Zirconia Crowns and FDPs with Feather-Edge Margins on Conical Implant Abutments—Up-To-5-year Clinical Retrospective Study

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Purpose: To retrospectively evaluate the survival rate and technical and biologic complications of feather-edge zirconia and metal-ceramic implant restorations cemented on conical titanium abutments. Materials and Methods: Patients rehabilitated with implant-supported single crowns or fixed dental prostheses (FDPs) were divided into four groups: ZR-TL = tissue-level implant with a convergent collar and zirconia restoration; ZR-BL = bone-level implant and zirconia restoration; MC-TL = tissue-level implant with a convergent collar and metal-ceramic restoration; MC-BL = bone-level implant and metal-ceramic restoration. All of the restorations were cemented onto conical titanium abutments and had feather-edge margins, following the biologically oriented preparation technique (BOPT). Crown-level survival rates, technical and biologic complications, and bone resorption were registered. Chi-square test was performed to analyze all evaluated parameters among the groups. Nonparametric Mann-Whitney test was performed to analyze changes in bone level. Results: A total of 85 patients (133 implants, 66 single crowns, and 28 FDPs) were included in the present study with a mean follow-up time of 4.98 years. The overall survival rate was 98.2% for zirconia and 97.5% for metal-ceramic restorations at the crown level. No significant differences were found between the zirconia (ZR-BL and ZR-TL) and the metal-ceramic (MC-BL and MC-TL) groups for technical complications ($P > .05$). Bone resorption was 0.33 (0.37) mm in MC-TL; 0.61 (0.52) mm in MC-BL; 0.39 (0.51) mm in ZR-TL; and 0.77 (0.64) mm in ZR-BL, showing significantly greater bone loss in bone-level implants ($P = .011$). Conclusion: Zirconia implant restorations with feather-edge margins seem to be a viable alternative in cases of both tissue-level and bone-level implants. Int J Prosthodont 2022;35:380–386. doi: 10.11607/ijp.7426

Ceramic materials, especially zirconia, are commonly used nowadays in dental implant restorations due to their optimal mechanical and esthetic properties.1–4 To stabilize the implant-abutment connection, zirconia or lithium disilicate crowns are typically used with individual titanium abutments. A straightforward computer-aided manufacturing (CAM) process has directed the material choices to titanium base restorations; ie, hybrid abutments where ceramic crowns are cemented onto titanium implants.5,6 Existing clinical studies with 1 to 3 years of follow-up show high survival rates for zirconia and lithium disilicate crowns on titanium bases.7–9 However, the design of the hybrid abutment seems to be related to a higher risk of biologic complications.7,10 Moreover, the durability of the ceramic materials is based on the support from the shoulder preparation in tooth-supported restorations and the titanium implant abutment or titanium base in implant-supported restorations in order to avoid technical
complications. Limitations in material thickness exist due to the brittle nature of ceramic materials. For zirconia restorations, material thicknesses < 0.5 mm can be prone to framework fractures. A recent in vitro study presented high load-bearing capacities of ultrathin zirconia tabletop restorations supported by an underlying tooth structure. However, ceramic margins in feather-edge–type restorations could be at risk of fracture. Moreover, technical complications (including chipping and fracture of the ceramic restoration) are more common in implant rehabilitations compared to tooth-supported rehabilitations due to the lack of the shock-absorption capacity of the periodontal ligament.

The so-called biologically oriented preparation technique (BOPT), without a finishing line on the preparation, was introduced for tooth-supported restorations in order to gain soft tissue stability and favorable esthetic results. BOPT restorations provide feather-edge margins, and soft tissue stability can be achieved by a minimally invasive preparation technique, as well as by avoiding gingival retraction and horizontal overcontouring of the crown. A randomized controlled trial with 5 years of follow-up showed 100% survival of tooth-supported zirconia FDPs manufactured following the BOPT. In implant restorations, the same kind of design can be achieved by using conical abutments. The BOPT design allows more space for peri-implant soft tissues and can positively affect peri-implant mucosal sealing and supracrestal tissue attachment. The dimensions of the crown itself are different due to the smaller diameter of the conical abutment compared to the abutment tooth in tooth-supported restorations. For the individual emergence profile of the implant-supported crown, the crown structure might have thicker margins (Figs 1 and 2). However, the crown is fitted with a feather-edge–type design to a conical abutment, without any supporting shoulder. A 3-year prospective study on tissue-level implants with zirconia conical abutments and lithium disilicate crowns showed a survival rate of 100%, without any technical or biologic complications. Additionally, recent systematic reviews concluded that concave/convergent implant transmucosal profiles result in less marginal bone loss and good soft tissue response.

There is a lack of long-term clinical data for zirconia restorations with feather-edge margins on conical implant abutments. Therefore, the aim of this retrospective study was to assess the survival rate, as well as the technical and biologic complications, of zirconia (ZR) implant crowns and fixed dental prostheses (FDPs) cemented on conical titanium abutments and to compare these findings to metal-ceramic (MC) crowns and FDPs cemented on conical titanium abutments. The null hypothesis was that zirconia restorations with feather-edge margins present a lower survival rate and more complications than metal-ceramic restorations.
The current retrospective study was performed in a private clinic in Rome, Italy, where all patients treated by the same operator (L.C.) between January 2012 and June 2017 were consecutively enrolled. Each included patient was asked to sign an informed consent, and the study was conducted in compliance with the Declaration of Helsinki.

The inclusion criteria were:
- Patients who were 18 years of age or older
- Patients in good health (American Society of Anesthesiologists [ASA] Class I or II)
- Patients with an implant-supported restoration in function for at least 6 months
- Patients with a healthy periodontium (probing pocket depth [PPD] ≤ 4 mm, no bleeding on probing [BoP])
- Patients rehabilitated with single- or multiple-implant–supported restorations (partial rehabilitations) were included in the present study and divided into four groups according to the type of implant restoration chosen at the moment of implant placement:
  - ZR-TL = tissue-level implant (Prama, Sweden & Martina) with convergent collar and feather-edge zirconia crown or FDP veneered with lithium disilicate (Fig 1).
  - ZR-BL = bone-level implant (Premium Khono, Sweden & Martina) with convergent titanium abutment and feather-edge zirconia crown or FDP veneered with lithium disilicate (Fig 2).
  - MC-TL = tissue-level implant (Prama) with convergent collar and feather-edge metal-ceramic crown or FDP.
  - MC-BL = bone-level implant (Premium Khono) with convergent titanium abutment and a metal-ceramic crown or FDP.

While the metal-ceramic crowns and FDPs followed the traditional technical workflow, the zirconia restorations were fabricated using a CAD/CAM system (Echo, Sweden & Martina) equipped with a scanner (NeWay, Open Technologies; Dots, Sweden & Martina). The FDP and single-crown frameworks were designed by using a software program (Exocad, Sweden & Martina) with an anatomical shape and a coping thickness of at least 0.5 mm and connector dimensions of 3 × 3 mm. They were milled from a block of presintered zirconia (Katana 550, Kuraray Noritake) and sintered in a furnace (Nabertherm LHT) according to the manufacturer’s instructions. A circumferential lithium disilicate veneer was then added. The materials are presented in detail in Table 1. Marginal trimming of the crowns and FDPs was performed under a microscope using abrasive diamond burs (Cerapro 8002.040HP, Edenta). The margins were then polished using a titanium polisher (StarGloss R1530HP and R1540HP, Edenta).

Crowns and FDPs in both material groups were cemented using provisional cement (Temp-Bond, Kerr).

The restorations were evaluated at the final hygienic visit by two examiners (L.C. and F.B.). A metallic periodontal probe (PCPUNC15, Hu-Friedy) was carefully run along the crown perimeter to identify marginal chipping of the prosthetic rehabilitation and BoP. BoP was defined as the presence of bleeding (yes/no) evaluated at four points for each implant (mesial, distal, buccal, and lingual). Other technical complications (screw loosening and crown decementations) were registered.

Additionally, intraoral digital periapical films were taken to assess interproximal bone levels using the parallel long-cone technique. The implant body-collar interface was used as a reference point for bone-level measurements. Two examiners (F.B. and G.P.) performed the clinical measurements at the mesial and distal aspects of each implant with CS Imaging 7 software (Carestream Dental). Measurements were compared to intraoral periapical films collected at the time of implant placement surgery. All measurements were collected after a

### Table 1  Description of Study Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Brand name</th>
<th>Manufacturer</th>
<th>Flexural strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold alloy</td>
<td>Keramit 515</td>
<td>Nobil Metal</td>
<td>530–670a</td>
</tr>
<tr>
<td>Feldspathic ceramic veneer for metal-ceramic framework</td>
<td>Initial MC</td>
<td>GC Dental</td>
<td>84</td>
</tr>
<tr>
<td>Zirconia</td>
<td>Katana Zirconia HT</td>
<td>Kuraray Noritake</td>
<td>1,200</td>
</tr>
<tr>
<td>Lithium disilicate veneer for zirconia</td>
<td>IPS e.max press</td>
<td>Ivoclar Vivadent</td>
<td>500</td>
</tr>
</tbody>
</table>

Information about flexural strength was provided by the manufacturers.

*aDue to material ductility, yield strength (MPa) is reported instead of flexural strength.*
calibration exercise demonstrating 95.9% concordance within ± 0.5 mm for measurements.

Variables analyzed in the statistical analysis included patient age, follow-up time, and rehabilitation type (MC-TL, ZR-TL, MC-BL, ZR-BL). The statistical analysis was performed at the crown level. Chi-square test was performed to analyze all evaluated criteria among the groups (screw loosening, decementation, and crown chipping). Nonparametric Mann-Whitney test was performed to analyze differences in bone level. A significance level of 5% was adopted in all tests. SPSS version 25.0 (IBM) was used as the statistical software.

RESULTS

A total of 85 patients (133 implants) were included in the present study with a mean follow-up time of 4.98 years (range 2.25 to 7.89 years). The main demographic information is reported in Table 2. A total of 94 implants were placed in the maxilla, and 39 in the mandible. There were a total of 94 restorations, including 66 single crowns and 28 FDPs. Of the FDPs, 7 had single-unit pontics, and the rest were multiple-unit crowns connected to each other. Of the zirconia restorations, 40 were single crowns and 14 were FDPs; and of the metal-ceramic restorations, 26 were single crowns and 14 were FDPs.

Two restorations (FDPs) were lost: one in the anterior maxilla, in the MC-BL group, due to marginal chipping of the ceramic veneers of 2 crowns at the 2-year follow-up, and another in the anterior maxilla, in the ZR-BL group, due to marginal fracture of the zirconia at the 2-year follow-up (Fig 3). Failed restorations were replaced with similar new ones. The overall survival rate of the restorations was 98.2% for zirconia crowns and 97.5% for metal-ceramic crowns at the time point of the evaluation.

The main clinical outcomes are reported in Table 3. No statistically significant differences were found between the test (ZR-TL and ZR-BL) and control (MC-TL and MC-BL) groups (P = .465) for fracture. Two loose abutment screws were identified in the MC-TL group, and one in the MC-BL group. The difference between the zirconia and metal-ceramic groups was not statistically significant (P = .057). Decementation was seen in one FDP (3 crowns) in the ZR-BL group and in one FDP (4 crowns) in the MC-BL group. There was no statistically significant difference between the test (ZR-BL and ZR-TL) and control (MC-BL and MC-TL) group materials (P = .538), nor among all groups.

In all groups, BoP was maintained below 25%, and PPD was lower than 3 mm. The mean BoP values for groups are summarized in Table 3. Statistical analysis failed to reach any significant difference between groups.

Marginal bone level values among all four groups are reported in Table 3. Greater bone resorption was identified in bone-level implants than in tissue-level implants. A statistically significant difference was identified between the MC-TL and MC-BL (P = .043), the ZR-BL and MC-TL (P = .001), and the ZR-TL and ZR-BL (P = .011) groups. No differences were identified in an overall comparison of the test (ZR-BL and ZR-TL) vs control (MC-BL and MC-TL) group materials.

DISCUSSION

This retrospective study assessed the survival rate and technical and biologic complications of zirconia implant crowns and multiple-unit FDPs cemented on conical titanium abutments and of metal-ceramic crowns and FDPs cemented on conical titanium abutments. On the basis of the results, the null hypothesis (zirconia restorations with feather-edge margins present a lower survival rate and more complications than metal-ceramic restorations) was rejected. No statistically significant differences in the amount of complications were seen among the four groups; however, greater bone resorption

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Descriptive Summary of all Groups</th>
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<tbody>
<tr>
<td></td>
<td>Total Mean (SD) Minimum Maximum</td>
</tr>
<tr>
<td>ZR-TL</td>
<td>Implants, n 44 – – –</td>
</tr>
<tr>
<td>Age, y</td>
<td>– 69 (12) 51 62</td>
</tr>
<tr>
<td>Follow-up, y</td>
<td>– 4.54 2.96 7.89</td>
</tr>
<tr>
<td>MC-TL</td>
<td>Implants, n 42 – – –</td>
</tr>
<tr>
<td>Age, y</td>
<td>– 61 (10) 38 74</td>
</tr>
<tr>
<td>Follow-up, y</td>
<td>– 5.4 3.38 7.89</td>
</tr>
<tr>
<td>ZR-BL</td>
<td>Implants, n 26 – – –</td>
</tr>
<tr>
<td>Age, y</td>
<td>– 66 (16) 48 75</td>
</tr>
<tr>
<td>Follow-up, y</td>
<td>– 5.3 2.25 6.52</td>
</tr>
<tr>
<td>MC-BL</td>
<td>Implants, n 13 – – –</td>
</tr>
<tr>
<td>Age, y</td>
<td>– 66 (18) 40 91</td>
</tr>
<tr>
<td>Follow-up, y</td>
<td>– 4.67 2.92 5.75</td>
</tr>
<tr>
<td>Total</td>
<td>Implants, n 133 – – –</td>
</tr>
<tr>
<td>Age, y</td>
<td>– 65.5 38 91</td>
</tr>
<tr>
<td>Follow-up, y</td>
<td>– 4.98 – – –</td>
</tr>
</tbody>
</table>
was identified around bone-level implants than around tissue-level implants with a convergent neck.

Conical abutments have previously been used with removable overdentures. There are few studies reporting the use of conical abutments in fixed implant-supported restorations. The present study showed high survival rates of zirconia (98.2%) and metal-ceramic (98.3%) crowns supported by metal or zirconia abutments. This systematic review showed that significantly more zirconia ceramic crowns failed due to material fractures. In the present study, a core fracture in one of the zirconia FDPs was identified, while the two failures in the metal-ceramic crowns were seen due to detrimental chipping of the porcelain veneer on the crown margin area. The difference in survival rates of metal-ceramic crowns between the previous review article and the present study could be explained by the support of the restoration structure by the abutment.

**Table 3  Main Clinical Outcomes Among Study Groups**

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>MC-TL (n = 31)</th>
<th>MC-BL (n = 30)</th>
<th>ZR-TL (n = 18)</th>
<th>ZR-BL (n = 53)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Failure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marginal fracture, n</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Marginal chipping of the ceramic veneer, n</td>
<td>–</td>
<td>2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Technical complications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screw loosening, n</td>
<td>2</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Decementation, n</td>
<td>–</td>
<td>4</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td><strong>Biologic complications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD) bone resorption, mm</td>
<td>0.33 (0.37)</td>
<td>0.61 (0.52)</td>
<td>0.39 (0.51)</td>
<td>0.77 (0.64)</td>
</tr>
<tr>
<td>Mean (SD) bleeding on probing, %</td>
<td>0.45 (0.62)</td>
<td>0.5 (0.68)</td>
<td>0.44 (0.62)</td>
<td>0.5 (0.64)</td>
</tr>
</tbody>
</table>
In fact, in the present study, due to the conical shape of the abutment, tension stress caused by masticatory function might have caused the detrimental chippings of the ceramic veneer on the marginal crown area. In the previous retrospective study of zirconia-based single crowns and FDPs with a 5-year follow-up, 3 out of 91 FDP frameworks and 1 out of 65 single-crown frameworks fractured, resulting in a survival rate of 94.2% during the observation period. Some of the framework fractures seemed to occur in the implant connection area, where the framework was thinner. This supports the findings of the present study, where the detrimental fracture was seen on the thin margin of the zirconia framework.

The clinical success of zirconia restorations in the present study is particularly important considering the “digital era” that dentistry is facing. The use of zirconia material, in fact, presents the additional benefit of simplifying the digital workflow, as the crown can be directly milled without any analog phase.

Screw loosening and decementation were recorded as technical complications in the present study. After an estimated 5 years of follow-up, a systematic review revealed that technical complications like screw loosening and decementation were more commonly seen in MC crowns compared to zirconia crowns. A similar trend was also found in the present study, although the differences between the materials were not statistically significant. The differences could be explained by different mechanical and adhesive behavior of metal- and zirconia-based crowns.

During the present study’s average follow-up time of 4.98 years, the mean marginal bone loss was less than 1 mm in both material groups. However, a significant difference was seen between the two implant types; namely, greater marginal bone loss occurred in bone-level implants (0.61 to 0.77 mm). Better outcomes with tissue-level implants (0.33 to 0.39 mm) might be due to the supracrestal position of the implant-abutment junction, which reduces bacterial access in the critical area of the peri-implant connective tissue and crestal bone. However, the clinical relevance of such a small difference must be questioned. A randomized controlled trial did not reveal any difference in marginal bone loss between bone- and tissue-level implants after 1 year of follow-up, showing a mean marginal bone loss of 0.33 mm for tissue-level and 0.53 mm for bone-level implants. On the contrary, another randomized controlled trial with a 4- to 6-year follow-up showed significantly higher mean marginal bone loss for bone-level implants (1.35 mm) compared to tissue-level implants (0.49 mm). However, bone-level implants had an external connection, which could also have affected the MBL values. Bone-level implants with internal connection have shown minimal changes (0.14 mm) in marginal bone levels at 5 years of loading in a prospective randomized controlled trial comparing two different types of implant systems. It must be underlined that tissue-level implants with a convergent collar were used in the present study. Traditional tissue-level implants with a divergent collar might present higher esthetic complications, and, due to the position of the implant shoulder on the soft tissue level, it is not recommended to apply the BOPT technique, as was done in the present study.

The zirconia crowns and FDPs manufactured with a BOPT protocol seemed to be a viable alternative to titanium-base hybrid crowns. The biologic response seemed very good in terms of PD and BoP values, while higher PD and BoP values have been reported already after 1 year of follow-up with titanium-based implant crowns. However, biologic complications could also be a risk when the feather-edge crowns are cemented onto conical abutments. The cementing procedure is relatively technique-sensitive, and removal of the residual cement can be difficult when the abutment-crown profile is concave. In the present study, a small amount of the Temp-Bond cement was used, and no biologic complications were recorded.

Limitations of the present study are mainly linked to its retrospective nature and to the great amount of variables involved (implant type, restorative material, arch, etc.). Future randomized clinical studies comparing the two types of crown materials are needed. Additionally, due to the retrospective study design, technical complications were not recorded according to USPHS criteria—however, the findings could be compared within the present study population.

CONCLUSIONS

Within the limits of the present retrospective study, zirconia implant crowns and FDPs show a high survival rate and seem to be a viable alternative in cases of both tissue-level and bone-level implants rehabilitated according to the BOPT protocol.

ACKNOWLEDGMENTS

The authors declare no conflicts of interest.

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Zirconia Issue


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