EC DENTAL SCIENCE
Case Report

Novel Prosthesis Technique for Fabricating a CAD/CAM Implant Superstructure Frame Using a 3D Printer

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Abstract

The purpose of this case study is to evaluate the efficacy of a simple novel technique using a 3D printer derived customized ring-frame index and bite plate (3D-CRIB) method for use in clinical implantation of a fully edentulous maxilla. Eight fixtures were placed using the conventional technique. Before the second-stage operation, a cone beam CT (CBCT) was taken for the 3D-CRIB method. The CBCT DICOM data was rendered and transformed into STL data, and a fixture model was printed for fabrication of the ring-frame index. Immediately after fastening the intermediate abutment, a conventional impression was obtained, and the implant position was confirmed. Moreover, the maxillo-mandibular relationship was recorded. The superstructure was completed, and the next appointment was fastened without test fitting. The fixing screws were fastened at a specific torque force. A novel prosthesis technique, the 3D-CRIB method, was proposed for high-accuracy complex implant fabrication with a shortened treatment period.

Keywords: *Implant Treatment; Prosthesis; CAD/CAM; Impression; 3D-Printer*

Abbreviations

3D-CRIB: 3D Printer Derived Customized Ring-Frame Index and Bite Plate; CAD/CAM: Computer Aided Design Computer Aided Milling; CBCT: Cone Beam Computed Tomography; DICOM: Digital Imaging and Communications in Medicine; PMMA: Polymethylmethacrylate; 3D: Three Dimension

Introduction

Implant-supported fixed prosthetic appliances are effective with a high success rate for oral rehabilitation of fully and partially edentulous patients [1,2]. Implant treatment consists of surgical and prosthetic treatments, and prosthetic treatment consists of impression, registration of the implant position, recording of the maxillo-mandibular relationship, and superstructure fabrication. The first step of prosthesis treatment, impression, is particularly important because the implant-implant position should be reproduced on the mastercast model in order to obtain the passive fit superstructure. In the conventional procedure, impression copings are printed with polymethyl methacrylate (PMMA) resin to fix the implant-implant position. However, the conventional procedure might lead to implant-implant position errors in the dental model due to polymerization shrinkage [3,4]. Furthermore, superstructure fabrication using a computer-aided design and computer-aided manufacturing (CAD/CAM) method is required, particularly for precise reproduction of the implant-implant position during the impression procedure in order to obtain an accurate clinical fit [5]. Therefore, the metal frame index is used to fix the implant-implant position after impression. However, this requires many complicated steps, such as fixing the implant-implant position, recording the maxillo-mandibular relationship, and frame try-in (Table 1). Therefore, technical errors may occur and incompatible superstructures may be constructed during the prosthesis treatment.

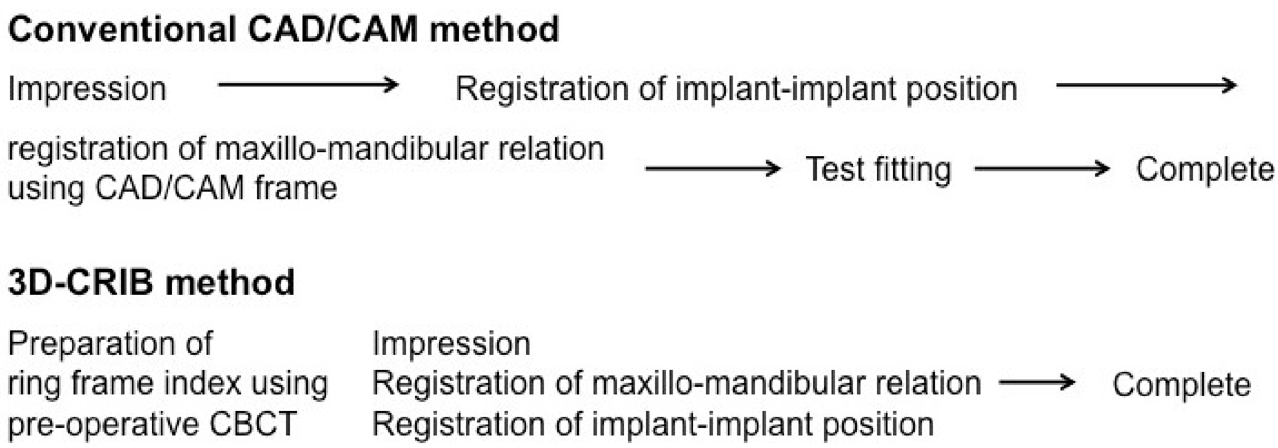

Table 1: *Comparison of the conventional method and the 3D-CRIB method.*
The conventional method is a complicated procedure for superstructure fabrication, whereas the 3D-CRIB method can complete the superstructure in only one step.

Recently, by virtue of the development of three-dimensional (3D) printing technology, a 3D printed model can be used for effective simulation before surgical treatment as well as for guiding surgery [6,7]. In implant dentistry, however, 3D printed models have not been used for impressioning, fixing of the implant-implant position, or recording of the maxillo-mandibular relationship.

The purpose of the present case study is to evaluate the efficacy of a simple novel technique using a 3D printer-derived customized ring-frame index and bite plate (3D-CRIB) method in a fully edentulous maxilla in a clinical setting.

Materials and Methods (Treatment Procedure)

Patient status

A 65-year-old woman with a fully edentulous maxilla was evaluated for implant treatment (Figure 1). During treatment planning, a digitally guided system and a temporally fixed restoration were not available due to the patient’s financial situation. The patient had no systemic disease and no problems related to bone quantity or quality.

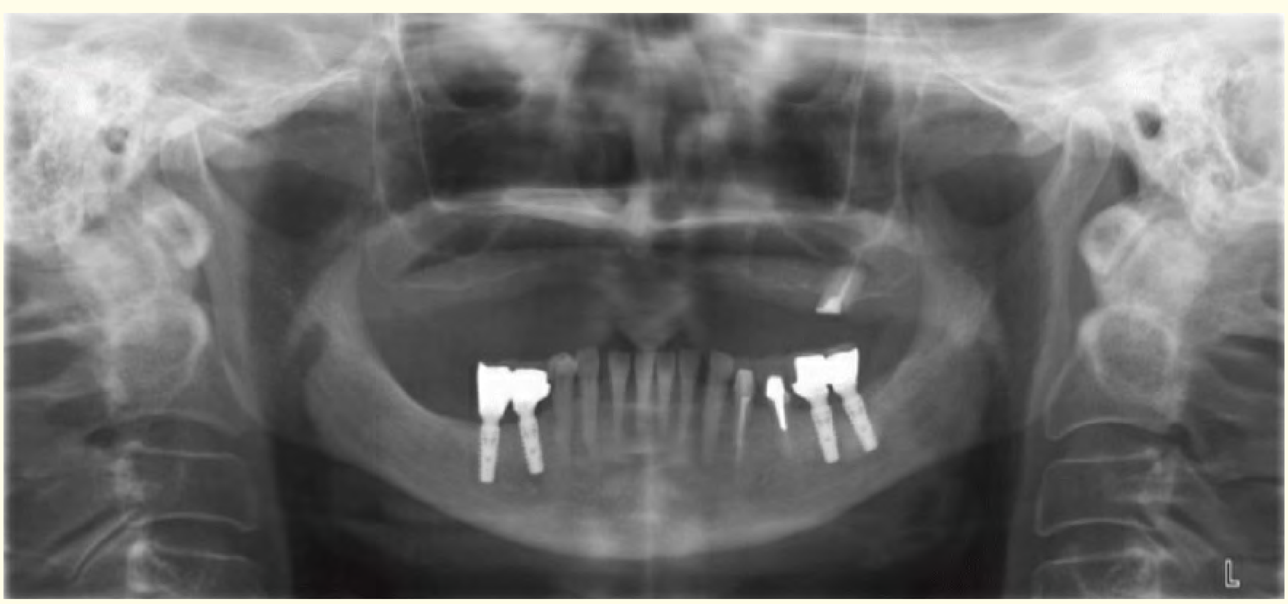

Figure 1: *Preoperative panoramic X-ray image.*
The surgical procedure was planned using panoramic X-ray and CBCT images.

Surgical procedure

Prior to maxilla implant treatment, the mandibular occlusal plane was flattened for stabilization of occlusion. The surgical procedure was planned as follows: 17, 13, 23, and 25; fixture placement without bone grafting 15; angled fixture placement 12 and 22; fixture placement with minor bone grafting 27; and extraction and simultaneous fixture placement with bone grafting. After local anesthesia, eight fixtures (Aadva standard and tapered, GC Corp., Tokyo, Japan) were placed at predetermined positions, and a CBCT was taken using the 3D-CRIB method (Figure 2 and 3). Immediate loading was not performed because of poor primary stabilization.

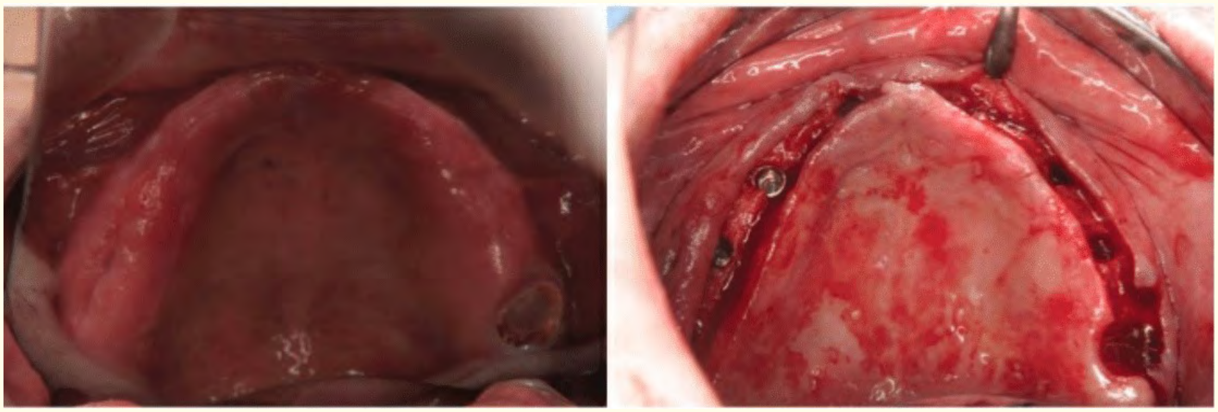

Figure 2: *Fixture placement.*
Eight fixtures were placed following the treatment plan.

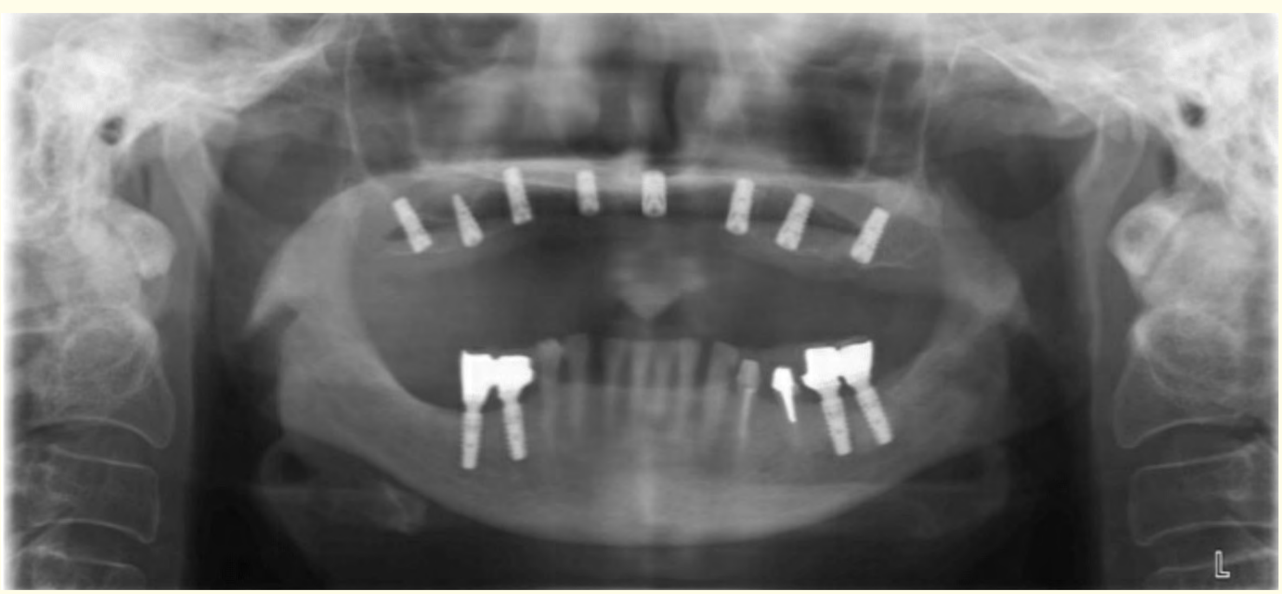

Figure 3: *Panoramic X-ray image after fixture placement.*
Each fixture was placed in an adequate position.

Prosthesis procedure

A maxillary fixture model, in which the positional relationship among eight implants in the maxilla was duplicated and reconstructed by 3D printer (VIDA, EVISIONTEC TEC GmbH, Gladbeck, Germany) with postoperative CBCT data, in the form of an image of deleted bone and soft tissue (Figure 4,5). A ring-frame index made of cobalt chromium alloy, was fabricated based on the fixture model, and rip support projection was added using auto-polymerization resin (pattern resin, GC corp., Tokyo, Japan) (Figure 6).

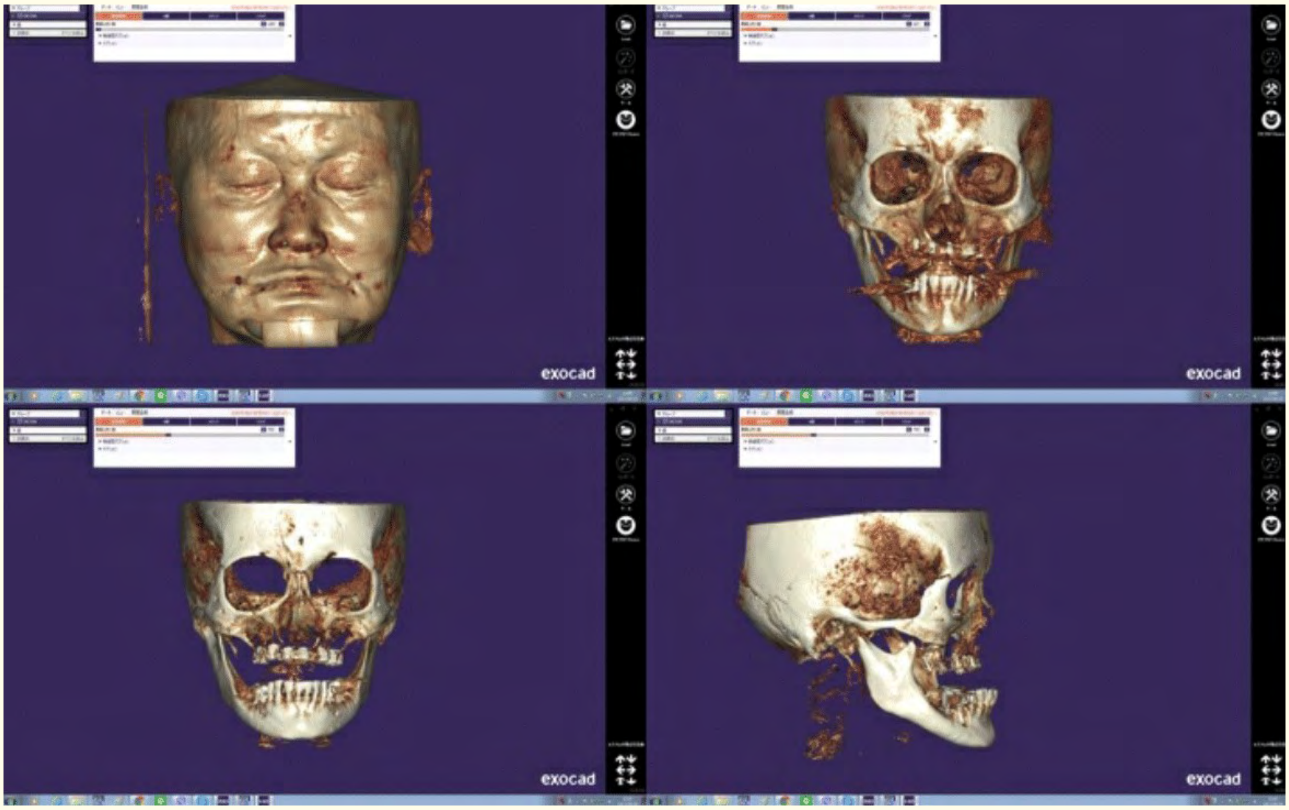

Figure 4: *DICOM data rendering.*
The DICOM data was rendered in order to remove soft and hard tissues.

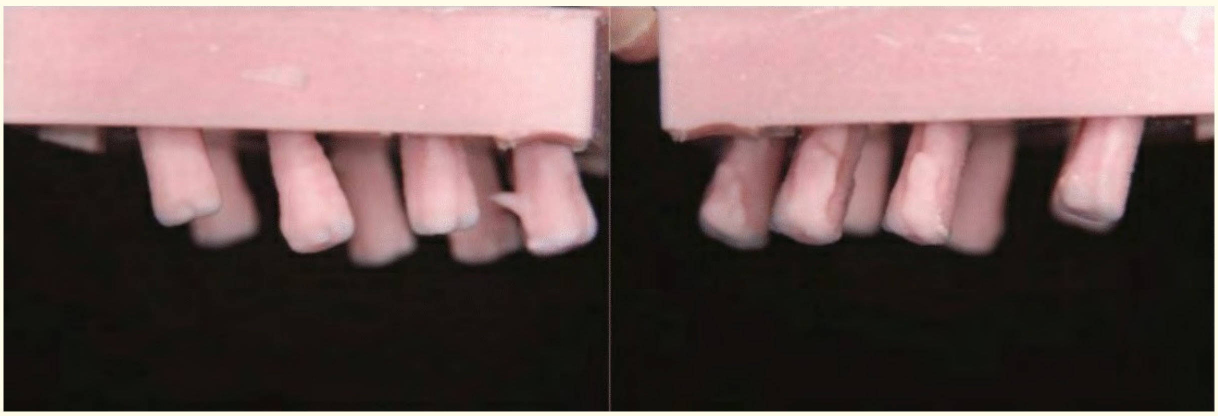

Figure 5: *Fabrication of the 3D printed model.*
The 3D printed model was fabricated using the rendered DICOM data. Each fixture was clearly reconstructed.

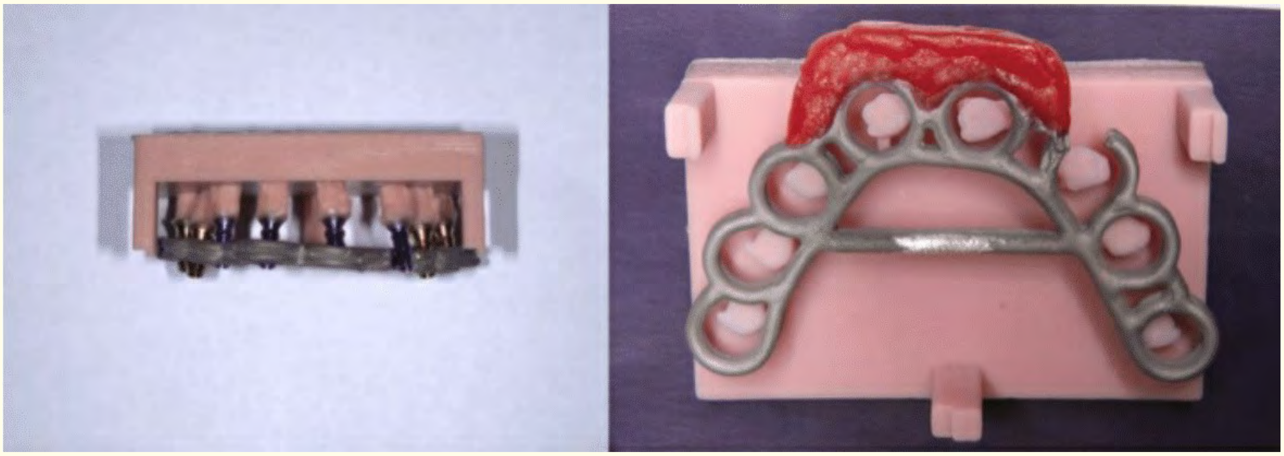

Figure 6: *Wax-up and casting of the ring-frame index.*
The ring-frame index was fabricated using the lost wax method.

During the second stage, the soft tissue on the molar area fixture was removed using the punch-out method using the ring-frame index to guide the fixture position. After fastening an intermediate abutment (SR abutment, GC Corp., Tokyo, Japan), an impression coping was placed onto the intermediate abutment and an impression was taken (Figure 7). Subsequently, the ring-frame index and the impression coping were printed with auto-polymerization resin (Fixpeed, GC Corp., Tokyo, Japan) to confirm the implant-implant position (Figure 8) and, simultaneously, the maxillo-mandibular relationship in centric relation was recorded with silicon material (Figure 9).

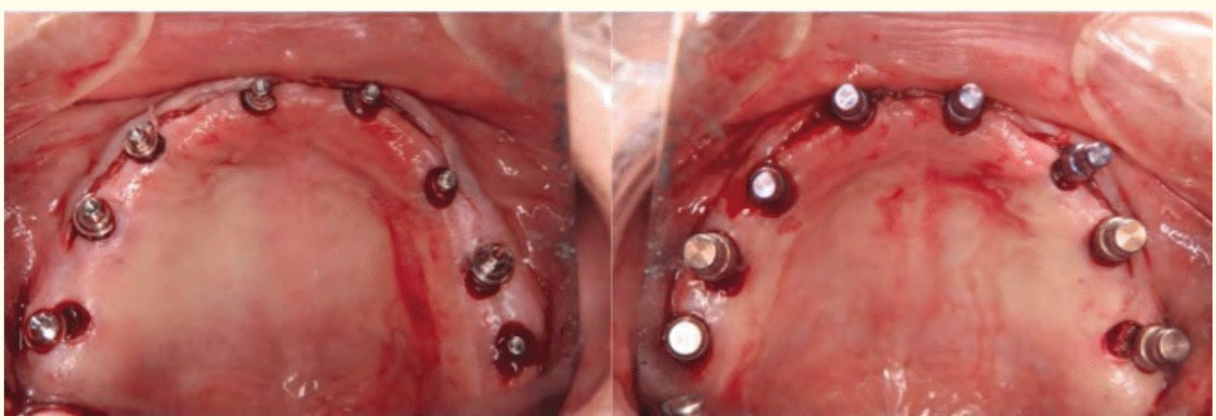

Figure 7: *Second stage operation.*
After fastening the intermediate abutments, impressioning was performed without printing the impression coping.

Figure 8: *Confirmation of the fixture position.*
The impression coping was printed using a prepared ring-frame index.

Figure 9: *Maxillo-mandibular relationship record.*
The maxillo-mandibular relationship was recorded in centric relation using the ring-frame index.

A mastercast model was fabricated and then was costumed and mounted to the articulator using the ring-frame index (Figure 10a). The titanium framework of the superstructure was designed by wax-up following scanning and was milled with a CAD/CAM system (GM-1000, GC corp., Tokyo, Japan) (Figure 10b, Figure 11a, and 11b). Finally, hard resin was veneered onto the facing area (Figure 12). The screw-retained metal-resin superstructure was completed without the try-in step, the retaining screws were fastened with a specific torque force (Figure 13). A minor occlusal adjustment was performed for resin contraction, and no difference in the centric relation and centric occlusion points was observed. During maintenance, good oral hygiene was maintained, and satisfactory occlusion and aesthetics were obtained.

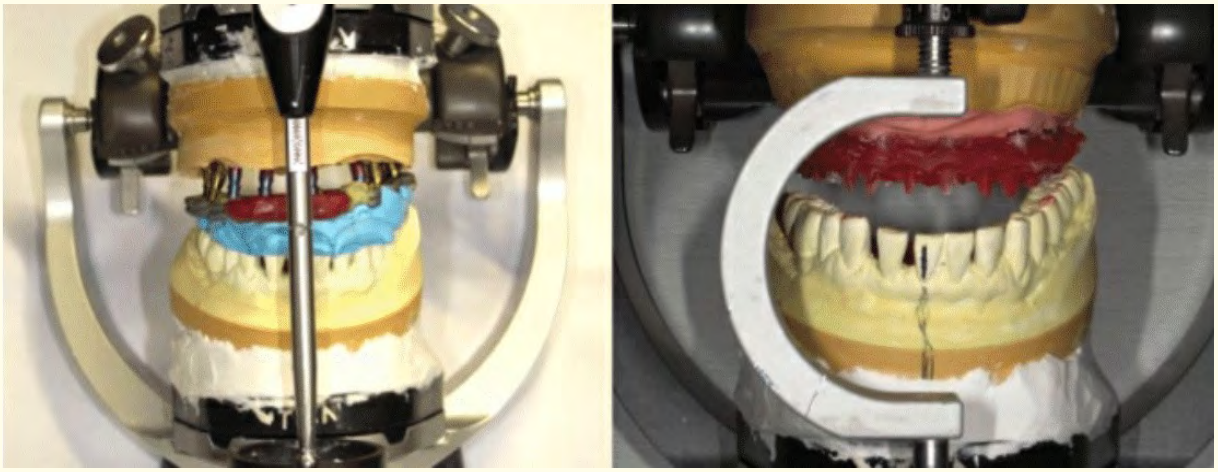

Figure 10: *Mastercast fabrication, articulation, and CAD/CAM frame wax-up.*
Mastercast fabrication and articulation were performed using the ring-frame index, and the wax-up was fabricated for CAD/CAM framework.

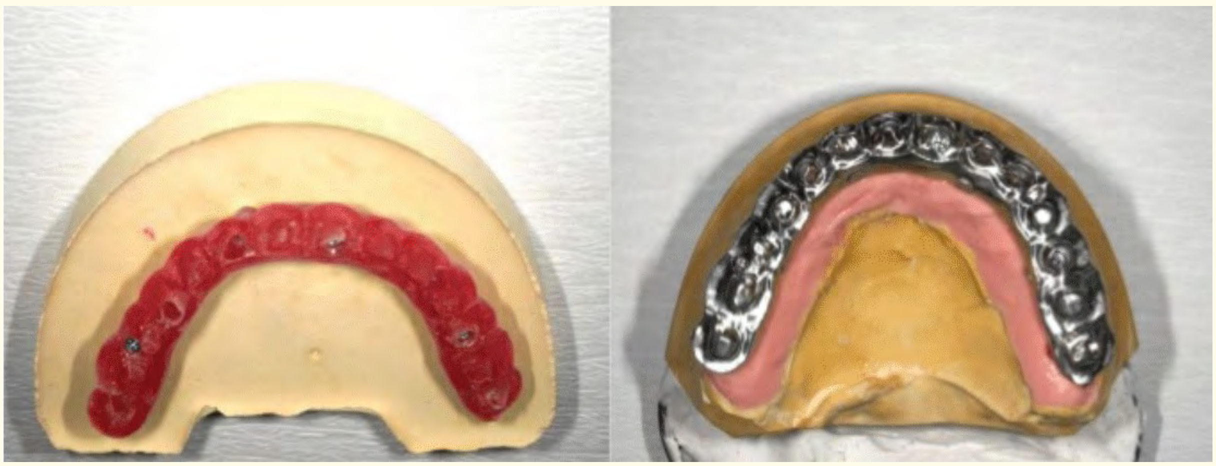

Figure 11: *Framework fabrication.*
The titanium framework was milled by GM-1000.

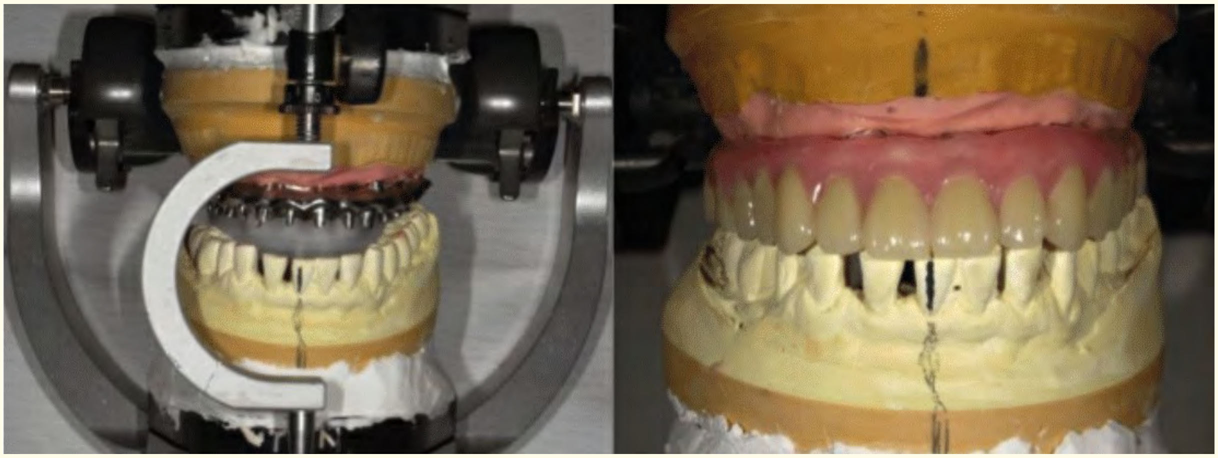

Figure 12: *Veneering and completion.*

Veneering was performed on the CAD/CAM framework, and the screw retaining superstructure was completed.

Figure 13: *Fastened superstructure.*

Each fixing screw was fastened until slight resistance was encountered, and a passive fit was obtained.

Results and Discussion

Discussion

Recently, digital dentistry techniques, such as guided surgery and CAD/CAM systems, have become widely used [8,9]. Accordingly, both patient demand for implant treatments and the demand for more precise treatments by dentists and dental technicians have increased. CAD/CAM systems have been applied to titanium and zirconia frames of superstructures [10]. CAD/CAM frameworks are precise and more highly reproducible than conventional frameworks that are constructed by casting and soldering [11,12]. In the case of a CAD/CAM system, a highly accurate impression is required regarding the fixture position. Therefore, a metal ring-frame index was used to fix the fixture position [5]. Although producing the ring-frame index and superstructure requires a great deal of time, in order to solve this problem, a temporary working model of the ring-frame index was constructed using a surgical guide. However, complex situations, such as the use of a mucosa-supported fixture in a fully edentulous patient, involve numerous errors with regard to fixture position, as compared with using a tooth-supported surgical guide in the partial edentulous case [13]. Therefore, the working model constructed using a surgical guide was inaccurate.

In the 3D-CRIB procedure, a CBCT was taken after fixture placement, and a mastercast model was constructed by 3D printer using post-operative CBCT data. Wax-up was performed on the 3D printed model for the ring-frame index. After casting wax-up, a prepared ring-frame index was applied to the fixed implant position, and the maxillo-mandibular relationship was recorded simultaneously during the second stage. Thus, the 3D-CRIB method reduced the time required to complete the superstructure without lowering the fabrication accuracy.

3D-CRIB method was effective for all cases of multiple implant retained prosthesis, especially, in the no occlusal contact case, there is a possibility that the fixture is failed for over road caused by contact to the antagonist. Therefore, period shorting of the superstructure fabrication was improved implant treatment success rate. At the fabricating step for the superstructure, metal frame fabrication using CAD/CAM system and surface veneering steps were in the similar to the conventional method, accordingly, technical in the lab side error was extremely was difficult to occur.

In the future, instead of a cast metal index, a 3D printed ring-frame index will be applied in clinical situations. At present, the strength of the 3D printed ring-frame index is less than that of metal index, and the possibility of deformation of the implant position exists. However, if the material strength is improved, the 3D-CRIB method can be performed completely digitally.

Conclusion

The 3D-CRIB method was proposed as a high-accuracy fabrication method for complex implants with a reduced treatment period. The 3D-CRIB method is promising for application in next-stage digital dentistry.

Acknowledgements

None.

Conflict of Interest

None.

Bibliography

1. Adell R., *et al*. "A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws". *International Journal of Oral and Maxillofacial Implants* 5.4 (1990): 347-359.

2. Block MS. "Long-Term Maintenance of Full Arch Maxillary Restorations". *Journal of Oral and Maxillofacial Surgery* 74.12 (2016): 2342-2344.

3. Assif D., *et al*. "Accuracy of implant impression techniques". *The International Journal of Oral and Maxillofacial Implants* 11.2 (1996): 216-222.

4. Lee H., *et al*. "The accuracy of implant impressions: a systematic review". *The Journal of Prosthetic Dentistry* 100.4 (2008): 285-291.

5. Papaspyridakos P. *et al*. "Accuracy of implant casts generated with splinted and non-splinted impression techniques for edentulous patients: an optical scanning study". *Clinical Oral Implants Research* 23.6 (2012): 676-681.

6. Flügge TV., *et al*. "Three-dimensional plotting and printing of an implant drilling guide: simplifying guided implant surgery". *Journal of Oral and Maxillofacial Surgery* 71.8 (2013): 1340-1346.

7. Van Assche N., *et al*. "Accuracy of implant placement based on pre-surgical planning of three-dimensional cone-beam images: a pilot study". *Journal of Clinical Periodontology* 34.9 (2007): 816-821.

8. Conejo J., *et al*. "Performance of CAD/CAM monolithic ceramic Implant-supported restorations bonded to titanium inserts: A systematic review". *European Journal of Oral Implantology* 10.1 (2017): 139-146.

9. Wittneben JG., *et al*. "Esthetic and Clinical Performance of Implant-Supported All-Ceramic Crowns Made with Prefabricated or CAD/CAM Zirconia Abutments: A Randomized, Multicenter Clinical Trial". *Journal of Dental Research* 96.2 (2017): 163-170.

10. Al-Meraikhi H., *et al*. "In vitro fit of CAD-CAM complete arch screw-retained titanium and zirconia implant prostheses fabricated on 4 implants". *The Journal of Prosthetic Dentistry* 119.3 (2018): 409-416.

11. Tan PL., *et al*. "An in vitro comparison of vertical marginal gaps of CAD/CAM titanium and conventional cast restorations". *Journal of Prosthodontics* 17.5 (2008): 378-383.

12. Miyazaki T. *et al*. "A review of dental CAD/CAM: current status and future perspectives from 20 years of experience". *Dental Materials Journal* 28.1 (2009): 44-56.

13. Schneider D., *et al*. "A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry". *Clinical Oral Implants Research* 20.4 (2009): 73-86.

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