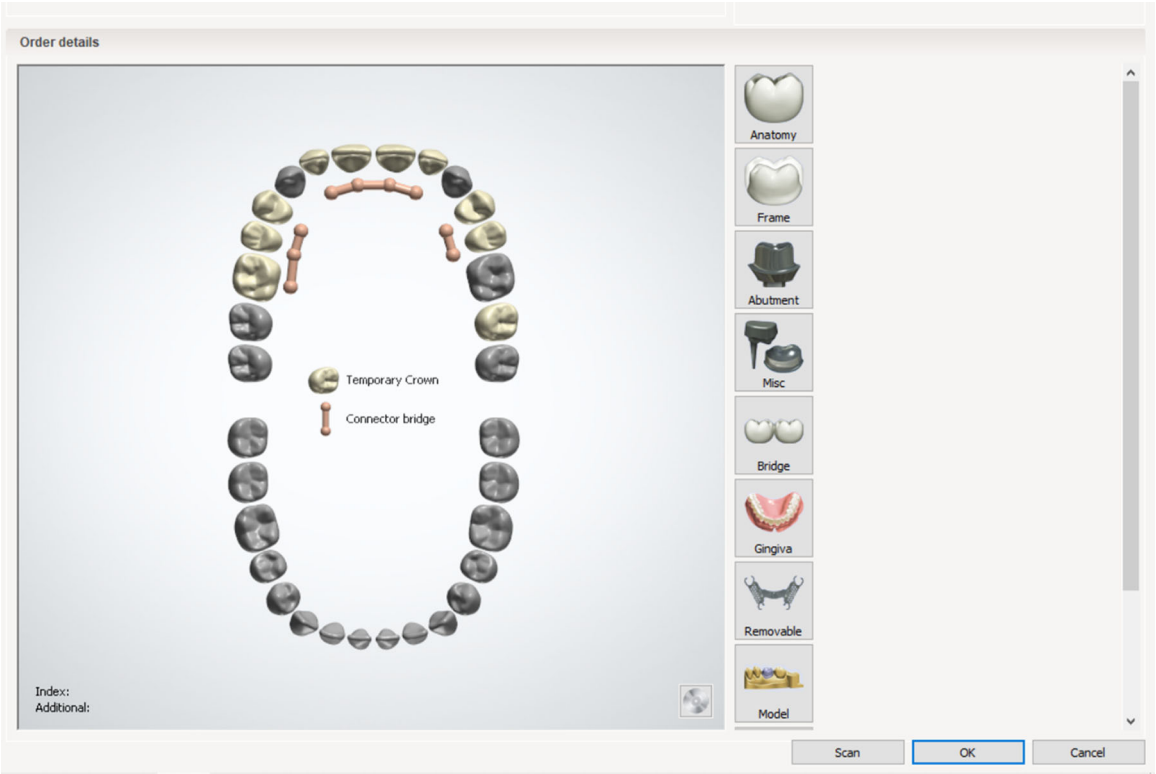

Figure 3 Order settings for design of segmental individual tooth tray in a dental CAD software.

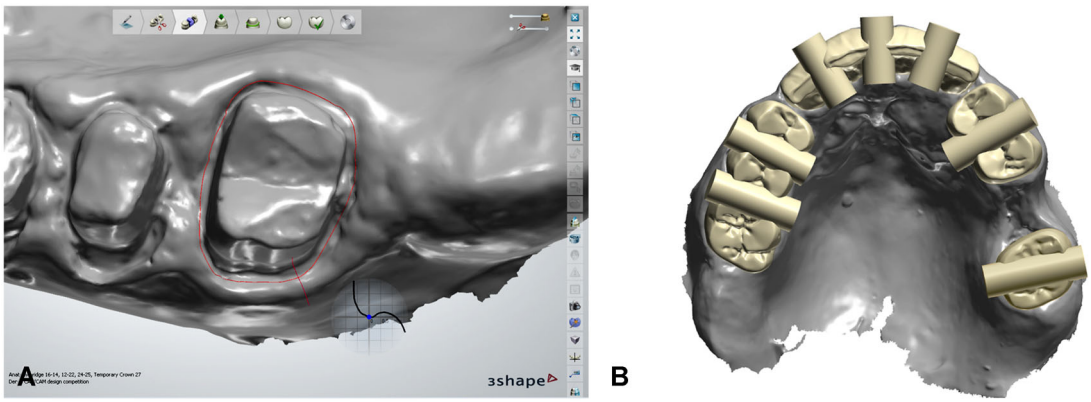

Figure 4 Design segmental individual tooth trays with a dental CAD software. A, Placement of margin line for each preparation. B, Design of segmental individual tooth trays with retention attachments.

impression material (Variotime Light Flow; Heraus Kulzer GmbH, Hanau, Germany) directly on the abutment teeth for each section without placing the gingival cords (Fig 9B). Remove the trays after the impression sets. Clean and inject the low-viscosity impression material over the entire surface of the teeth. Insert the relined individual tooth tray again. Conduct the same pick-up procedure at the final step (Fig 10). Inject the low-viscosity impression material around the individual trays. Insert the full arch tray loaded with high-viscosity impression material (Variotime Dynamix Monophase; Heraus Kulzer GmbH) and keep it stable.

Discussion

The design and fabrication of segmental individual tooth trays with digital technologies have several advantages. First, the hands-on labor to produce and adjust these special trays in the traditional approach can be saved. There is no direct contact with volatile substances or dust that is potentially harmful to

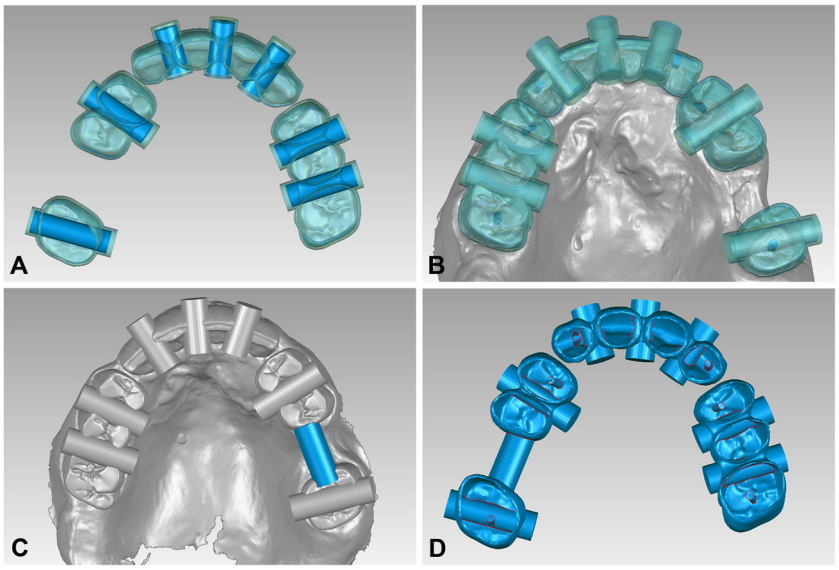

Figure 5 Design the hollow attachments, tissue stops, and connector with a 3D CAD software. A, Formation of hollow retention attachments by establishing cylinder objects with suitable size at the inside of the attachments and performing Boolean subtraction. B, Formation of tissue stops by thickening the selected occlusal or incisal area of the prepared teeth at the end of each section, subtracting the exceeding part and combining the rest with the tray body. C, Formation of the connector between the separate tray bodies within the same section. D, Configurations of segmental individual tooth trays.

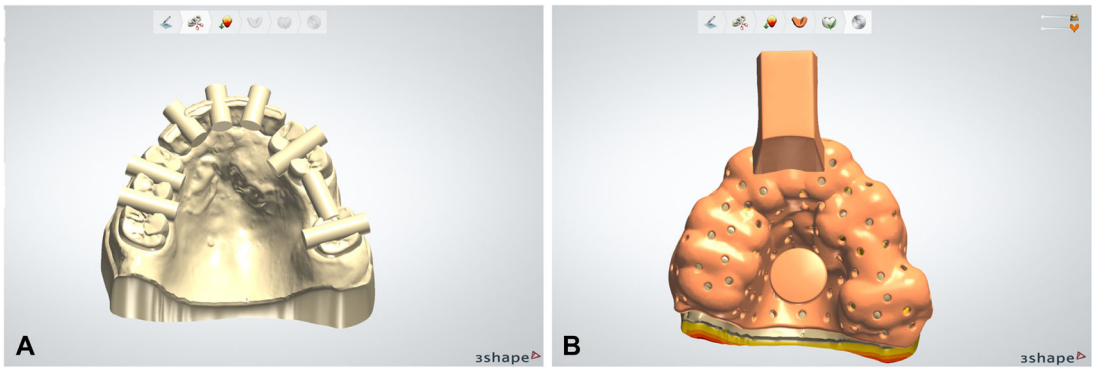

Figure 6 Design the individual full arch tray with a dental CAD software. A, Combined data of the dentition and the inserted segmental individual tooth trays. B, Design of individual full arch tray.

Figure 7 3D printed segmental individual tooth trays.

Figure 8 Try-in the segmental individual tooth trays.

health.[12] Second, high-level precision and accuracy of production can be achieved. The finished trays have an ideal spatial relationship with the prepared teeth, with suitable margin position, uniform thickness, small size, and sufficient internal space for impression material. No further adjustment is required for fully inserting the trays on the abutment teeth. Third, with digital technology, more delicate structures can be incorporated into the tray design, such as the hollow attachments which provide retentive form for both external and internal impression and the tissue stops which facilitate the precise insertion of the tray. These structures are difficult to fabricate through traditional methods.

There are several tips for successfully obtaining an impression with this technique. The first important step is to design the segments of the prepared dentition. This should be determined according to the number of preparations, the undercut

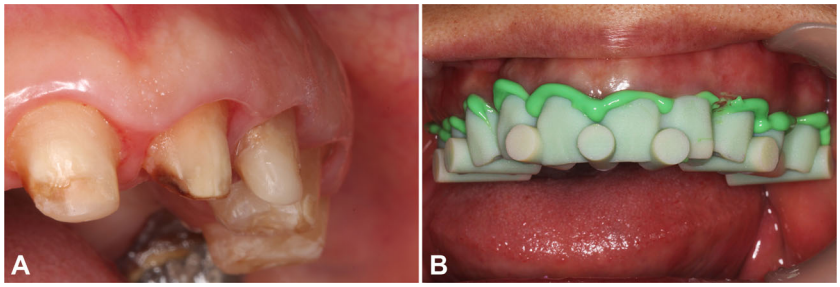

Figure 9 Make the impression of preparations with the segmental individual tooth trays. A, Conditioned gingival tissue before impression making. B, Insert the segmental individual tooth trays loaded with final impression material.

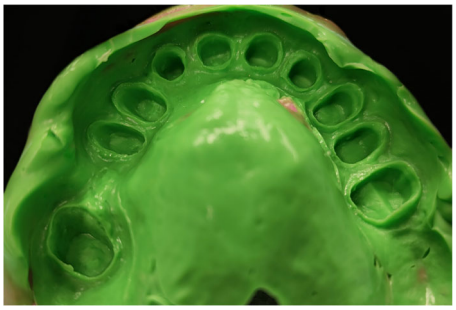

Figure 10 The final impression of the prepared teeth picked up by the full arch impression. Knife-edge finishing line was adopted for proximal and lingual surfaces of left lateral incisor in order to preserve the limited remaining tooth structure for adequate ferrule.

distribution, and the interspace between adjacent teeth. Usually, 3 to 4 sections would be appropriate for full arch rehabilitation. Each section contains 3 to 6 preparations with the same insertion pathway. The recommended setting of thickness is 0.4 to 0.6 mm for the tray body and 0.15 to 0.2 mm for the margin, which allows the ideal formation design even for adjacent abutments with limited interspace and ensures a high success rate of 3D printing. In addition, the printed trays not only have adequate strength to support and hold the impression, but also have the resilience which is important to avoid die breakage when separating from the cast. For the clinical procedure, the segmental individual tooth trays loaded with impression material should maintain their positions following their insertion for the accuracy of impression and the safety of patients. One assistant is recommended to pull and stabilize the perioral tissue with retractors for better space exposure and the stability of the trays. Patients should be instructed to relax and immobilize their tongues. For the lower jaw, the operator should maintain the segmental tray positions manually, or prevent the tongue movement interfering with the tray with a retractor or oral mirror, till the impression sets, then start the procedure for the next section sequentially. After the impression sets, the trays are able to maintain their positions without support, except for the intentional application of a strong dislodging force. To obtain the pick-up impression, we recommend engaging all retentive structures of the segmental individual tooth trays with final impression materials, including the overflowed impression along the tray margin, to produce the maximum retentive force for the pick-up impression. Thus, the segmental trays can be reliably picked up in the final impression, without the necessity of applying tray adhesive for retention.[13] It is very important that when inserting the pick-up full arch tray, it does not interfere with the segmental individual tooth trays. The size of the full arch tray should be determined properly in advance. We recommend designing the custom pick-up tray directly based on the combined data of the dentition with proposed individual tooth trays in place. This can ensure the inner space of the pick-up tray is properly adapted to the configuration of individual tooth trays.

The segmental individual tooth tray can be used for the classic segmental impression technique, which needs to displace the gingiva to expose the finishing line of preparations before impression making.[4,10] We also propose a modified segmental impression that uses a relined individual tooth tray to hydraulically press the impression into the gingiva sulcus, eliminating the need for arduous gingiva displacement. This approach will further simplify the clinical operation and improve patient's comfort. Noteworthy, this approach is suggested for use in the cases where the soft tissue has been conditioned well by provisional restorations. In these circumstances, the gingiva will maintain its original position for a short time after removing the provisional restoration. This is necessary for the successful registration of the subgingival morphology.

The limitation of this technique is that it requires access to the digital equipment including the scanner and a 3D printer, and the CAD software, as well as the ability to use them.[14] Another limitation is that it takes a longer time for the whole impression-making procedure compared with the general overall impression approach. However, this disadvantage can be remedied by its high success rate to obtain an acceptable outcome at one try.[11]

Summary

A digital technique to design and fabricate the segmental individual tooth tray is described, which can be used to efficiently and accurately obtain a definitive impression for multiple preparations.

Acknowledgments

The authors thank Lu Jia from the Dental Laboratory of Peking University School and Hospital of Stomatology for technical assistance.

References

1. Wassell RW, Barker D, Walls AWG: Crowns and other extra-coronal restorations: impression materials and technique. Br Dent J 2002;192:679-690
2. Kihara H, Hatakeyama W, Komine F, et al: Accuracy and practicality of intraoral scanner in dentistry: a literature review. J Prosthodont Res 2020;64:109-113
3. Su TS, Sun J: Comparison of repeatability between intraoral digital scanner and extraoral digital scanner: an in-vitro study. J Prosthodont Res 2015;59:236-242
4. Alraheam IA, Donovan T: The segmental impression technique: a straightforward solution to a difficult problem. J Prosthet Dent 2020;124:10-13
5. Jung BY, Lee KW: Alternative impression technique for multiple abutments in difficult case to control. J Adv Prosthodont 2010;2:1-3
6. Garcia LT, Bohnenkamp DM: The use of sectional impressions and a transfer index for extensive fixed prosthodontic treatment. Compend Contin Educ Dent 2004;25:26, 8, 30-11
7. Gardner K, Loft GH: An intraoral coping technique for making impressions of multiple preparations. J Prosthet Dent 1981;45:570-571
8. Hoffman JM: Nontraumatic final impressions for fixed partial dentures. J Prosthodont 1992;1:61-64
9. Vasilakis GJ, Vasilakis MD: Cast impression coping technique. Gen Dent 2003;51:48-50
10. Livaditis GJ: The matrix impression system for fixed prosthodontics. J Prosthet Dent 1998;79:208-216
11. Xu XX, Cao Y, Zhao YJ, et al: In vitro evaluation of the application of digital individual tooth tray in the impression making of mandibular full-arch crown abutments. J Peking Univ Health Sci 2020;53:54-61
12. Hu SW, Lin YY, Wu TC, et al: Workplace air quality and lung function among dental laboratory technicians. Am J Ind Med 2006;49: 85-92
13. Xu Y, Unkovskiy A, Klaue F, et al: Compatibility of a silicone impression/adhesive system to FDM-printed tray materials-a laboratory peel-off study. Materials (Basel) 2018;11:1905
14. Alauddin MS, Baharuddin AS, Mohd Ghazali MI: The modern and digital transformation of oral health care: a mini review. Healthcare (Basel) 2021;9:118