Management of non-restorable maxillary premolars with immediate implants, immediate provisional restorations, and definitive screw-retained CAD/CAM zirconia abutment crowns: a report of five cases

ABSTRACT
Replacing a non-restorable maxillary premolar with an implant has always been a clinical challenge. This article shows how a good outcome was obtained in five cases by following a new protocol using an immediate implant and an immediate provisional restoration, followed by a definitive screw-retained computer-assisted design and computer-assisted manufacturing (CAD/CAM) zirconia abutment crown. Using this technique, the clinician can replace the tooth immediately, preserve hard and soft tissue architecture, and achieve a good esthetic outcome. The screw-retained zirconia abutment crown eliminates the abutment-to-crown interface and allows retrievability for esthetic improvement and maintenance.

Key words: Computer-Aided Design; Dental abutments; Dental implants

Introduction
When a maxillary premolar becomes non-restorable due to vertical fracture or extensive caries, extraction followed by immediate implant placement is one of the usual options. Even where there is established bone loss or infection, poor periodontal support, endodontic failure, internal or external root resorption, weak or short roots, implant treatment should also be discussed with the patient and seriously considered.

The original protocols for implant installation recommended that an implant be placed in the healed edentulous ridge and submerged, for 3 months in the mandible and 6 months in the maxilla, for osseointegration before uncovering. Where the patient has a failing tooth in the esthetic zone planned for implant treatment, however, the clinician should decide when to install the implant. Conventionally, a period of 3 to 4 months after tooth extraction is needed for socket healing and bone remodeling before implant placement. Such a delay may lead to 23% of bone resorption in the anterior maxilla during the first 6 months, something particularly undesirable in the esthetic zone, where resorption of the buccal plate may increase the chance of recession and loss of the papilla. In 1989, Lazzara began to place implants.
immediately after extraction in order to preserve bone at the site of implantation. Becker et al.\textsuperscript{5} reported a 5-year cumulative survival rate of 94% for implants placed at the time of extraction with expanded polytetrafluoroethylene for augmentation. Nevertheless, for implants placed under suboptimal conditions such as in dehiscence or fenestration defects, the 5-year cumulative rates were much lower, at about 77% and 84% in the maxilla and mandible, respectively. The form and biotype of the periodontium, the level of gingival margin and the underlying osseous crest of the failing tooth often affect the esthetic outcomes of implant treatment.\textsuperscript{6} If the gingival and osseous architecture of the failing tooth is acceptable, the goal is to maintain the existing condition.\textsuperscript{7} With improvements in implant design and surface treatment, and a better understanding of bone biology, immediate implant placement followed by immediate provisionalization has been shown to be predictable. This requires proper diagnosis and treatment planning, and adherence to sound biological principles. If this is done, the functional and esthetic outcomes can be highly satisfactory for both patients and clinicians.\textsuperscript{8-11} In addition, the immediate placement of a fixed provisional restoration can minimize the emotional trauma of losing a tooth and eliminate the need for a removable provisional prosthesis.

With careful planning, the trajectory for an implant replacing a premolar can allow a screw-retained restoration to be fabricated in most cases. Screw-retained restorations eliminate the cement layer, require minimal occlusal clearance from the opposing dentition, and provide retrievability for maintenance and the possibility of connection to future implants.\textsuperscript{12} Computer-assisted design and computer-assisted manufacturing (CAD/CAM) technology has enabled the custom-made zirconia (ZrO\textsubscript{2}) abutment with transmucosal collar and gingival margin to adapt precisely to the peri-implant soft tissue. Zirconia abutment eliminates the metallic gray shadow through the buccal gingiva and allows direct veneering with porcelain to build up the clinical crown. The CAD/CAM zirconia abutment crown thus has superior biocompatibility, esthetics, and retrievability.

Materials and methods

Patient selection

From November 2006 to January 2008, patients who required a single maxillary premolar extraction and agreed to have immediate implants were recruited. All patients were in good general health and had no contra-indications to oral surgery.

Exclusion criteria

Patients who were smokers, had acute infection around the tooth, insufficient bone to support an implant, or no intact buccal plates after tooth extraction were excluded. Patients were also excluded if the screw access hole could not be confined within the occlusal table, or the inserted implant did not have adequate primary stability (insertion torque <32 Ncm).

Preoperative preparation

Preventive and restorative treatments were completed before implant treatment. In addition to the standard radiographic assessment using orthopantomography and periapical radiography, cone-beam computed tomography (CT) [EPX-Impla, E-Woo, Korea] was taken in patients with possible anatomical complications. The anatomy was studied and the implant position was planned with Proceras Clinical Design Premium (Nobel Biocare AB, Göteborg, Sweden). Treatment options were discussed with each patient and an informed consent was obtained.

Implant surgery and provisionalization

Bone sounding was performed under local anesthesia to assess the height of the osseous crest. The premolar was extracted atraumatically with a periotome, leaving the buccal plate intact. A NobelReplace Tapered Groovy Regular Platform implant Ø 4.3 mm (Nobel Biocare AB, Göteborg, Sweden) was installed, and the insertion torque was measured. The implant (collar) shoulder was placed at about 3 to 4 mm apical to the predetermined mucosal margin to respect the biological width.\textsuperscript{14,15} The gap between the implant and the socket wall was augmented with deproteinized bovine bone mineral (Bio-Oss, Geistlich AG, Wolhusen, Switzerland) to support the buccal plate and the soft tissue contour.\textsuperscript{13,16} An Immediate Temporary Abutment (Nobel Biocare AB, Göteborg, Sweden) was attached and a provisional restoration, using Luxatemp (DMG, Germany) and StarFlow flowable composite (Danville, USA), was fabricated at the chairside. It was then highly polished before cementation with TempBond NE (Kerr, USA). A periapical radiograph was taken to ensure complete removal.
Management of non-restorable maxillary premolars of the cement. The occlusion of the provisional was adjusted to avoid any occlusal contact in centric occlusion or excursions.

Screw-retained CAD/CAM zirconia abutment crown

The patients were reviewed after 3 months for definitive restoration. The soft tissue health, contours and the emergence profiles were assessed; the provisional restorations were modified if necessary. The implant stability quotient (ISQ) was measured with the Ostell Mentor (Integration Diagnostics AB, Göteborg, Sweden). A polyether Impregum F impression (3M ESPE, USA) with open-tray impression coping was taken at the fixture level. A full-contour wax pattern of the final restoration was made over the fixture-level Titanium Temporary Cylinder (Nobel Biocare AB, Göteborg, Sweden). The wax pattern was cut back for veneering porcelain and then scanned with a Procera Piccolo scanner (Nobel Biocare AB, Göteborg, Sweden). A Procera zirconia abutment was fabricated by the Procera manufacturing facility using the CAD/CAM technique. NobelRondo Zirconia veneer porcelain (Nobel Biocare AB, Göteborg, Sweden) was applied in layers onto the abutment to form the clinical crown with a 1-mm submucosal margin (Figure 1). At the insertion appointment, the accurate seating of the restoration was verified with a periapical radiograph using a long cone, paralleling technique with Hawe Film holder (Kerr, USA). The occlusion was then checked and adjusted. After glazing, the Procera zirconia abutment crown was inserted and the abutment screw was tightened to 35 Ncm, using a Manual Torque Wrench Prosthetic (Nobel Biocare AB, Göteborg, Sweden). The screw access channel was temporarily sealed with Fermit temporary filling material (Ivoclar Vivadent, USA). Provided that the soft tissue maturation was satisfactory and there was no screw loosening, the screw access channel was filled with composite resin during the follow-up visit. Patients were asked to use the visual analog scale (VAS) of 10 cm in length to grade their satisfaction with this treatment protocol.

Maintenance care

Individual maintenance care was offered to every patient after implant therapy. The implant stability, peri-implant hard and soft tissue condition, and the zirconia abutment crown were assessed clinically and radiographically; maintenance care was provided as needed.

Results

Five patients (2 males and 3 females; mean age of 51 years) who presented with non-restorable maxillary premolars were successfully treated according to the protocol. All implants were installed with an insertion torque of 45 Ncm. The ISQ measured prior to the implant impression ranged from 64 to 76 (mean, 72). Periapical radiographs taken immediately after abutment crown connection were compared with those taken during follow-up visits. Two assessors measured the mesial and distal marginal bone changes using digital calipers. The marginal bone change ranged from -0.7 mm to +1.6 mm, with a mean of 0.0 mm (Table 1).

Table 1 Patient particulars, implant characteristics, and marginal bone change after abutment crown connection

<table>
<thead>
<tr>
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<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
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<tbody>
<tr>
<td>Gender/age (years)</td>
<td>F/50</td>
<td>F/42</td>
<td>M/54</td>
<td>F/56</td>
<td>M/55</td>
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<tr>
<td>Tooth/reason for extraction</td>
<td>14/Vertical fracture</td>
<td>15/Non-restorable</td>
<td>15/Non-restorable</td>
<td>25/Vertical fracture</td>
<td>25/Vertical fracture</td>
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<tr>
<td>Implant Ø x length (mm)</td>
<td>4.3x10</td>
<td>4.3x10</td>
<td>4.3x10</td>
<td>4.3x16</td>
<td>4.3x13</td>
</tr>
<tr>
<td>Implant stability quotient before impression</td>
<td>76</td>
<td>64</td>
<td>75</td>
<td>73</td>
<td>74</td>
</tr>
<tr>
<td>Follow-up period after abutment connection (months)</td>
<td>18</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Mesial/distal marginal bone change (mm)</td>
<td>-0.4/-0.7</td>
<td>-0.2/0.0</td>
<td>-0.3/-0.1</td>
<td>1.6/0.0</td>
<td>0.0/0.0</td>
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The clinical parameters and patient satisfaction results are shown in Table 2. The mean follow-up period for peri-implant soft tissue was 16 months. The peri-implant probing depths (PPD) were no more than 4 mm at all sites around the implant, and there was no bleeding on probing (BOP) at follow-up appointments. The peri-implant soft tissue was generally well preserved, and had even improved in certain cases. No biological complications were observed. The main prosthetic complication was decementation of the provisional crown in three cases. Two patients were provided with night guards after zirconia abutment crown connection because of signs of tooth wear or a history of veneer porcelain fracture. All patients were very satisfied, with a mean VAS score of 9.8.

**Discussion**

The short-term results presented in this study suggest that the immediate implant, immediate provisional, and definitive CAD/CAM zirconia abutment crown can be successfully applied in selected cases. All five cases had implant restoration in accordance with the preoperative planning using a study cast, conventional radiograph and in one case, a cone-beam CT scan and implant planning software. It must be emphasized that the success of this protocol is highly dependent on careful case selection, treatment planning, and execution of the clinical procedures.

**Immediate implant versus delayed implant**

Hämmerlé et al. made consensus statements at the third ITI Consensus Conference recommending clinical procedures for the placement of implants in extraction sockets. Placing implants immediately after tooth extraction offers the advantages of fewer surgical procedures, reduced overall treatment time, and optimal availability of existing bone. There are disadvantages however, namely, (1) site morphology may complicate optimal placement and anchorage, and (2) a thin tissue biotype may compromise optimal outcome. Kan et al. studied the effects of facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration. Although their 1-year results showed an implant success rate of 100%, labial mucosal recessions of greater than 1.5 mm were noted in 8.3% of V-shaped, 42.8% of U-shaped, and 100% of ultra–U-shaped osseous defects. Therefore, the osseous crest should be carefully evaluated preoperatively. In patients with pre-existing osseous defects and thin biotypes, delayed implant placement with adjunctive augmentation would be preferred. Thus, patients with buccal osseous defects were excluded from the present study.
Although the bone gap between the implant and the socket wall after immediate implant placement should heal with new bone formation, substantial external bone resorption was found on both buccal and lingual aspects of the ridge. Such resorption of the buccal osseous crest may result in recession of the peri-implant mucosa and thus adversely affect the esthetic outcome. Chen et al. showed that bone graft with slow resorption rate such as Bio-Oss significantly reduced horizontal resorption of the buccal...

Figure 3  Case 2: (a) Tooth 15 extraction due to failed post/crown; (b) 18 months after implant surgery. Note superior esthetics compared to 14 ceramo-metal crown and preservation of soft tissue architecture. Mucosal margin moved coronally to planned position in accordance with 3-dimensional positioning of implant.

Figure 4  Case 3: (a) Tooth 15 extraction due to failed post/crown; (b) 16 months after implant surgery. Note loss of tip of interdental papilla and slight coronally positioned buccal mucosal margin. Note Procera alumina crown on 14. Both all-ceramic crowns showed good esthetics.

Figure 5  Case 4: (a) Tooth 25 extraction due to vertical fracture; (b) 15 months after implant surgery. Note well-preserved soft tissue architecture.

Figure 6  Case 5: (a) 25 extraction due to vertical fracture; (b) 9 months after implant surgery. Note well-preserved soft tissue architecture.
bone. Recently, Botticelli et al. 25 reported that implant sites located adjacent to the teeth showed bone gain during a 5-year period, and most bone-level change occurred during the first 12 months after cementation of the prosthesis. The bone-level changes (Table 1) and the stable buccal mucosal margin (Figures 2-6) observed during the initial period in our study concur with data from the above prospective studies.

Criteria for immediate provisional

In a critical review of immediate implant loading, Gapski et al. 26 stated that: (1) immediate implant loading can achieve similar success rates as those reported in the delayed two-stage approach, and (2) primary implant stability is a key factor to consider before attempting immediate implant loading. Ottoni et al. 27 conducted a randomised controlled trial to study the correlation between placement torque and the survival of single-tooth implants replacing non-molars. Implants were restored with provisional crowns to receive occlusal loading within a 24-hour period. In the experimental group, nine out of 10 implants placed with an insertion torque of 20 Ncm failed, whereas only one of the 10 implants placed with an insertion torque of 32 Ncm failed. Hence, immediate loading in single-tooth replacement should only be considered if an insertion torque of greater than 32 Ncm can be achieved. The stability of the implant can also be verified objectively using a resonance frequency analysis (RFA). Meredith et al. 28 applied RFA to measure implant stability. A reduced value is related to a decrease in stiffness, indicating a potential implant failure. Becker et al. 29 placed 73 implants in 52 patients at the time of extraction with the initial stability measured by RFA. The mean ISQ value at implant installation was 62, while the value after 1 year was 64. At 2 to 3 years, the cumulative survival rate was 97.2% 28.

In this study, an insertion torque of ≥32 Ncm was used as a criterion for immediate provisionalization, while an ISQ value of ≥64 was used as a criterion for definitive zirconia abutment crown connection. By preparing a slightly undersized osteotomy site, good primary stability could be achieved, even when implants of only 10 mm in length were used (Table 1). Since there may be a higher risk of failure with immediate implants and immediate provisionalization, a temporary cement with low tensile strength was used 30. Although decementation may cause inconvenience to the patient, it may help to protect the implant from excessive loading.

Screw-retained CAD/CAM zirconia abutment crown

Zirconia is an excellent biocompatible material with mechanical properties similar to those of metal. When a zirconia surface is stressed, a crystalline modification opposes the propagation of cracks; thus zirconia can achieve a compression resistance of about 2000 MPa 31. Zirconia stabilized with yttrium oxide (Y2O3) exhibits a high bending strength (900-1200 MPa) and a high fracture toughness. Its average grain size of 0.5 μm allows a surface roughness as low as 0.008 μm 32. Zirconia has been used as a core material for all-ceramic single crowns and fixed partial dentures with promising results 33. When zirconia is used for abutment fabrications, the fracture rate is similar to that of their titanium counterparts 34. Its color enables better mucogingival esthetic outcomes. Reporting on their 4-year prospective clinical study, Glauser et al. 35 concluded that zirconia abutments offered sufficient stability to support single crowns in anterior and premolar regions. The soft and hard tissue reactions toward zirconia were also favorable. This might be explained by lower bacterial adhesion to the zirconia surface compared to that of titanium 36. A lower rate of inflammation-related processes was found in the peri-implant soft tissues around the zirconia healing caps than the tissues around the titanium ones. Lower intensities of nitric oxide synthase expression also indicated lower amount of bacteria around zirconia 37.

The Procera zirconia abutment crown can provide beauty, strength, and biocompatibility. The NobelRondo Zirconia veneer porcelain fired directly onto the zirconia abutment has good bond strength and is well supported 38. Since no coping is required, there is greater freedom to design the crown and the requirement for interocclusal clearance is reduced. The laboratory time and cost of fabrication of the coping are also reduced. The screw-retained connection allows retrievability, and eliminates the cement layer and potential irritation due to subgingival cement residue. The transmucosal collar of pure zirconia has excellent biocompatibility for optimizing soft tissue health. The emergence profile can be fabricated in exact accordance with the soft tissue cast captured from
the impression. The color of the abutment eliminates the metallic gray shadow showing through thin mucosa. Where the soft tissue recedes and the zirconia is exposed, the screw-retained crown can be retrieved for the addition of veneering porcelain.

Although a screw-retained prosthesis offers retrievability, which is advantageous for maintenance, replacement, or salvaging of the implant restoration, it does affect the occlusion and the esthetics. Hebel and Gajjar stated that the 3-mm diameter of the screw access hole was unesthetic and might occupy more than 50% of the occlusal table of the premolar. In our study, the screw access channel measured only 2.5 mm in diameter. The white zirconia screw access channel can be filled with opaque composite yielding reasonably good esthetics for the maxillary premolar.

Ultimately, the success of any treatment depends on patient satisfaction. Under the above protocol, patients underwent only one surgical appointment, left the clinic with a fixed provisional restoration, and received a retrievable, definitive esthetic crown in 3 to 5 months. This may explain why all five patients in the study were highly satisfied with their outcomes.

Conclusion

A protocol for the replacement of non-restorable maxillary premolars with immediate implants, immediate provisional restorations, and definitive screw-retained CAD/CAM zirconia abutment crowns has been presented. It follows biological principles to ensure the best possible preservation of bone and gingival architecture. With advances in ceramics, imaging and CAD/CAM technology, this treatment is highly predictable, biocompatible, esthetically pleasing, and allows easy maintenance. It also addresses the patient’s desire for good esthetics and immediate function. Nonetheless, long-term follow-up and more clinical studies are required to fully evaluate this treatment modality.

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References


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