The Conometric Concept: Coupling Connection for Immediately Loaded Titanium-Reinforced Provisional Fixed Partial Dentures—A Case Series

Marco Degidi, MD, DDS¹
Diego Nardi, DDS¹
Adriano Piattelli, MD, DDS²

The aim of this prospective study was to demonstrate the feasibility of the conic coupling connection as a novel approach for the retention of immediately loaded, titanium-reinforced, temporary fixed partial restorations. The patients received a fixed, immediate partial restoration, attached using the conic coupling connection to two implants placed in a fresh extraction socket. Changes in marginal peri-implant bone level or probing depth measurements, biologic or technical complications, and any other adverse event were recorded at yearly follow-ups up to 3 years after implantation. A total of 78 implants placed in 39 patients reached the 3-year follow-up. A trend of bone overgrowth over the implant platform (mean: 0.2 mm) and a complete fill of the vertical gap between the implant platform level and the first point of contact of the bone with the implant surface was seen after the 6-month follow-up. No disconnection of any prosthesis was noted during 3 years of full occlusal function. The results of this study suggest that titanium-reinforced, temporary partial restorations with conic coupling retention supported by immediate implants provide a successful, cost-effective treatment modality. Int J Periodontics Restorative Dent 2016;36:347–354. doi: 10.11607/prd.2428

A debate exists within dentistry over the optimal connection between a fixed restoration and an implant. A recent systematic review¹ concluded that no statistically significant difference was found between cement- and screw-retained restorations in terms of survival or failure rates. Screw-retained restorations exhibited fewer technical and biologic complications overall, and the failure rate of cemented restorations was not influenced by cement choice. The screw-retained approach is cost effective, as it facilitates prosthesis retrieval without the risk of damaging the prosthesis. Conversely, the presence of excess cement in cement-retained restorations has been associated with a higher incidence of peri-implant disease² and bone loss.³ The proposed use of a vent hole⁴ would reduce the volume of cement at the margin during cementation but would not, however, eliminate the problem. Furthermore, the access opening may weaken the restoration and compromise the esthetics. The access hole of a screw-retained restoration also creates a weak spot in the ceramic surface that, over the long term, can cause a statistically significant increase in ceramic fractures when compared with the cemented approach.⁵ It was demonstrated in the literature that cement-retained restorations without an occlusal screw-access

¹Private Practice, Bologna, Italy.
²Full Professor, Department of Medical, Oral, and Biotechnological Sciences, University of Chieti-Pescara, Chieti, Italy.

Correspondence to: Prof Adriano Piattelli, Via F Sciacchi 63, 66100 Chieti, Italy.
Fax: +39 0871 3554076. E-mail: apiattelli@unich.it

©2016 by Quintessence Publishing Co Inc.
hole showed significantly higher mean fracture loads than those with a hole. The use of conic coupling abutments for the retention of removable prostheses has been well documented in the literature. Recently, Bressan and Lops reported favorable results in a study involving the use of the conic coupling abutments for full-arch fixed prostheses supported by four implants. Bressan et al also concluded in a recent paper that the Morse taper conometric system can provide a fixed connection between the implant and dental prosthesis if adequate insertion force is applied. The aim of this prospective study is to demonstrate the feasibility of the conic coupling connection as a novel approach for the retention of immediately loaded, titanium-reinforced, temporary fixed partial restorations.

Materials and methods

This case series included adult patients planned to receive a fixed titanium-reinforced temporary restoration attached using the conic coupling connection to two 3.5- or 4.5-mm-diameter square-threaded, grit-blasted, acid-etched implants with a Morse taper connection (Ankylos, Dentsply). All implants were to be placed in a fresh extraction socket. The patients were fully informed regarding the scope of the study and gave written consent. The included patients were consecutively treated between January 2010 and June 2011 by one experienced operator (MD) in a private dental office in Bologna, Italy. The study was designed in accordance with the October 2008 revision of the World Medical Association Declaration of Helsinki. All the restorations were designed as three- or four-unit bridges with no natural tooth support. Patients were not accepted into the study if they met any of the following exclusion criteria: (1) presence of active periodontal infection, (2) systemic disease that could compromise osseointegration, (3) treatment with radiation therapy in the craniofacial region within the previous 12 months, (4) smoked more than 10 cigarettes per day; (5) pregnant or lactating; (6) previous treatment with intravenous injection of bisphosphonates, (7) treatment with oral bisphosphonates within the previous 12 months.

Preoperative analysis of anatomical features was performed with panoramic radiographs. Alginate impressions were obtained of both maxillary and mandibular arches, and laboratory casts were made. The shade and mold of the prosthetic teeth were selected, and appropriate wear-resistant commercial denture teeth (VITA PHYSIODENS, VITA Zahnfabrik) were chosen. Three or four teeth were arranged on a cast, mounted on a semiadjustable articulator, and joined with autopolymerizing acrylic resin to create a template. Antimicrobial prophylaxis was administered with the oral use of 1 g beta-lactam (Clavamox, Pfizer) twice daily for 5 days, starting 1 hour before surgery. After administration of profound local anesthesia (2% articaine/adrenaline 1:100,000), the compromised teeth were traumatically extracted to preserve the integrity of the socket (Fig 1). The implants were placed in a subcrestal position using a flapless protocol (Fig 2). During the surgical procedure, the insertion torque and the implant stability quotient (ISQ) were recorded by a surgical hand piece (FRIOS Unit E, W&H) and a digital measurement probe (Ostell AB, Gamlestadsvägen 3B). Patients were excluded from the study if at least one of the following surgical exclusion criteria was met: (1) implant insertion torque < 25 Ncm; (2) ISQ < 60; or (3) any kind of loss of integrity in the socket walls, such as dehiscence, fenestration, or fracture caused by tooth extraction or implant insertion. If none of these exclusion criteria was met, the appropriate standard nonindexed prosthetic abutment (Standard A/Standard B, Dentsply) was connected to the implant. The appropriate length of the abutment was determined by observing the vertical leeway space in maximum intercuspation. Straight or 15-degree angled abutments were selected, depending on implant inclination (Fig 3). In case of angled abutment, the screw was slightly tightened so that the abutment was engaged but free to rotate. The abutments were then rotated using the dedicated parallel gauge until parallelism was achieved (Fig 4). The straight one-piece abutments were then tightened using a calibrated torque wrench applying a force of 25 N. The retaining screw of the angulated abutments was tightened using the same wrench applying a force of 15 N (Fig 5). The polymerization sleeve (Polymerization Sleeve for SynCone, Dentsply)
was placed over the two abutments to protect the soft tissues and avoid the displacement of the relining composite resin. A specifically designed titanium welding coping (Welding Cap for Standard Abutment, Dentsply) was then placed over each abutment and the Morse taper connection was achieved by applying 20 N force twice using a calibrated striker (Abutment Beater, Leone). Once the welding copings were engaged, a 2.0-mm-diameter bar (Titanium Wire D 2.0, Dentsply) made of commercially pure titanium (Grade 2) was shaped with a kit of specific pliers (WeldOne, Ustomed) to be in contact with both copings. The bar was then welded to the two copings intraorally using an electric resistance welding unit (WeldOne, Dentsply) (Fig 6). The framework was then retrieved (Fig 7) and sandblasted. A layer of opaque resin (OVS II Opaque, Dentsply) was applied and the framework was placed again in the oral cavity (Fig 8). The temporary shell was relined over the framework with a small quantity of dual cure composite resin (Combo.lign, Bredent). The restoration was then removed from the oral cavity with a spring bridge remover, relined with composite resin, trimmed, polished, and reinserted (Fig 9). Proper occlusal contacts were confirmed with an 8-µm aluminum foil (Hanel Shimstock, Coltène/Whaledent). The restoration was engaged to the abutments using only the conic coupling, without the use of cement or lingual screws (Figs 10 to 15). No sutures were used. Oral hygiene instructions were provided, and patients were instructed to follow a soft diet for 8 weeks. All the restorations were designed and manufactured to be replaced only in case of major failure or following a specific patient request. In the latter case, the patient was dropped from the study.
Clinical and radiographic evaluation

The following dataset was recorded for each patient.

- Biologic or technical complications or any other adverse event.
- Pocket probing depth measured (round to the nearest mm) at the mesial, buccal, distal and lingual/palatal sites using a periodontal pressure-calibrated (0.25 N) plastic probe (TPS probe; Ivoclar Vivadent).
- Dimensional changes of the bone (rounded to the nearest tenth of a mm) in the post-extractive socket at the mesial and distal sites performed using periapical radiographs taken at each follow-up and a customized positioning jig (Fig 16). Each radiograph was digitized (7600 CS, Carestream Health) and analyzed with a measurement software (Measure 2.0 Build 158, C Thing Software) using platform height and implant length as double cross references. The mesial and the distal measurement for each implant were averaged. The implant was used as statistical unit. Three measurements were taken for each site:
  - The vertical distance between the perpendicular projection of the top of the bone crest and the implant platform.
  - The horizontal distance between the implant surface and the inner wall of the socket at the implant platform level. This measurement had a positive or negative value depending on the presence of a gap (positive) or implant platform bone overgrowth (negative).
  - The vertical distance between the implant platform and the first point of contact of the bone to the implant surface. This measurement assumed a zero value when implant platform bone overgrowth was present.
The frequency of the follow-up was as follows:

- $T_0$: after surgery and fitting of the immediate temporary restoration
- $T_1$: 6 months after surgery
- $T_2$: 1 year after surgery
- $T_3$: 2 years after surgery
- $T_4$: 3 years after surgery

All the measurements were performed by the same observer (N.D.), who was not involved in the surgery. A Shapiro-Wilk test was performed to verify the normality of distribution. The Friedman test followed by a Bonferroni corrected Wilcoxon paired sign-rank test was applied to test the differences between the experimental times. Intraobserver reliability checks were carried out for the radiologic and probing measurements to evaluate the reliability and a possible method error. A random number generator software (QuickCalc, GraphPad Software) was used to select 10 patients, and the complete dataset of measurements was acquired again by the same operator no later than 2 weeks after the first assessment. Reliability tests were performed using the Pearson correlation coefficient. The statistical analysis was performed by an external statistician using a specific software (SPSS 20, IBM).

**Results**

A total of 53 patients that fulfilled the primary inclusion criteria were treated between January 2010 and June 2011. The mean age of the patients at the time of surgery was 44.7 years ($SD = 14.2; n = 53; min = 19; max = 72$). In three of these cases, the postextraction socket was found to be unsuitable due to bone defects detected after the removal of the root. These patients were dropped from the study and underwent a case reevaluation. A total of four implants failed to achieve the desired ISQ value, and two failed to achieve the desired insertion torque. These cases were consequently dropped and

**Fig 14** Panoramic radiograph after 3 years.

**Fig 15** Welding caps.

**Fig 16** Periapical radiographs taken immediately after surgery (left) and at the 3-year follow-up (right).
treated using a delayed one-stage approach. One patient was unsatisfied with the color and shape of the immediate restoration. The temporary prosthesis was then replaced by a metal-ceramic final restoration after 4 months of load following the patient’s request, and the case was excluded from the study. In another case, the lack of parallelism between the two implants was beyond the compensation capabilities of the angled abutments (greater than 30 degrees). This case was consequently excluded and restored using a different prosthetic approach. Another three cases were excluded because they were unavailable for follow-up.

A total of 78 implants placed in 39 patients reached the 3-year follow-up. The average ISQ and insertion torque values of those implants were, respectively, 66.8 Ncm (SD = 4.2; n = 78; min = 61; max = 74) and 47.7 Ncm (SD = 11.7, n = 78; min = 27; max = 68) at the time of the surgery. The measurement results are listed in Table 1. Values of 0.924 mm for the radiologic measurements and 0.821 mm for the probing measurements were reported for the Pearson correlation coefficient.

One patient reported pain and edema associated with an external ecchymosis immediately after surgery. Pain was controlled with 1,000 mg of paracetamol (Tachipirina 1000, Angelini Farmaceutici) twice daily for 5 days, and gradually ceased by 10 days after surgery. Inflammation subsided after 2 weeks with no need for additional treatment.

Two patients reported gingival irritation immediately after restoration delivery. Restorations were removed, carefully modified to reduce pressure on the soft tissue, and reinserted.

Four patients reported small chipping in the occlusal portion of the prosthesis after 15, 23, 26, and 31 months, respectively, of full occlusal load. The bridges were detached, repaired with composite resin, polished, and placed in position again. An average of 30 minutes was needed for these appointments.

### Table 1 Hard Tissue and Pocket Probing Depth Measurements

<table>
<thead>
<tr>
<th></th>
<th>T₀</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
<th>T₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.8</td>
<td>1.2⁺</td>
<td>1.1⁺</td>
<td>1.1⁺</td>
<td>1.1⁺</td>
</tr>
<tr>
<td>SD</td>
<td>0.12</td>
<td>0.11</td>
<td>0.13</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Min</td>
<td>1.6</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Max</td>
<td>2.2</td>
<td>1.5</td>
<td>1.4</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Horizontal distance between the implant surface and the inner wall of the socket at implant bevel level (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.0</td>
<td>−0.2⁺</td>
<td>−0.1⁺</td>
<td>−0.2⁺</td>
<td>−0.2⁺</td>
</tr>
<tr>
<td>SD</td>
<td>0.40</td>
<td>0.37</td>
<td>0.26</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Min</td>
<td>0.3</td>
<td>−0.7</td>
<td>−0.7</td>
<td>−0.6</td>
<td>−0.6</td>
</tr>
<tr>
<td>Max</td>
<td>2.0</td>
<td>0.7</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.1</td>
<td>0.2⁺</td>
<td>0.2⁺</td>
<td>0.1⁺</td>
<td>0.1⁺</td>
</tr>
<tr>
<td>SD</td>
<td>0.42</td>
<td>0.26</td>
<td>0.24</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Min</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>2.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Pocket probing depth measurements (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Media</td>
<td>2.0</td>
<td>1.4⁺</td>
<td>1.2⁺</td>
<td>1.3⁺</td>
<td>1.3⁺</td>
</tr>
<tr>
<td>SD</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Min</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Max</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*Difference from baseline was statistically significant (P < .05).

Discussion

This study analyzed dimensional changes in the postextraction sockets during healing and the first 3 years of function of immediately placed tapered implants using periapical radiographs and pocket probing depth. All the implants were immediately restored with a three- or four-unit bridge with no tooth support. The bone remodeling...
pattern showed excellent filling of the horizontal gap between the implant surface and the inner wall of the socket. A trend of bone overgrowth over the implant platform (mean: 0.2 mm) and a complete fill of the vertical gap between the implant platform level and the first point of contact between the bone and the implant surface was seen after the 6-month follow-up. At the same follow-up, moderate resorption of the bone crest (0.6 mm) was observed. The statistical analysis showed that significant differences ($P < .05$) were present only between baseline ($T_0$) and follow-up ($T_1, T_2, T_3$, and $T_4$). No statistically significant difference was found between the follow-up measurements. The data observed at the first follow-up ($T_1$) were confirmed at almost every subsequent follow-up. After major remodeling activity during the first months after the surgery, the hard tissue around the implants was substantially stable. Pocket probing depth measurements confirmed those assessments. After a substantial reduction in pocket depth following the healing of the socket (~0.6 mm after 6 months), only minor probing changes were found. The bone remodeling patterns seen in this study are comparable with those observed in the test group of a previous study involving the nonremoval of immediate abutments in cases of subcrestally placed immediate tapered single implants. These findings suggest that placement of the final abutment on the day of implantation seems to improve peri-implant tissue stability around single crowns as well as bridge restorations.

To the authors’ knowledge, this is the first report of Morse taper connection for fixed restorations in partially edentulous cases. This novel approach does not incorporate cement or screw retention. Cemented restorations have superior esthetics but are associated with complications related to incomplete removal of luting cement. Screw-retained restorations may present with poor esthetics due to screw access holes, and screw loosening or porcelain fractures may occur. The conic coupling approach has all the advantages of the cemented approach without its limitations, since it is completely cement free. The precision is superior compared with cemented restorations as the bridge-abutment connection is achieved by means of prefabricated components assembled intraorally. Conic coupling is achieved only when the coping is fully seated on the abutment. Incomplete seating of the coping will lead to lack of retention. Care should be taken to avoid soft tissue or bone debris entrapment between the conic components that will prevent complete seating.

The coping engages the coronal part of the standard abutment that has a common design between straight and angled. The prosthodontist may choose between four dimensions of the coronal part of the abutments and the respective conic welding caps. The coronal part is designed with a 5.5-degree taper and is able to compensate for a mild disparallelism without interfering with the conometric retention. The restorations are delivered to the patient as temporary durable prostheses. This concept was presented by the authors in a recent manuscript reporting the performance of full-arch restorations over a 6-year follow-up period. During the years of function the prosthodontist can choose, in concordance with the patient and depending on factors such as surface wear or esthetic requests, whether to keep the immediate restoration or proceed with a new one. The temporary restoration is manufactured with stock components that have several advantages over customized abutments. They are ready-made and immediately available, they are less expensive, and no impression is required. The emergence profile is simply obtained by the crown or bridge design sculpting the soft tissue, as opposed to the digitally designed anatomical abutment. The prosthetic margin can be placed deeper below the gingival margin without risk of undetected cement. Maintenance and hygiene around implant-supported bridges can be challenging. Moreover, repeated screw loosening may cause material fatigue, stripping, or fracture. On the contrary, cemented restorations require additional luting procedures that carry an increased risk of incomplete cement removal. Restorations retained using the conic coupling approach can be removed by means of a spring bridge remover. As already reported by Bressan and Lops, maintenance and check-up can be easily performed and the bridge can subsequently be tapped back in position. Although no disconnection of any bridge was noted
during 3 years of full occlusal function, the chance of an undesired dislocation cannot be ignored. Further studies are needed to determine the pull-out forces of the welding caps, especially if the conic coupling approach is to be used for the retention of single crowns or the restoration of implants that have not achieved optimal primary stability.

Conclusions

The results of this study suggest that titanium-reinforced, temporary partial restorations with conic coupling retention supported by immediate implants provide a successful, cost-effective treatment modality.

Acknowledgments

The authors would like to thank Dr E. Cholakis, Dr J. Tsourounakis, and Dr T. Ntounis for their support. The authors reported no conflicts of interest related to this study.

References