THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL REPORT

Treatment with a CAD-CAM–fabricated, double-crown–retained, removable partial denture: A clinical report

Regina A. Danielczak, Dr med dent,[a] Thomas Stober, Prof Dr med dent,[b] and Wolfgang Bömicke, Dr med dent, MSc[c]

ABSTRACT

This clinical report describes treatment with a double-crown–retained, removable partial denture with a 2-year follow up. Primary and secondary crowns and a removable partial denture metal-alloy framework were fabricated using computer aided design and computer aided manufacturing (CAD-CAM) and milled from cobalt-chromium (Co-Cr) alloy. (J Prosthet Dent 2019;121:220-4)

Double-crown–retained removable partial dentures (RPDs) are, from an international perspective, among the lesser known prosthetic options for the restoration of partial edentulism. These prostheses are anchored by means of primary crowns attached to teeth or implants and by secondary crowns attached to the removable denture framework.[1] The crowns are usually cast from high noble or cobalt-chromium (Co-Cr) alloy.[2,3] The use of ceramics for the primary crowns, galvanic gold for the secondary crowns, and composite resin for the frameworks has also been described.[4,5] High success with such designs, especially in the long term, have been reported.[5-7]

Since the development of computer aided design-computer aided manufacturing (CAD-CAM) technology, new methods of metal processing have become available, including selective laser melting/sintering or milling. The internal and marginal fit of milled crowns are better than,[8] or similar to,[9,10] those of cast crowns. Trials on fracture and corrosion resistance have also reported better results for milled specimens.[11,12] The CAD-CAM fabrication of primary crowns has become a routine option for double-crown–retained RPDs. By contrast, the use of CAD-CAM technology for fabricating secondary crowns and denture frameworks is still quite unusual. However, this could help simplify the fabrication of this kind of denture, because inaccuracies caused by casting can be avoided, and thus the need for adjustments by a dental technician is very likely to be reduced. However, clinical reports on double-crown–retained RPDs with both CAD-CAM–fabricated primary and secondary crowns, including the denture framework milled from Co-Cr alloy, are lacking.

CLINICAL REPORT

A 69-year-old man who presented at the Department for Prosthodontics of the Dental School of the University of Heidelberg reported dental anxiety and not having visited a dentist for more than 5 years. His medical history indicated mild arterial hypertension that did not require medication. Clinical and radiographic examination showed a severely damaged and carious dentition with lack of posterior dental support and poor oral hygiene (Fig. 1). Periodontal assessment showed a generalized severe chronic periodontitis.[13] Nonrestorable carious lesions and Class II to III mobility[14] were also observed for several teeth in the maxilla. After initial professional tooth cleaning, nonrestorable teeth were extracted, and the patient was provided with a clasp-retained mandibular interim RPD and a maxillary complete denture.

[a]Assistant Professor, Department of Prosthodontics, University Hospital Heidelberg, University of Heidelberg, Heidelberg, Germany.
[b]Associate Professor, Department of Prosthodontics, University Hospital Heidelberg, University of Heidelberg, Heidelberg, Germany.
[c]Assistant Professor, Department of Prosthodontics, University Hospital Heidelberg, University of Heidelberg, Heidelberg, Germany.

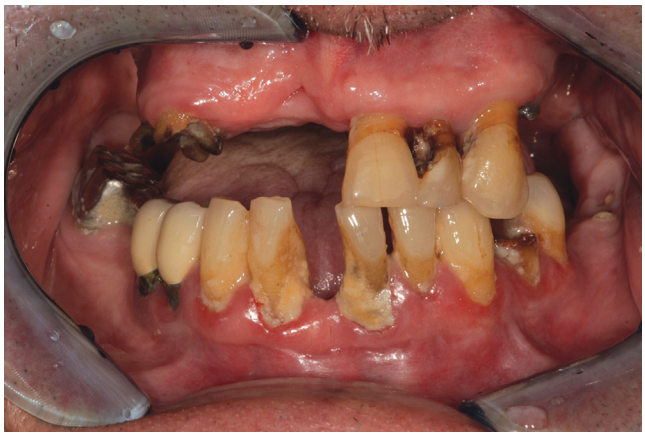

Figure 1. Preoperative frontal view in maximal intercuspal position.

The remaining teeth (mandibular canines and mandibular left second premolar) were subjected to systematic periodontal therapy; this resulted in stable, inflammation-free periodontal conditions at the re-evaluation appointment 6 months later. For the definitive restoration of the mandible, a double-crown–retained RPD with CAD-CAM–generated primary and secondary crowns was planned. Treatment was conducted over 7 appointments. A replacement maxillary complete denture was also provided, but this will not be addressed in detail in this article. After preparation of the abutment mandibular teeth, interim crowns were fabricated chairside from dual-polymerizing composite resin material (Luxatemp Automix Solar; DMG Chemisch-Pharmazeutische Fabrik GmbH) by using a vacuum-formed splint, adjusted to fit to the interim RPD, and cemented to the abutment teeth with interim cement (Temp Bond NE; Kerr Corp).

A polyether definitive impression (Impregum Penta Soft; 3M ESPE) of the mandibular teeth was made and poured with Type IV dental gypsum (GC Fujirock EP; GC Europe NV). The cast (Fig. 2A) was digitized with a laboratory scanner (D9001; 3Shape A/S), and the primary crowns (Fig. 2B) were designed with a total occlusal convergence of 2 degrees by using dental design software (MetaNova; Metaux Precieux Dental GmbH). The data were sent to a milling center (CADstar Austria), where the crowns were milled from a Co-Cr blank (Organic CoCr; R+K CAD/CAM Technologie GmbH & Co KG).

The primary crowns were fitted to the gypsum cast and then evaluated clinically for proper marginal and internal fit with a sharp dental explorer and low-viscosity condensation silicone disclosing agent (Xantopren L blue; Kulzer GmbH). The thickness of the cement film and the quality of the marginal seal were recorded (Fig. 2C). A pick-up impression of the primary crowns, fixed to the abutment teeth with a small quantity of interim cement (Temp-Bond NE; Kerr Corp), was made with a polyether impression material (Impregum Penta Soft; 3M ESPE) and poured with Type IV dental gypsum. Occlusion rims on light-polymerizing resin material record bases (Palatray; Kulzer GmbH) fabricated on the resulting casts were adjusted intraorally in accordance with the intended position and the shape of the dental arches, and a centric relation record was made.

The casts were then mounted on a semi-adjustable articulator (SAM 2P; SAM-Dental) with a facebow and the centric relation record. The mounted casts were rescanned, and the secondary crowns and the framework were designed as a unit by using the same dental design software as for the primary crowns. The secondary crowns were designed to complete anatomic contour, with the labial surface reduced to provide space for resin veneering. The data were sent again to the milling center, and the framework with integrated secondary crowns was milled from the same material as the primary crowns (Fig. 2D). The intaglio surfaces of the secondary crowns and the cameo surfaces of the primary crowns were adjusted with rotary rubber polishing instruments (polishers 9551.900.070 VPE 100 and 9702M.900.060 VPE 10; Komet and Gebr Brasseler GmbH & Co KG) until a swing-free fit of the framework was achieved. This means that alternate loading of the secondary crowns did not lead to tipping of the framework or lifting of the framework, including the primary crowns at the unloaded abutment teeth, and that removal of the primary crowns from the framework was possible with cone pliers with a pull-off force of approximately 8 to 10 N, indicating sufficient retention but permitting removal of the prosthesis without applying excessive stress of the abutments.[15,16] Pressure-indicating spray (OkkluSpray; Omnident GmbH) was used to show any discrepancies between primary and secondary crowns; these were then removed from the intaglio surface of the secondary crowns.

During an intermediate clinical evaluation, the internal and marginal fits of the primary crowns were verified with a low-viscosity condensation silicone disclosing agent (Xantopren L blue; Kulzer GmbH); the marginal fit was also verified with a sharp dental explorer. Correct seating of the framework on the primary crown was also assessed visually—exposure of the preparation margin caused by the primary crown slipping coronally with the framework inserted would be indicative of an unacceptable fit. The primary crowns also had to remain in the secondary crowns when the framework was removed from the mouth.

The denture teeth (Pala Premium; Kulzer GmbH) were subsequently arranged on the metal framework with base plate wax and evaluated in the patient's mouth. The secondary crowns were tribochemically silica-coated (Rocatec System; 3M ESPE), silanated (ESPE Sil; 3M

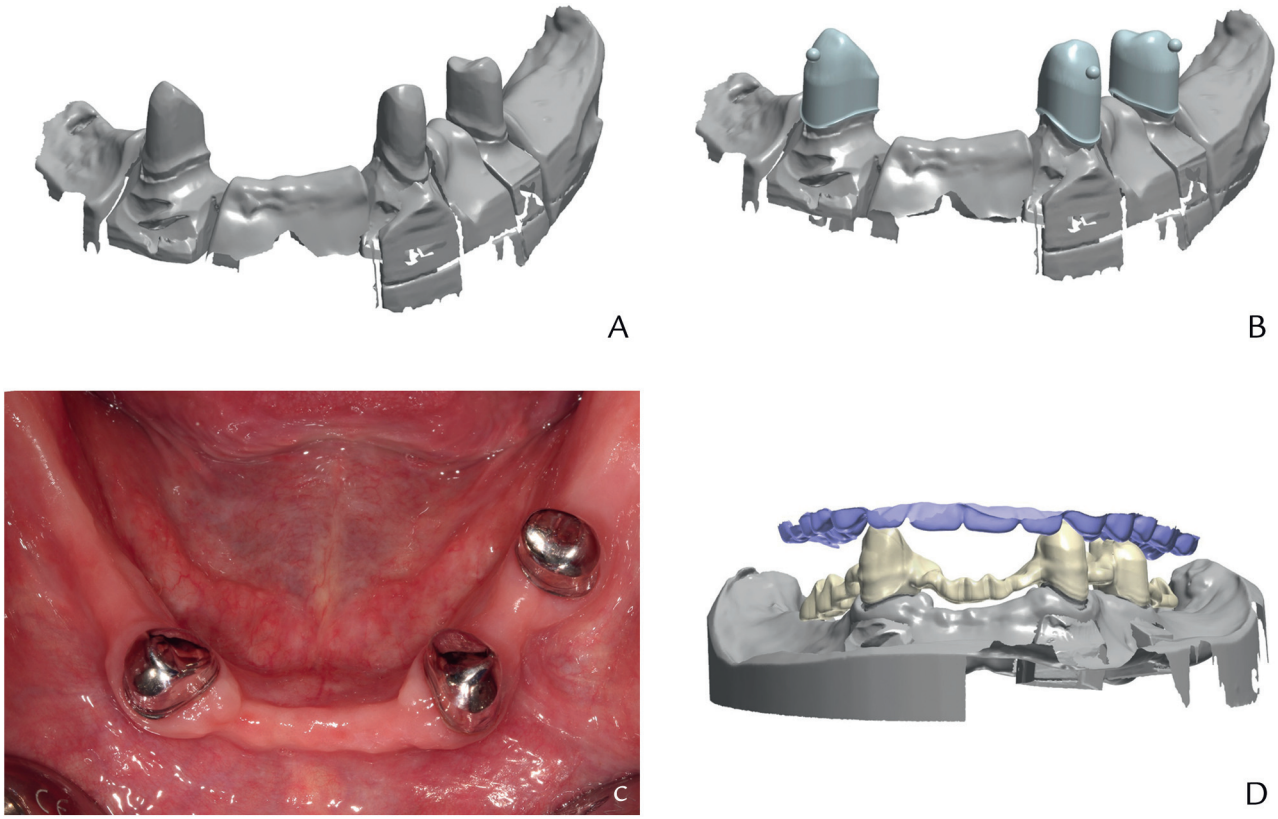

Figure 2. Removable partial denture fabrication process. A, Digitized prepared abutment teeth. B, Computer-aided–designed primary crowns. C, Seated milled primary crowns. D, Computer-aided framework design with secondary crowns and framework designed as one piece.

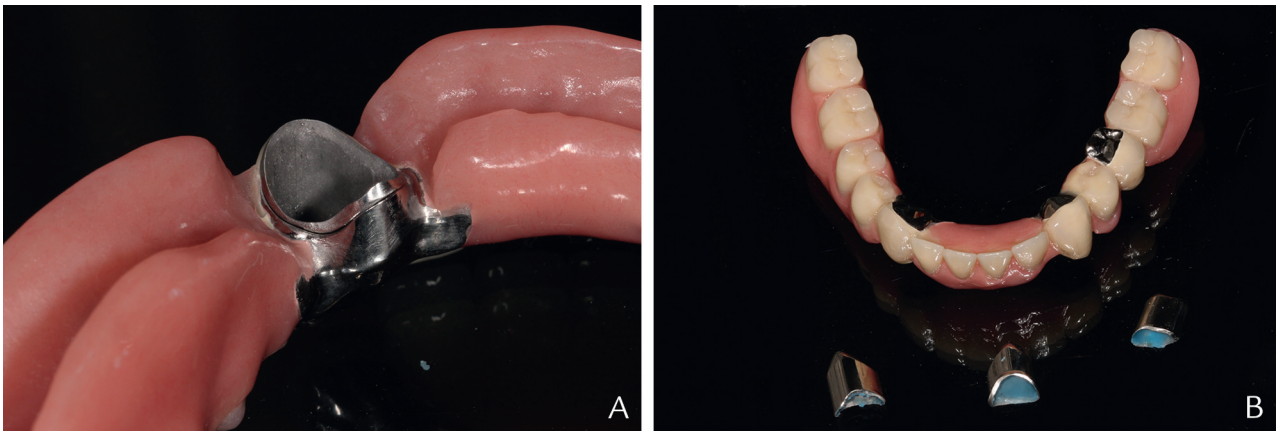

Figure 3. Clinical evaluation of definitive restoration. A, Evaluation of fit between primary and secondary crowns. B, Evaluation of fit of primary crowns on abutment teeth with silicone disclosing agent.

ESPE), and veneered with composite resin (Ceramage; Shofu Inc). Autopolymerizing acrylic resin was used as the denture base material (Aesthetic Autopolymerisate; Candulor AG).

For the definitive clinical evaluation of the completed prosthesis, the testing steps were repeated and complemented by confirming proper fit and the extension of the acrylic resin base, again with a condensation silicone disclosing agent (Xantopren L blue; Kulzer GmbH) (Fig. 3A, B). Before definitive cementation of the primary crowns, the secondary crowns were isolated with petroleum jelly. The primary crowns were lined with cement (Ketac Cem; 3M ESPE) and seated on the abutment teeth under moderate pressure. Large amounts of excess cement were removed immediately. The prosthesis was then quickly inserted and left in this position for a setting

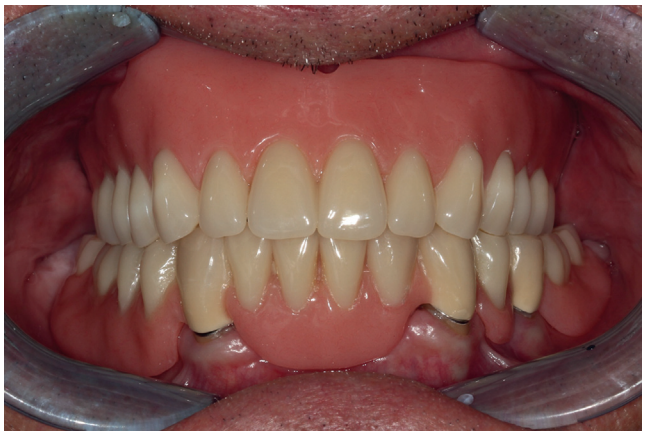

Figure 4. Frontal view of prostheses after 2 years.

time of 6 minutes. The RPD was removed from the mouth, and the abutment teeth were cleaned to remove cement residue.

At the 2-year follow-up appointment, inadequate dental hygiene was observed. Although professional tooth and prosthesis cleaning were administered, recurrent gingival inflammation had led to significant soft tissue recession around the abutment teeth (Fig. 4).

DISCUSSION

This clinical report describes the restoration of a severely compromised dentition with a double-crown–retained RPD with all-metal components milled from Co-Cr using CAD-CAM technology. In Germany, the double crown prosthesis is the standard treatment for patients with statutory health insurance who only have 3 or fewer teeth per jaw. As a result, treatment costs are partially covered by the health insurance company. Nevertheless, treatment with a clasp-retained prosthesis would be less expensive initially. However, maintenance costs have been reported to be twice as high for clasp-retained dentures than for double crown systems over a mean observation period of 4.2 years.[17] Additionally, oral health-related quality of life can be improved with telescopic dentures,[18] especially in patients with few teeth.[19] Placing dental implants and providing a combined tooth/implant-supported double-crown–retained RPD improves denture retention and stability while preserving the residual dentition[20,21]; however, this is associated with significantly higher costs.

Milling secondary crowns and the prosthesis framework as one piece saves time and improves the cost effectiveness of the laboratory workflow, because a secondary joining process using welding or bonding is omitted. A precise, passive fit is essential for the success of an RDP.[22] Because Co-Cr is a Type IV extra-hard alloy, a small total angle of convergence (2 degrees) was chosen. Even slight deviations in taper of the primary crowns affect the fit of the prosthesis. Selection of the total angle of convergence depends on the materials used.[23] During the reworking of cast primary crowns, deviations from the planned cone angle can occur, especially when high pressure and high rotational speed are used.[24] Primary crown fabrication using CAM enables easy preparation of the appropriate cone angle and dimensions. This is also true for fabrication of the secondary crowns and the framework. The milling process may reduce the risk of significant deviations from the planned geometry compared with cast frameworks.[25] Milling from a homogeneous blank has been discussed favorably. Microporosities (for example, cavities or rough surfaces), which have been associated with cast components, may contribute to an increase in retentive force, thus weakening the periodontium.[16] Although successful in the short term, information is lacking about the long-term performance of this type of prosthesis.

SUMMARY

In this clinical report, the prosthetic restoration of a partially edentulous patient with CAD-CAM–fabricated, double-crown–retained RPD was presented. Primary crowns and secondary crowns with the RPD framework were milled from Co-Cr. This method seems successful for the fabrication of a double-crown–retained RPD on abutment teeth or implants.

REFERENCES

1. Rammelsberg P, Bernhart G, Lorenzo Bermejo J, Schmitter M, Schwarz S. Prognosis of implants and abutment teeth under combined tooth-implant-supported and solely implant-supported double-crown-retained removable dental prostheses. Clin Oral Implants Res 2014;25:813-8.
2. Stober T, Bermejo JL, Séché AC, Lehmann F, Rammelsberg P, Bömicke W. Electroplated and cast double crown-retained removable dental prostheses: 6-year results from a randomized clinical trial. Clin Oral Investig 2015;19:1129-36.
3. Schwindling FS, Deisenhofer UK, Séché AC, Lehmann F, Rammelsberg P, Stober T. Randomized trial investigating zirconia electroplated telescopic retainers: quality of life outcomes. Clin Oral Investig 2017;21:1157-63.
4. Weigl P, Lauer HC. Advanced biomaterials used for a new telescopic retainer for removable dentures. J Biomed Mater Res 2000;53:337-47.
5. Zahn T, Zahn B, Janko S, Weigl P, Gerhardt-Szép S, Lauer HC. Long-term behavior of double crown retained dentures with metal and metal-free secondary crowns and frameworks made of Vectris on all-ceramic primary crowns: a prospective, randomized clinical trial up to 14 years. Clin Oral Investig 2016;20:1087-100.
6. Schwindling FS, Dittmann B, Rammelsberg P. Double-crown-retained removable dental prostheses: a retrospective study of survival and complications. J Prosthet Dent 2014;112:488-93.
7. Wöstmann B, Balkenhol M, Weber A, Ferger P, Rehmann P. Long-term analysis of telescopic crown retained removable partial dentures: survival and need for maintenance. J Dent 2007;35:939-45.
8. Nesse H, Ulstein DM, Vaage MM, Øilo M. Internal and marginal fit of cobalt-chromium fixed dental prostheses fabricated with 3 different techniques. J Prosthet Dent 2015;114:686-92.
9. Lövgren N, Roxner R, Klemendz S, Larsson C. Effect of production method on surface roughness, marginal and internal fit, and retention of cobalt-chromium single crowns. J Prosthet Dent 2017;118:95-101.
10. Tamac E, Toksavul S, Toman M. Clinical marginal and internal adaptation of CAD/CAM milling, laser sintering, and cast metal ceramic crowns. J Prosthet Dent 2014;112:909-13.

11. Tuna SH, ÖzçiçekPekmez N, Kürkçüoğlu I. Corrosion resistance assessment of Co-Cr alloy frameworks fabricated by CAD/CAM milling, laser sintering, and casting methods. J Prosthet Dent 2015;114:725-34.
12. Bilgin MS, Erdem A, Dilber E. Ersoy İ. Comparison of fracture resistance between cast, CAD/CAM milling, and direct metal laser sintering metal post systems. J Prosthodont Res 2016;60:23-8.
13. Armitage GC. Development of a classification system for periodontal diseases and conditions. Ann Periodontol 1999;4:1-6.
14. Lindhe J, Nyman S. The effect of plaque control and surgical pocket elimination on the establishment and maintenance of periodontal health. A longitudinal study of periodontal therapy in cases of advanced disease. J Clin Periodontol 1975;2:67-79.
15. Bayer S, Stark H, Gölz L, Keilig L, Kraus D, Hansen A, et al. Telescopic crowns: extra-oral and intra-oral retention force measurement—in vitro/in vivo correlation. Gerodontology 2012;29:340-7.
16. Wang CH, Lee HE, Lan TH, Igarashi Y. Method of retention control for compromised periodontal bone support abutment of conical crown retained denture. Kaohsiung J Med Sci 2010;26:435-43.
17. Hofmann E, Behr M, Handel G. Frequency and costs of technical failures of clasp- and double crown-retained removable partial dentures. Clin Oral Investig 2002;6:104-8.
18. Grossmann AC, Hassel AJ, Schilling O, Lehmann F, Koob A, Rammelsberg P. Treatment with double crown-retained removable partial dentures and oral health-related quality of life in middle-and high-aged patients. Int J Prosthodont 2007;20:576-8.
19. Wöstmann B, Balkenhol M, Kothe A, Ferger P. Dental impact on daily living of telescopic crown-retained partial dentures. Int J Prosthodont 2008;21:419-21.
20. Nickenig HJ, Spiekermann H, Wichmann M, Andreas SK, Eitner S. Survival and complication rates of combined tooth-implant-supported fixed and removable partial dentures. Int J Prosthodont 2008;21:131-7.
21. Lian M, Zhao K, Feng Y, Yao Q. Prognosis of combining remaining teeth and implants in double-crown-retained removable dental prostheses: a systematic review and meta-analysis. Int J Oral Maxillofac Implants 2017;22:1-17.
22. Greven B, Luepke M, von Dorsche SH. Telescoping implant prostheses with intraoral luted galvano mesostructures to improve passive fit. J Prosthet Dent 2007;98:239-44.
23. Ohida M, Yoda K, Nomura N, Hanawa T, Igarashi Y. Evaluation of the static frictional coefficients of Co-Cr and gold alloys for cone crown telescope denture retainer applications. Dent Mater 2010;29:706-12.
24. Schwindling FS, Stober T, Rustemeier R, Schmitter M, Rues S. Retention behavior of double-crown attachments with zirconia primary and secondary crowns. Dent Mater 2016;32:695-702.
25. Paniz G, Stellini E, Meneghello R, Cerardi A, Gobbato EA, Bressan E. The precision of fit of cast and milled full-arch implant-supported restorations. Int J Oral Maxillofac Implants 2013;28:687-93.

Corresponding author:
Dr Regina A. Danielczak
Im Neuenheimer Feld 400
69120 Heidelberg
GERMANY
Email: Regina.Danielczak@med.uni-heidelberg.de

Acknowledgments
The authors would like to thank Ian Davies for proofreading the manuscript; and the team at the dental laboratory Bernd Schenk from Schriesheim, Germany, for their professional dental technical services.

https://doi.org/10.1016/j.prosdent.2018.02.019

Noteworthy Abstracts of the Current Literature

Preparation techniques used to make single-unit crowns: Findings from the national dental practice-based research network

Minyé HM, Gilbert GH, Litaker MS, Mungia R, Meyerowitz C, Louis DR, Slootsky A, Gordan VV, McCracken MS; National Dental PBRN Collaborative Group

J Prosthodont 2018 Dec;27:813-20

Purpose. To: (1) determine which preparation techniques clinicians use in routine clinical practice for single-unit crown restorations; (2) test whether certain practice, dentist, and patient characteristics are significantly associated with these techniques.

Material and methods. Dentists in the National Dental Practice-Based Research Network participated in a questionnaire regarding preparation techniques, dental equipment used for single-unit crown preparations, scheduled chair time, occlusal clearance determination, location of finish lines, magnification during preparation, supplemental lighting, shade selection, use of intraoral photographs, and trimming dies. Survey responses were compared by dentist and practice characteristics using ANOVA.

Results. Of the 2132 eligible dentists, 1777 (83%) responded to the survey. The top two margin configuration choices for single-unit crown preparation for posterior crowns were chamfer/heavy chamfer (65%) and shoulder (23%). For anterior crowns, the most prevalent choices were the chamfer (54%) and the shoulder (37%) configurations. Regarding shade selection, a combination of dentist, assistant, and patient input was used to select anterior shades 59% of the time. Photographs are used to communicate shade selection with the laboratory in about half of esthetically demanding cases. The ideal finish line was located at the crest of gingival tissue for 49% of respondents; 29% preferred 1 mm below the crest; and 22% preferred the finish line above the crest of tissue. Average chair time scheduled for a crown preparation appointment was 76 ±21 minutes. Practice and dentist characteristics were significantly associated with margin choice including practice type ($p<0.001$), region ($p<0.001$), and years since graduation ($p<0.001$).

Conclusions. Network dentists prefer chamfer/heavy chamfer margin designs, followed by shoulder preparations. These choices were related to practice and dentist characteristics.