Clinical Outcome Study of Customized Zirconia Abutments for Single-Implant Restorations

Luigi Canullo, DDS[a]

Purpose: This study evaluated the clinical performance of cemented customized zirconia abutments. Additionally, the marginal fit between the selected implant components was measured and the clinical gingival response was monitored. ***Materials and Methods:*** Twenty-five patients were consecutively selected for a prospective study of 30 implant-supported single-tooth restorations. Customized titanium post and zirconia abutment complexes were prepared, and scanning electron microscopy (SEM) analysis was used to study bicomponent marginal gaps. The abutments were screwed onto the implants and restored with all-ceramic crowns. Plaque and gingival indices were recorded at 6 monthly intervals over a 36- to 44-month period. ***Results:*** SEM analysis showed mean marginal gaps of 10.161 μm (SD: 0.7) horizontally and 4.783 μm (SD: 0.67) vertically. Abutment fractures and screw loosening were neither reported nor observed throughout the clinical observation period. Mean Plaque Index scores were 0.57 (SD: 0.32) on abutments and 0.74 (SD: 0.34) on teeth, while mean Gingival Index scores were 0.54 (SD: 0.2) on abutments and 0.72 (SD: 0.3) on teeth. ***Conclusions:*** These preliminary results suggest that metallic-zirconia abutments may be comparable to currently available esthetic implant abutments. *Int J Prosthodont 2007;20:489–493.*

New technologies to improve the physical properties and processing of zirconia implant abutments offer the promise of optimized esthetic outcomes and long-term functional results.[1] However, the internal connection between a customized abutment and the implant continues to be a technical challenge.

The aim of this preliminary prospective clinical report was to study the efficacy of a zirconia abutment cemented to an antirotational titanium component attached to the implant. This customized bicomponent approach also permitted additional observations, including laboratory analysis of the marginal fit and clinical gingival response.

[a]*Private Practice, Rome, Italy.*

Correspondence to: *Dr Luigi Canullo, Via Nizza, 46 00198, Rome, Italy. Fax: +39 06 8411980. E-mail: luigicanullo@yahoo.com*

Materials and Methods

Twenty-five patients requiring 30 single implant-supported crowns were selected for the study. The inclusion criteria comprised *(1)* consecutive patient selection and informed consent, *(2)* patients 18 years of age or older with no history of systemic disease or recent (within a 12-month period) therapeutic cranial or cervical radiation, and *(3)* no history of parafunction or presence of any inflammation in the proposed implant site.

The treatment was carried out in a private practice on 14 women and 11 men with an age range of 25 to 70 years (mean age: 52.28 years). Each patient received a bicomponent developmental abutment and a cemented all-ceramic crown. The 30 crowns replaced 6 incisors, 2 canines, 8 premolars, and 2 molars in the maxilla, plus 6 incisors, 2 canines, 2 premolars, and 2 molars in the mandible. Treatment took place between February and November 2003 with a clinical follow-up period of 36 to 44 months and a mean observation period of 40 months.

Fig 1 *(left)* Zirconia closure margin on the metallic abutment (group 1).

Fig 2 *(center)* Zirconia closure margin on the metallic abutment (group 2).

Fig 3 *(right)* Finished plastic abutment.

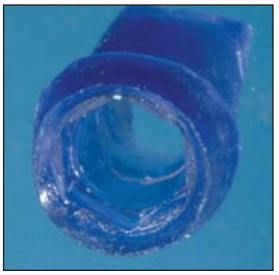

Fig 4 Plastic abutment separated from the component in titanium.

Fig 5 Zirconia abutment made using a computer-aided design system.

Fig 6 Mechanical restraints on the base of the abutment.

Following traditional clinical and radiographic examination protocols, TSA implants (Impladent) were placed according to the standard surgical submerged protocol and using a surgical splint as an implant positioning guide. Each implant was restored with a provisional crown following the second-stage implant-exposure surgery. The crowns were worn for 2 to 3 months to facilitate both the soft tissue response and preliminary esthetic judgment. A modified pick-up impression coping technique was used,[2] and an interocclusal record was registered prior to laboratory fabrication of the abutment and crown.

Thirty titanium connections (ProUnic abutment, Impladent) and zirconia abutment complexes were constructed and divided into 2 groups (n = 15). In group 1, abutments with diameters smaller than the implant platform were used. This permitted the lower margin of the zirconia abutment to be positioned directly on the implant margin (Fig 1). In group 2, the metallic structure occupied the entire thickness of the implant neck, with a more coronal position for the marginal closure (Fig 2). Group 1 abutments were placed in clinical situations with shallow peri-implant platform sulci. Group 2 abutments were used whenever the implant shoulder was surrounded by a deep mucosal sulcies.

Laboratory Procedures

To construct the abutment, a high fluidity photopolymerizable compound (Visioform, 3M ESPE) was used. It was photopolymerized and reduced onto the titanium post in thin layers to achieve its full setting. The finished abutment (Fig 3) was polished to attain the final shape and dimensions. An optical microscope was used to optimize the finishing margins. The quality of the surfaces was then inspected and any necessary corrections were made by adding material to the abutment.

After photopolymerization and finishing of the transmucosal area, the plastic abutment was separated from the component in titanium (Fig 4). A computer-aided design (CAD) system (Zirkozahn) was used to transform the compound into zirconia (Fig 5). "Green"-type zirconia was used to create the abutment because it can be used in its softest form; subsequently, it was subjected to a sintering process to obtain the final framework. During this phase, it was possible to achieve the desired chromatic result by adding dyes to the sintering bath.

After the zirconia cast was fabricated and before moving on to the cementing phase, the abutment was inspected under a microscope to assess the precision

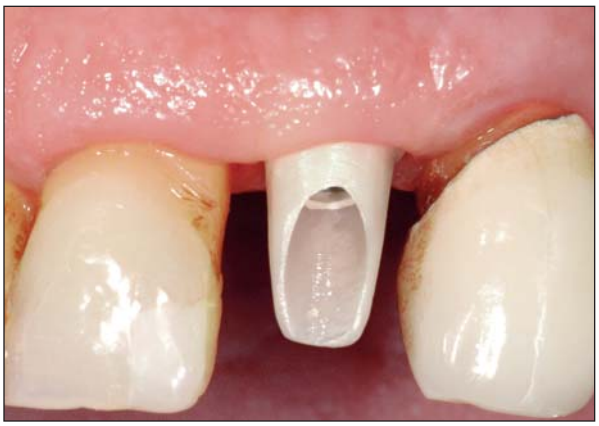

Fig 7 Metallic zirconia abutment (group 2).

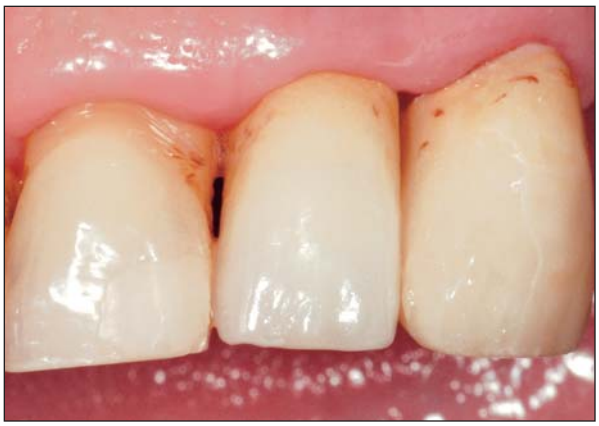

Fig 8 Implant-supported esthetic restoration (group 2).

of the coupling and confirm the absence of any structural defects. Mechanical restraints were fabricated on the base of the titanium abutment to improve the seal of the cement (Fig 6) and then subjected to a sandblasting cycle with alumina dioxide with a granulometry of 150 µ at a pressure of 2 atm. Finally, the components were cleaned with dry air and methylated spirits in an ultrasonic bath. The access canal of the screw was protected with a layer of wax.

The 2 components were joined with anaerobic cement consisting of a base paste and a catalyst at a ratio of 1:1 (Nimetic-Cem, 3M ESPE). After setting, any excess material was removed using a cotton pellet.

Scanning Electron Microscopy

Four randomly selected areas on abutments of both groups were studied using scanning electron microscopy (SEM) (Vega Tescan, Tesca USA) before clinical use. They were analyzed to determine the occurrence and dimensions of vertical and horizontal gaps between the zirconia abutment and implant shoulder (group 1) or metallic core (group 2).

Restorative Procedures

Following the laboratory phases, the components were mechanically screwed at a torque level of 32 Ncm (Fig 7). To ensure controlled cementation of the crown, the abutment screw access channel was filled with a layer of gutta-percha and resin composite. The final restoration (Fig 8) was cemented with resin cement (Panavia TC, Kuraray) and a standardized digital radiograph was taken to evaluate marginal adaptation.

Follow-up visits were scheduled every 6 months. Radiographic and clinical evaluations, including modified Plaque Index (mPI) and modified Gingival Index (mGI) at implants and neighboring teeth, were carried out.[3] Furthermore, every restoration was examined for technical failures, such as implant or crown fracture and component loosening.

Statistical Analysis

Descriptive statistics (mean values and SDs) were used to evaluate the data. Statistical analysis of changes in mPI or mGI over time was performed using the sign test. Using a multivariate statistical technique, a principal component analysis was carried out to evaluate the correlation between the horizontal and vertical microgaps of the abutments and the periodontal indices.

Results

SEM analysis revealed an excellent fit between the titanium support and zirconia abutment. In all samples, extremely low marginal gap values were observed between the zirconia abutment and implant margin (group 1) or titanium connection platform (group 2). Horizontal measurements showed values from 8.963 to 11.65 µm (average: 10.161 µm; SD: 0.700), while the vertical gap of both groups showed values from 3.570 to 7.001 µm (average: 4.783 µm; SD: 0.675) (Fig 9).

No abutment fracture or screw loosening was reported during clinical loading, resulting in a cumulative survival rate of 100%. On one crown, minimal marginal porcelain chipping was observed at the 1-year follow up. In this case, polishing of the fractured area was an adequate solution.

The mean mPI was 0.57 (SD: 0.32) on abutments and 0.74 (SD: 0.34) on teeth. The mean mGI was 0.54 (SD: 0.2) on abutments and 0.72 (SD: 0.3) on teeth. There were no statistically significant differences ($P > .05$) regarding periodontal indices when implant sites and

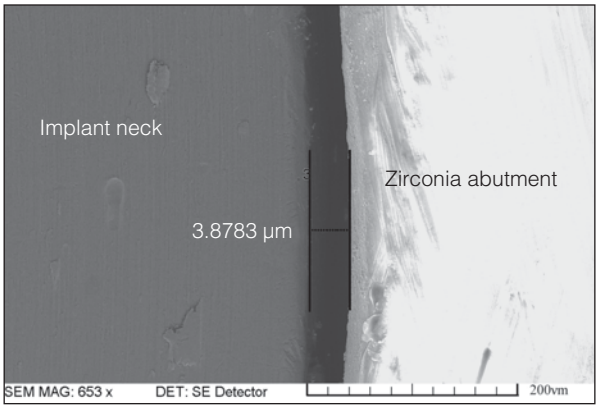

Fig 9 SEM analysis: vertical gap between the implant neck and zirconia abutment.

neighboring teeth were compared at baseline and at the final follow-up. The principal component analysis showed a statistically significant correlation between abutment microgaps and periodontal indices.

Discussion

Die-cast integral ceramics offer solutions to the esthetic problems associated with the use of metallic abutments and compensate for the fact that ceramic materials are not fully suitable to bear occlusal loads in the posterior areas.

The introduction of CAD/computer-assisted manufacture (CAM) systems, in addition to the use of materials like zirconia and alumina oxide, has helped improve the mechanical properties of the prostheses without altering their esthetic characteristics.[4]

In this prospective study, the marginal fit and preliminary clinical behavior of a new abutment with internal connections were studied. This component consists of a metallic post and zirconia abutment joint with an anaerobic cementing system. Use of a metallic core for an esthetic abutment permits an internal connection system with acceptable precision. Current literature suggests that it is possible to create completely "metal free" abutments for the external hexagon connecting implant system.[5,6]

In vitro experimentation was based on SEM analysis and mechanical resistance tests. In the SEM analysis, the measurements of the vertical and horizontal marginal gaps between the zirconia abutment and the metallic support revealed very low values: 10.161 µm (SD: 0.7) horizontally and 4,783 µm (SD: 0.67) vertically. This suggests a low risk for bacterial infiltration and presumably good biocompatibility. In this regard, Volker et al[7] attributed an average value of 5 µm to the horizontal marginal fit among implant components. Despite being a "customized" prosthesis, built according to normal laboratory procedures, the marginal gap of the cast studied is in accordance with the average values of prefabricated connection systems.

From a clinical point of view, Glauser et al[6] showed good behavior of all-zirconia abutments with external connections used for restoration of esthetically demanding regions. They reported no abutment fractures with a low incidence of adverse clinical events such as screw loosening. Andersson et al[8] showed slightly worse results. Their results could be explained by Vigolo,[5] who demonstrated that CAD/CAM technology allows the creation of a zirconia abutment with about 3 degrees of rotation on the external connection. In response, Gehrke et al[9] showed a direct correlation between hexagon misfit and screw loosening or ceramic fracture.

In the present study, no fractures or screw loosening were recorded, with a survival rate of 100%, even though a high percentage of posterior teeth were restored. Hence, it may be speculated that by using bicomponent abutments with internal connection, adverse technical events are reduced in the posterior regions. Nevertheless, further long-term studies with a larger sample size are needed to support this speculation.

The mPI and mGI indicated healthy soft tissue conditions at neighboring teeth and zirconia abutments. Esthetic components performed slightly better than natural teeth, with no statistically significant differences at any follow-up period. This favorable soft tissue reaction to ceramic abutments is in line with similar studies on implant-supported restorations and could be correlated to the optimal biocompatibility of zirconia and the acceptable marginal gap of this experimental device.[10–13]

Overall, the clinical and technical results from the present study suggest that the use of zirconia for this kind of abutment fabrication offers several advantages. The material is characterized by superior physical properties and allows radiographic visualization.[14,15] Further, as opposed to prefabricated esthetic abutments, it is possible to color the custom-made bicomponent abutment before zirconia stabilization, thus enhancing the esthetic results. Finally, it is possible to modify and individualize the emergence profile.

Conclusions

The aim of this study was to investigate whether a new esthetic abutment can be used in both anterior and posterior sites. Within the limitations of this study (small sample size), it was demonstrated that the gap present

in the zirconia core-metallic abutment system is comparably compliant with the main gap values of the abutment-implant systems available on the market, despite being a laboratory product. Further clinical and comparative studies between the mechanical capabilities of this system and those of commercially available esthetic abutments are encouraged.

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