Intraoral scanner and computer-aided design/manufacturing technology for the fabrication of double-crown-retained removable dental prosthesis: A clinical report

Akinori Tasaka*, Takahiro Shimizu, Shuichiro Yamashita
Department of Removable Partial Prosthodontics, Tokyo Dental College, Tokyo, Japan

Abstract

**Patient:** This clinical report describes treatment with a double-crown-retained removable dental prosthesis fabricated using an intraoral scanner (IOS) and computer-aided design/manufacturing technology (CAD/CAM). A 68-year-old female patient presented with complaints of missing maxillary right first and left second premolars. CAD/CAM technology was applied to plan treatment with a double-crown-retained removable dental prosthesis. The patient consented to this treatment option but did not want orthodontic treatment for the anterior crossbite of the right side. After the definitive preparation of the abutment teeth, the shape of the provisional restoration was adjusted to match the definitive prosthesis. An IOS was used to obtain digital scans of the provisional restoration, occlusion, antagonist arch, and prepared surface of the abutment teeth. First, the primary crowns were milled from cobalt-chromium alloy. Next, using an intraoral scanner, a pick-up impression of the primary crowns was performed, and the secondary crowns were designed, milled, and veneered. After delivery, the patient expressed satisfaction with the functionality, esthetics, and fit of the double-crown-retained removable dental prosthesis.

**Discussion:** The surface of the primary crowns was coated with scan spray when the pick-up impression was made using the IOS. Practice is needed to achieve a thin and homogeneous coating with scan spray to improve reproducibility.

**Conclusion:** Double-crown-retained removable dental prostheses can be successfully fabricated using an IOS and CAD/CAM technology, resulting in patient satisfaction.

**Keywords:** Intraoral scanner, CAD-CAM, Double-crown, Removable dental prosthesis

1. Introduction

The double crown is an attachment composed of a primary crown cemented to the abutment teeth and secondary crowns integrated within a removable prosthesis. The main advantage of double crowns is that they can transfer occlusal forces along the long axis of the abutment tooth [1]. Oral hygiene for the abutment teeth is easy to perform [2], and repairs and adjustments can be easily performed if one of the abutment teeth requires extraction [3]. Skilled dental technicians typically cast primary and secondary crowns from gold or cobalt-chromium (Co-Cr) alloys [4], which are well suited for the double-crown technique because of their precise fitting, high mechanical strength, resistance to corrosion, high elastic modulus, and biocompatibility. The Co-Cr alloy also has a lower density, and therefore a lower weight, than gold alloy [5]. For these reasons, as well as its lower cost, Co-Cr alloy has become increasingly popular. Computer-aided design/computer-aided manufacturing (CAD/CAM) is being increasingly used to mill double crowns from a homogenous disk [6].

In addition, intraoral scanners (IOSs) have demonstrated sufficient accuracy in capturing impressions for the fabrication of prosthetic restorations, and remarkable innovations have been made in digital dentistry [7]. However, clinical reports on the use of IOSs for the fabrication of double-crown-retained removable dental prostheses are lacking [8-10]. Therefore, the aim of this clinical report was to describe a technique to fabricate a double-crown-retained removable dental prosthesis with the use of an IOS and CAD/CAM technology.

2. Outline of the case

A 68-year-old female patient presented at the Department of Prosthodontics of Suidoubashi Hospital at Tokyo Dental College with complaints of missing maxillary right first and left second premolars. She was also congenitally missing both maxillary lateral incisors. For treatment, a temporary partial fixed dental prosthesis was attached from the right canine to the right second premolar (Fig. 1). The patient had many endodontically treated maxillary teeth, and the maxillary left central incisor was the only vital tooth with mobility. The periodontal pocket around this tooth was maximum 4 mm deep, but the depth was 3 mm or less around other teeth, and no mobility of the remaining teeth was recorded. In addition, due to the anterior crossbite of the right side, a gingival margin discrepancy between the maxillary right and left central incisors was apparent (Fig. 2), but
the patient did not want orthodontic treatment for the malocclusion on the right side.

To improve the esthetics of the maxillary anterior teeth, surgical crown lengthening was planned. To reduce the dental mobility before surgery, cross-arch splinting (#15 to #26) with provisional restoration was performed after preparing the abutment maxillary teeth with autopolymerizing acrylic resin (UNIFAST; GC, Tokyo, Japan). After the completion of basic periodontal treatment, surgery was conducted to improve the gingival margin.

Root canal-treated teeth tend to become brittle and therefore increasingly prone to fractures [11, 12]; therefore, after tooth extraction, a double-crown-retained removable dental prosthesis with ease of repair was suggested. As a result, CAD/CAM technology was applied to plan treatment with a double-crown-retained removable dental prosthesis; the patient consented to this treatment option.

All abutment teeth were prepared with a minimum 2 mm occlusal reduction and 6 degrees convergence angle with a deep-chamfer finish line at 0.5 mm below the gingival margin. After definitive preparation of the abutment teeth, the shape of the provisional restoration was adjusted to match the definitive prosthesis. An IOS (Trios3; 3Shape, Copenhagen, Denmark) was used to obtain digital scans of the provisional restoration, occlusion, antagonist arch, and prepared surface of the abutment teeth (Fig. 3). Dental design software (CARES Visual 2020, Straumann AG, Basel, Switzerland) was then used to design the primary crowns with a convergence angle of 2 degrees (Fig. 4). Next, the data were sent to a milling center (CARES Solution Center, Tokyo, Japan), where the primary crowns were milled from a Co-Cr disc (coron: Straumann AG, Basel Switzerland) before being fitted to a three-dimensional printed dental cast and then ground and polished using a parallel milling machine (Fraезер-F1; Degussa, Frankfurt, Germany). Subsequently, a silicone-based fitting check material (Fit Checker Advanced; GC) and a sharp dental explorer were used to evaluate the crowns for proper marginal and internal fit. A small quantity of interim cement (HY-Bond Temporary Cement Hard; Shofu, Kyoto Japan) was used to fix the primary crowns to the abutment teeth, after which the surfaces of the crowns were coated with scan spray (CEREC Optispray; Sirona Dental Systems GmbH, Bensheim, Germany). The homogeneity of the coating and the minimum thickness without metallic reflection on the primary crown were visually checked. Next, an IOS was used to make a pick-up impression of the primary crowns (Fig. 5). The same dental design software was used to design the secondary crowns as a unit with a metal occlusal surface. To provide space for resin veneering, cutback was then performed on the labial surface. The data were resent to the milling center after all crowns had been joined (Fig. 6), and the secondary crowns were milled from the same material as that used for the primary crowns. After adjusting the intaglio surface of the secondary crowns, the primary crown could be removed with a retentive force of approximately 8–10 N (Fig. 7). Next, both the intra-
oral fit of the secondary crowns, as well as the occlusal relationship, were checked in the mouth. Subsequently, the secondary crowns were coated tribochemically using a silica-coating system (Rocatec System; 3M ESPE, Seefeld, Germany), silanated (ESPE Sil; 3M ESPE), and finally veneered with composite resin (Twiny; YAMAKIN, Tokyo, Japan) (Fig. 8a, b).

The primary crowns were definitively cemented (FUJI LUTING EX; GC), and the prosthesis was inserted, with appropriate adjustments. Follow-up appointments were scheduled for 1 day, 1 week, and 1 and 6 months after delivery of the double-crown-retained removable dental prosthesis. After delivery, the patient expressed satisfaction with the functionality, esthetics, and fit of the prosthetic (Fig. 9a, b).

3. Discussion

In this report, we described the fabrication of a double-crown-retained removable dental prosthesis with an IOS and CAD/CAM technology. In this clinical situation, the anterior to posterior dental arch of the maxilla, in which the arch length was reduced because of a congenital missing tooth, was treated with a prosthesis. It has previously been reported that IOSs can be used as a replacement for conventional impressions to restore as many as 10 prosthesis units [13]. However, the deviations of the IOS have also been reported to be larger in the posterior than in the anterior area [14]. Furthermore, errors introduced during stitching are more common in the mandibular compared with those in the maxillary arch [15]. Therefore, to ensure that no incompatibilities due to the above-mentioned causes had occurred, sufficient confirmation was made at the time of trial fitting.

In this case, primary crowns made of Co-Cr alloy were designed with a convergence angle of 2 degrees. Typically, the angle is set at 6 degrees for type-4 gold alloys, but in the present study, 2 degrees was chosen for material frictional coefficient [16]. The surface of the primary crowns was coated with scan spray when the pick-up impression was being made using the IOS, because mirror-polished primary crowns are reflective during scanning, which can distort the captured image (Fig. 10a, b). However, if the scan spray covering the abutment teeth is too thick, the retention of the double crown is reduced. In the case of an ill-fitting secondary crown on the primary, welding is required. Therefore, when using an IOS to make a pick-up impression of the primary crown, to provide a thin and homogeneous coating with scan spray, which improves reproducibility, prior practice is required. In addition, before conducting the CAD/CAM double crown, test milling of the crown and a check of the retentive force need to be performed. In some cases, it may be necessary to adjust the milling parameters. For this case, the authors considered two situations. First, the cement gap of the secondary crown to the scanning data of the primary crown is adjusted on the CAD. Second, the offset parameter used for the milling step of the secondary crown is adjusted for the inner diameter of the crown on the CAM. The test milling was performed in advance with the same milling machine as used in other cases, and the parameters were pre-adjusted. Therefore, test milling was not performed in this case. If the same operator can provide homogeneous coating with a scan spray each time, the same parameters could be used to obtain the retentive force of the double crown. However, a slight error is expected due to wear of the milling bar.

Until now, the fabrication of double crowns has required expert skills and involved many complex dental laboratory steps. This workflow using CAD/CAM has made it possible to simplify the steps and reduce the cost of materials. The limitations of using this technique include the cost of the intraoral scanner and the education required for the dental clinicians and technicians. However, establishing this workflow can increase the overall efficiency of fabrication of double crowns.
4. Conclusion

This clinical report described the fabrication of a double-crown-retained removable dental prosthesis by using an IOS and CAD/CAM technology that resulted in patient satisfaction.

Statement of informed consent and institutional approval

Written informed consent was obtained from the patient for publication of this clinical report and accompanying images. No institutional approval was required to publish the case details.
Acknowledgements

We are grateful to Motoyuki Nagashima, Kenichiro Yoneda and Isamu Usui (Center Labo Keiyo, Chiba, Japan) for helping with the manufacture of the crowns. We would also like to thank everyone in the Department of Prosthodontics, Heidelberg University Hospital for giving us technical information on CAD-CAM double crown.

Conflicts of interest

The authors declare no conflict of interest.

References

[1] Wenz HJ, Hertrampf K, Lehmann KM. Clinical longevity of removable partial dentures retained by telescopic crowns: outcome of the double crown with clearance fit. Int J Prosthodont 2001;14:207-13. PMID:11484566

[2] Widbom T, Löfquist L, Widbom C, Söderfeldt B, Kronström M. Tooth-supported telescopic crown-retained dentures: an up to 9-year retrospective clinical follow-up study. Int J Prosthodont 2004;17:29-34. PMID:15008229

[3] Ishida K, Nogawa T, Takayama Y, Saito M, Yokoyama A. Prognosis of double-crown-retained removable dental prostheses compared with clasp-retained removable dental prostheses: a retrospective study. J Prosthodont Res 2017;61:268-75. https://doi.org/10.1016/j.jpor.2016.12.006, PMID:28073636

[4] 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. https://doi.org/10.1007/s00784-013-1335-x, PMID:25307091

[5] Stock V, Schmidlin PR, Merk S, Wagner C, Roos M, Eichberger M, et al. PEEK Primary crowns with cobalt-chromium, zirconia and galvanic secondary crowns with different tapers—a comparison of retention force. Materials (Basel) 2016;10:9:187. https://doi.org/10.3390/ma9030187, PMID:28773311

[6] Danielczak RA, Stober T, Bömicke W. Treatment with a CAD-CAM-fabricated, double-crown-retained, removable partial denture: a clinical report. J Prosthodont Dent 2019;121:220-4. https://doi.org/10.1016/j.prosdent.2018.02.019, PMID:30337693

[7] Kihara H, Hatakeyama W, Komine F, Takafuji K, Takahashi T, Yokota J, et al. Accuracy and practicality of intraoral scanner in dentistry: A literature review. J Prosthodont Res 2020;64:109-13. https://doi.org/10.1016/j.jpor.2019.07.010, PMID:31474576

[8] Adali U, Schober S, Beuer F, Spies BC. Digital Impression-Taking Facilitates Prosthetic Rehabilitation of Microstomia Patients: A Case History Report. Int J Prosthodont. 2019; 32: 1: 110-12. https://doi.org/10.11607/jip.9955, PMID:30192354

[9] Fueki K, Inamochi Y, Wada J, Araiz, Takaichi A, Murakami N, et al. A systematic review of digital removable partial dentures. Part I: Clinical evidence, digital impression, and maxillomandibular relationship record. J Prosthodont Res 2021, https://doi.org/10.2186/jpr_d_20_00116, PMID:33504721

[10] AlRumaih HS. Clinical Applications of Intraoral Scanning in Removable Prosthodontics: A Literature Review. J Prosthodont. 2021. https://doi.org/10.1111/jopr.13395, PMID:34043266

[11] Kishen A. Mechanisms and risk factors for fracture predilection in endodontically treated teeth. Endodontic Topics 2006; 13: 57–83. https://doi.org/10.1111/j.1601-1546.2006.00201.x

[12] Tang W, Wu Y, Smalles RJ. Identifying and reducing risks for potential fractures in endodontically treated teeth. J Endod. 2010; 36: 609-17. https://doi.org/10.1016/j.joen.2009.12.002, PMID:20307722

[13] Nedelcu R, Olsson P, Nyström I, Rydén J, Thor A. Accuracy and precision of 3 intraoral scanners and accuracy of conventional impressions: a novel in vivo analysis method. J Dent 2018;69:110-8. https://doi.org/10.1016/j.jdent.2017.12.006, PMID:29246490

[14] Moon YG, Lee KM. Comparison of the accuracy of intraoral scans between complete-arch scan and quadrant scan. Prog Orthod 2020;21:36. https://doi.org/10.1186/s40510-020-00337-1, PMID:33000308

[15] Tomita Y, Uechi J, Konno M, Sasamoto S, Iijima M, Mizoguchi I. Accuracy of digital models generated by conventional impression/plaster-model methods and intraoral scanning. Dent Mater J 2018;37:628-33. https://doi.org/10.4012/dmj.2017-208, PMID:29669951

[16] Ohida M, Yoda K, Nomura N, Hanawa T, Igashiri Y. Evaluation of the static frictional coefficients of Co-Cr and gold alloys for cone crown telescope denture retainer applications. Dent Mater J 2010;29:706-12. https://doi.org/10.4012/dmj.2010-011, PMID:21099161

This is an open-access article distributed under the terms of Creative Commons Attribution-NonCommercial License 4.0 (CC BY-NC 4.0), which allows users to distribute and copy the material in any format as long as credit is given to the Japan Prosthodontic Society. It should be noted however, that the material cannot be used for commercial purposes.