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Implant-Supported Fixed Dental Prostheses with CAD/CAM-Fabricated Porcelain Crown and Zirconia-Based Framework

Masayuki Takaba, Shinpei Tanaka, Yuichi Ishiura, & Kazuyoshi Baba, DDS, PhD

Department of Prosthodontics, Showa University School of Dentistry, Tokyo, Japan

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Correspondence
Masayuki Takaba, Showa University, Prosthodontics, 2-1-1 Kitasenzoku Ohta-ku, Tokyo 145-8515, Japan. E-mail: mtakaba@dent.showa-u.ac.jp

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Abstract

Recently, fixed dental prostheses (FDPs) with a hybrid structure of CAD/CAM porcelain crowns adhered to a CAD/CAM zirconia framework (PAZ) have been developed. The aim of this report was to describe the clinical application of a newly developed implant-supported FDP fabrication system, which uses PAZ, and to evaluate the outcome after a maximum application period of 36 months. Implants were placed in three patients with edentulous areas in either the maxilla or mandible. After the implant fixtures had successfully integrated with bone, gold-platinum alloy or zirconia custom abutments were first fabricated. Zirconia framework wax-up was performed on the custom abutments, and the CAD/CAM zirconia framework was prepared using the CAD/CAM system. Next, wax-up was performed on working models for porcelain crown fabrication, and CAD/CAM porcelain crowns were fabricated. The CAD/CAM zirconia frameworks and CAD/CAM porcelain crowns were bonded using adhesive resin cement, and the PAZ was cemented. Cementation of the implant superstructure improved the esthetics and masticatory efficiency in all patients. No undesirable outcomes, such as superstructure chipping, stomatognathic dysfunction, or periimplant bone resorption, were observed in any of the patients. PAZ may be a potential solution for ceramic-related clinical problems such as chipping and fracture and associated complicated repair procedures in implant-supported FDPs.

Dental implants are now widely recognized as a viable treatment option for prosthetic replacement of missing teeth. After implant fixtures are successfully placed and abutments are connected, implant-supported fixed dental prostheses (FDPs) are fabricated on the abutments. Porcelain is the material of choice for most FDPs, and metal ceramic restorations are widely used for FDPs because of their clinically acceptable biological stability, esthetics, and mechanical properties. Previous reports suggest that porcelain-fused-to-metal (PFM) crowns[1,2] and FDPs[3,4] exhibit excellent long-term prognosis, and metal ceramics have thus also been applied to implant-supported FDPs.

On the other hand, metal ceramic FDPs are opaque, and the gingival marginal area is often discolored due to the metallic framework. In addition, they may induce metallic allergy,[5] although the number of such patients is not very high. The increasing demand for metal-free prostheses with better translucency that mimic the natural dentition has led to the recent development of several esthetically pleasing and biocompatible ceramics.[6,7] Feldspathic ceramics meet patient esthetic demands but do not provide adequate structural integrity, especially for implant-supported posterior FDPs.

In recent years, FDPs using a zirconia framework produced by a new fabrication system combined with computer-assisted fabrication (CAD/CAM) systems have attracted much attention and emerged as a popular treatment modality.[8,9] While zirconia ceramic FDPs exhibited a survival rate similar to metal ceramic FDPs after 3 years of function,[10] it has been noted that veneering porcelain on the zirconia framework by the conventional manual laboratory technique resulted in significantly lower fracture strength than the conventional PFM FDPs.[7,11] Actually, porcelain chipping or fractures are the most frequently reported technical complications of zirconia ceramic FDPs.[12,13]

Recently, machine-milled ceramic bonded to zirconia plate specimens using resin cement showed significantly higher fracture strength than that of conventional porcelain-fused-to-zirconia plate specimens.[14] The same authors reported clinical application of implant-supported FDPs with a hybrid structure of CAD/CAM porcelain crowns adhered to a CAD/CAM zirconia framework (PAZ).[15-17] In addition to the high fracture strength of this system demonstrated in vitro, this system allows re-fabrication of the CAD/CAM porcelain crown using the recorded CAD data without making an impression when

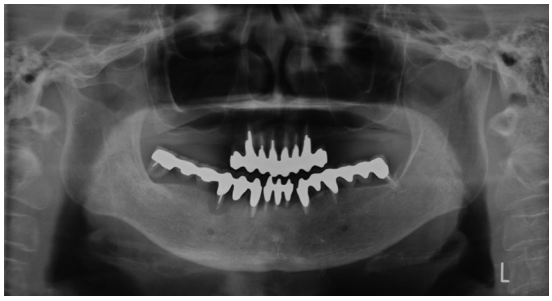

Figure 1 Panoramic radiograph taken at initial examination (patient 1).

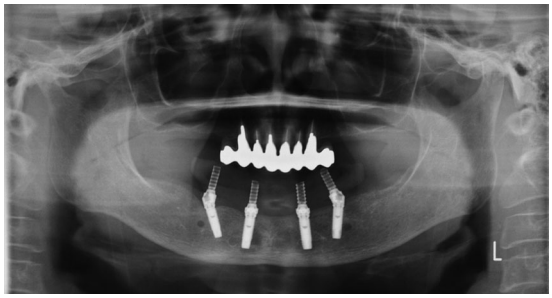

Figure 2 Panoramic radiograph taken after implant placement (patient 1).

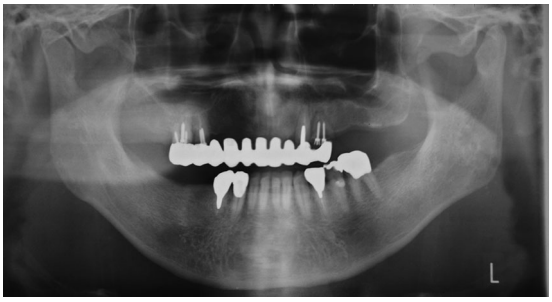

Figure 3 Panoramic radiograph taken at initial examination (patient 2).

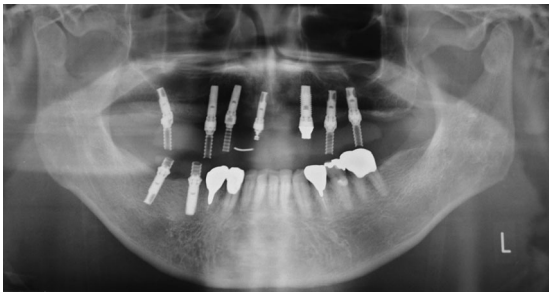

Figure 4 Panoramic radiograph taken after implant placement (patient 2).

porcelain fractures occur, which is expected to minimize the associated burden for both the patient and the clinician.

The aim of this clinical report was to describe the newly developed implant-supported FDP fabrication system, which uses PAZ, and evaluate the clinical outcome after a maximum application period of 36 months.

Clinical reports and initial treatments

Three patients with either an edentulous maxilla or mandible who requested implant prostheses and consented to participate were selected. The followings are overviews of the selected patients.

Patient 1

A 66-year-old woman presented with masticatory disturbance due to loose mandibular FDPs. Figure 1 shows a panoramic radiograph taken at the initial examination. The periodontal condition and appearance of the maxillary prosthesis were judged to be good. The edentulous area had insufficient bone width and height for placement of implant fixtures, and the patient was not willing to undergo sinus augmentation surgery. Clinical examination indicated that extraction of the remaining mandibular teeth was required due to severe chronic periodontitis. First, the remaining mandibular teeth were extracted, and a complete denture was immediately placed. When the extraction sockets had healed adequately, four implants were placed in the mandible based on the All-on-4 concept (Fig 2).[18]

Patient 2

A 55-year-old man presented with masticatory disturbance due to detachment of a maxillary FDP. Figure 3 shows the panoramic radiograph taken at the initial examination. Although the patient had a mandibular removable partial denture (RPD) fabricated by his dentist, he reported that he was not comfortable wearing it. The remaining mandibular teeth and restorations were in good condition. The patient also reported repeated detachment of the maxillary FDP. Clinical examination with radiographic assessment indicated that extraction of the remaining teeth was required due to chronic apical periodontitis, root fracture, and root caries. First, the remaining maxillary teeth were extracted, and a complete denture was immediately placed. When the extraction sockets had healed adequately, seven implants were placed in the edentulous maxilla and two implants in the mandible (Fig 4).

Patient 3

A 63-year-old man presented with masticatory disturbance due to multiple mobile teeth and ill-fitting RPDs. Figure 5 shows the panoramic radiograph taken at the initial examination. The patient was wearing RPDs in the maxilla and mandible but had difficulty chewing with the dentures. Clinical examination with radiographic assessment revealed that the quality of the dentures was not acceptable and extraction of all remaining teeth was indicated due to severe chronic periodontitis. First, six implants were placed in the maxilla immediately after extraction. Six months later, another six implants were placed in the mandible immediately after extraction (Fig 6).

Figure 5 Panoramic radiograph taken at initial examination (patient 3).

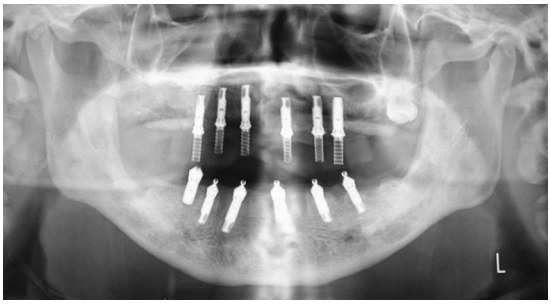

Figure 6 Panoramic radiograph taken after implant placement (patient 3).

Figure 7 Custom abutments made of gold-platinum alloy.

For all patients, Brånemark System® MK III implants (Nobel Biocare Services AG, Goteborg, Sweden) were used and were immediately loaded with acrylic interim prostheses.

PAZ fabrication

After the implant fixtures had successfully integrated with bone, final impressions were taken at the implant fixture level using the standard method, and a working model was fabricated. Then, the occlusion between the interim prosthesis and antagonistic dental arch was registered, and the interim prostheses screwed to the working models were mounted on a semiadjustable articulator using a facebow transfer technique. The diagnostic wax-up for abutment fabrication was performed on the working model attached to the articulator. Then gold-platinum alloy or zirconia custom abutments were fabricated (Figs 7, 8). Custom abutments were connected in the oral cavity, and their position was confirmed using jigs prefabricated on the working model. Zirconia framework wax-up was performed on the custom abutments (Fig 9), data were input into the CAD/CAM system using the double-scan

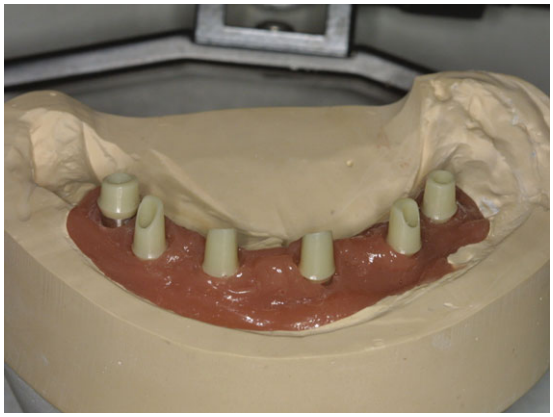

Figure 8 Custom abutments made of zirconia.

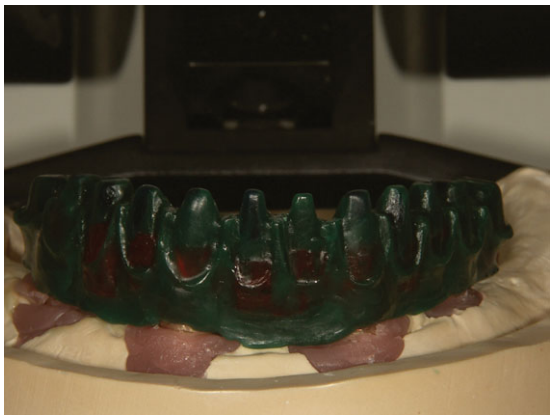

Figure 9 Zirconia framework wax-up.

Figure 10 Completed zirconia framework.

Figure 11 Porcelain crown wax-up.

Figure 12 Completed CAD/CAM porcelain crowns.

Figure 13 Completed superstructure (PAZ).

technique, and CAD/CAM zirconia frameworks (Zenotec System, Wieland Dental + Technology GmbH & Co. KG, Pforzheim, Germany) were fabricated (Fig 10). Next, impressions of the CAD/CAM zirconia frameworks were taken on the models using silicone impression material, and working models for porcelain crown fabrication were made. Wax-up was performed for porcelain crowns on the models (Fig 11), and CAD/CAM porcelain crowns (Decsy, Digital Process Ltd, Kanagawa, Japan) were fabricated using the CAD/CAM double-scan method (Fig 12). After the CAD/CAM zirconia frameworks and CAD/CAM porcelain crowns were primed, they were bonded using adhesive resin cement (Panavia F2.0, Kuraray Medical, Inc., Tokyo, Japan). Finally, zirconia frameworks were primed, and the gingival area was built using gingiva-colored hybrid hard resin (Gradiagum, GC Corp., Tokyo, Japan) to complete the PAZ (Fig 13). After connecting the custom abutments into the oral cavity, the PAZ was cemented using temporary cement (Temporary Cement, Shofu, Inc., Kyoto, Japan).

Figure 14 Definitive prosthesis in patient 1 (frontal view).

Figure 15 Definitive prosthesis in patient 2 (frontal view).

Figure 16 Definitive prosthesis in patient 3 (frontal view).

Outcome

Cementation of the implant superstructure improved esthetics and masticatory efficiency. In patient 1, a metal base partial denture was placed in the maxillary edentulous area. No clinical complications were reported or observed for 30 months after the PAZ was cemented to the mandible (Fig 14). For patient 2, as the implant fixture placed in the right posterior region of the maxilla fell out when the abutment was being connected, an additional implant fixture was placed distally in the same area. After osseointegration, the PAZ was fabricated. No clinical complications were reported or observed for 36 months after the PAZ was cemented (Fig 15). In patient 3, a standard screw-retained type superstructure was fitted to the edentulous maxilla. The PAZ was attached to the edentulous mandible, and no clinical complication was reported or observed for 18 months after the placement (Fig 16). No undesirable outcomes, such as superstructure chipping, stomatognathic dysfunction, or periimplant bone resorption, were observed in any of the patients.

Discussion

The implant superstructures in patients 1 and 3 were implant-supported cantilever FDPs. The risk of fracture in the frame or veneering porcelain over 10 years was reported to be 3.2% in tooth-supported conventional FDPs[19] and 5.9% in tooth-supported cantilever FDPs.[20] Moreover, veneer fractures represented the most frequent technical complication in implant-supported cantilever FDPs. The estimated cumulative rate of material complications in implant-supported cantilever FDPs was reported to be 10.3% over a 5-year observation period and 19.6% over a 10-year observation period.[21] These figures suggest that cantilever FDPs have a lower survival rate than conventional end-abutment-supported FDPs. Fortunately, no complication was found in the two cases followed up for 3 years, probably because of the high fracture strength of the PAZ system, but continued regular follow-up is necessary for a much longer period.

The 5-year prognosis based on a meta-analysis revealed that frequency of fracture was significantly higher in the veneering porcelain of implant-supported FDPs than in tooth-supported FDPs (8.8% vs. 2.9%).[22] These differences in fracture rate in implants vs. natural teeth may be because implants lack periodontal ligament and therefore lack the function of corresponding neural feedback structures.[23,24] The sensation threshold for implants is reported to be 8.75 times higher than that for natural teeth.[25] More specifically, not only is the cushioning mechanism of periodontal ligament missing, but the associated mechanoreceptors are also missing, resulting in reduced ability to adjust the bite force. Therefore, fracture of the veneering porcelain on implant-supported FDPs might be an unavoidable complication. When fracture occurs, clinicians need to replace the FDPs with temporary restorations and the FDPs have to be sent to a dental laboratory for repair. This takes time, requires technical expertise, and impairs patients' quality of life significantly. An implant superstructure that enables easy and quick repair when such complications occur, like our system, which allows easy re-fabrication of the CAD/CAM porcelain crown using prerecorded data, would be clinically significant. However, as no porcelain fracture was observed during the present study period, we could not demonstrate this in our patients.

It should also be noted that FDPs fabricated with our system have higher strength than FDPs with veneering porcelain on the zirconia framework prepared by the conventional manual laboratory technique.[14] Chipping and fractures of porcelain are reported to be caused by conventional porcelain layering and fusing methods, which may result in internal defects.[17] In contrast, machining of porcelain blocks using the CAD/CAM system can create crowns that maintain a high level of strength with no internal defects. In addition, advances in the adhesive material confer the advantage of better reinforcement of the ceramic. Although the study period was not very long, this might be why no mechanical complications such as chipping or fracture were observed in this study.

Lastly, this study described clinical application of the PAZ system and reported successful management of three patients using this system for 2 to 3 years. We intend to continue reviewing the present patients, increase our sample size, and optimize our fabrication techniques with the aim of improving long-term stability and prognoses. In the future, the long-term treatment outcome should be evaluated by well-designed clinical research.

Conclusion

Within the limitations of this clinical report, PAZ may be a potential solution for ceramic-related clinical problems, such as chipping and fracture and associated complicated repair procedures in implant-supported FDPs.

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