Randomized Clinical Trial on Single Zirconia Crowns with Feather-Edge vs Chamfer Finish Lines: Four-Year Results

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The objective of this study was to evaluate the influence of two finish lines on the fracture resistance and periodontal response of porcelain zirconia crowns. Ethical committee approval was obtained, and 50 zirconia single crowns were placed in posterior regions. Abutments were randomly distributed into two groups: Group 1 (feather-edge preparation) and Group 2 (chamfer preparation). Patients were recalled after 1 month, 6 months, and 1, 2, 3, and 4 years. The function, esthetics, and marginal adaptation of the restorations were evaluated. Bleeding on probing (BoP) and distance of margins from the bone crest were recorded. Statistical analyses were performed for survival and success rates. Group 1 had an 80% success rate (21/25 crowns) and a 96% survival rate (24/25 crowns; 1 encountered irreparable fracture of ceramic layer); Group 2 had a 76% success rate (20/25 crowns) and a 100% survival rate (25/25 crowns). Chippings were noticed on 4 crowns in Group 1 (one crown replacement). Five chippings occurred in Group 2, without any replacement. There were no statistically significant differences between the two groups. BoP was found in 18 of the 25 crowns in Group 1 (72%) and in 12 of the 25 crowns in Group 2 (48%). A statistically significant correlation between BoP and the distance of the margin to the bone crest was found. It was concluded that: (1) clinical survival and success rates of the two preparation methods on crowns are not significantly different; (2) due to the statistically significant correlation between BoP and the distance of the margin to the bone crest, margins should be placed at least 3 mm from the bone crest; and (3) higher probability of BoP is expected in cases with feather-edge preparation.


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there is a clear margin outlining this finish line. Consequently, the feather-edge technique leaves an undefined margin, whilst the chamfer results in a clear, defined margin. It has been argued that the choice of the finish line depends on the type of tooth,\(^4\) crown length,\(^11\) existing restorations,\(^11\) distance between adjacent abutments/teeth,\(^11\) location of the margin in relation with soft periodontal tissue,\(^11\) type of planned restorations,\(^11\) type of selected material to fabricate the crown(s) or bridge(s),\(^11\) periodontal health status,\(^3,12,13\) and skill, experience, and preference of the operators.\(^14\) However, there is no clear evidence from clinical trials on the superiority of a specific finish line.\(^10,15\) Carnevale et al\(^6,17\) introduced the feather-edge preparation during periodontal surgery and reported retrospectively on the clinical success of this combined periodontal-prosthetic procedure. Paniz et al more recently designed a randomized clinical trial (RCT) to evaluate the 12-month periodontal response to two subgingival restorative margin designs, reporting that feather-edge preparation was associated with a higher rate of bleeding on probing (BoP) than chamfer preparation.\(^18\) Furthermore, other authors have reported that the type of finish line could also affect the fracture resistance of esthetic crowns.\(^15,19\)

It was, therefore, the objective of this RCT to evaluate the influence of two margin finish lines on the periodontal health and fracture resistance of zirconia single crowns layered with dedicated ceramics. Furthermore, this RCT was designed to evaluate whether the distance between the margin and the bone crest had a direct influence on the periodontal parameters, independently from the type of finish line.

The following null hypotheses were tested: (1) There is no difference between two different finish lines (feather-edge vs chamfer) on fracture resistance; (2) there is no difference between two different finish lines on periodontal tissue health; and (3) there is a direct influence of the distance of the margin to the bone crest on the periodontal parameters, independently from the type of finish line.

Materials and Methods

Study Design

This study was designed as a parallel, single-center RCT to evaluate the effect of two different finish lines of posterior natural abutments on periodontal outcomes and the resistance to fracture of the restoration when loading. This RCT was approved by the Institutional Ethics Committee of the University of Siena (clinicaltrials.gov #NCT020906567) and was conducted according to the revised 2008 Declaration of Helsinki on experiments involving human subjects.\(^20\) The results of this RCT are presented in fulfillment of the CONSORT guidelines.\(^21\)

Participants

Subjects were enrolled at the Department of Prosthodontics of the University of Siena, Italy, between September 2013 and December 2013.

Patients were selected for the study on the basis of the following inclusion criteria: aged 18 years or older with one tooth in need of crowning; no active intraoral or systemic disease; no pregnancy or lactation; smoking fewer than 10 cigarettes/day; in good general health; presenting good oral hygiene and low caries activity; vital or satisfactory endodontically treated tooth with no pathologic signs on the radiograph or clinical symptoms of inflammation; no history of previous periodontal flap surgery; periodontal pocket depth less than 3 mm; BoP and Plaque Index inferior to 20%; no tooth mobility; occlusal function with a natural tooth; possibility to place the margins on sound dental structure; and lack of excessive parafunctional activity leading to an extensive loss of tooth structure, lesions, or cracks.

Conversely, the following exclusion criteria were adopted: addiction to alcohol and/or drugs; psychologically unstable patients; patients with acute symptoms of parafunctional disorders with the necessity of functional pretreatment before prostodontic therapy; patients with systemic life-threatening diseases (physical status corresponding to group IV or higher of the American Society of Anesthesiologists classification); patients requiring hard/soft tissue augmentation; patients with untreated periodontal disease/poor compliance; and teeth with deep intrausalcular restoration.

Fifty consecutive patients (28 females and 22 males) with a mean
age of 45.7 years (standard deviation: 10.2 years) who each needed one posterior layered zirconia single crown in premolar and/or molar regions were selected for the study. A total of 50 posterior teeth were selected: 30 molars (17 maxilla and 13 mandible) and 20 premolars (11 maxilla and 9 mandible). All treated posterior teeth had natural dentition in the opposite arch.

An experienced dental hygienist prepared the patients periodontally, and a first impression was taken with an irreversible hydrocolloid (Aroma Fine Plus, GC) in order to pour the study casts and fabricate the composite-resin temporary crowns. The casts of both dental arches were mounted into a semi-adjustable articulator (Artex, Ammann Girrbach).

Randomization, Allocation Concealment, and Masking Examiners

For evaluating the influence of finish lines on the fracture resistance and periodontal response of porcelain zirconia crowns, each patient was randomly assigned to one of two experimental groups, as follows:

Allocation concealment was performed by opaque sealed, sequentially numbered envelopes. The statistician (P.V.) generated the allocation sequence by means of a computer-generated random list and instructed a different operator to assign a sealed envelope containing the type of finish line (feather-edge [Group 1] or chamfer [Group 2]). The opaque envelope was opened before finish line selection and treatment assignment were communicated to the prosthodontist (M.F.). Blinding of the examiners was maintained throughout all experimental procedures. Abutments were randomly distributed into Group 1 or Group 2, with 25 samples each (Fig 1).

Surgical and Prosthetic Procedures

A single, calibrated examiner (M.F.), blinded to the experimental procedures, assessed all clinical outcomes of the investigation both at the baseline and at the follow-up examinations.

Standardized tooth preparation was performed with occlusal and axial reductions of 1.5 mm and a chamfer or knife-edge finish line, which was placed juxtagingivally. After 1 to 2 weeks, the temporary crowns were removed, a retraction suture silk cord (size OOO) was placed into the sulcus, and the tooth preparations were refined using a stereomicroscope (Zeiss OpMi1, Zeiss) at ×10 magnification, placing the margins 0.5 mm into the sulcus. All internal line angles were rounded. All preparations were made by the same experienced prosthodontist (M.F.). The interim restorations were relined intraorally on the prepared teeth, then smoothed with soft rubbers and polishing cups to obtain an optimal marginal adaptation between the crowns and the soft tissues. Finally, the interim restorations were cemented in the same session with a eugenol-free temporary cement (Freegenol, GC). Patients wore the interim restorations for 3 weeks to allow the soft tissues to recover from any possible preparation trauma and recover a complete health status.
One-step precision impressions were taken using vinyl polyether silicone impression materials (EXA'lence, GC) with custom auto-polymerizing acrylic resin trays (SR Ivomen, Ivoclar Vivadent) made by the same dental technician at least 24 hours before the impression. The impressions were poured using an extra-stone plaster type IV (Fuji Rock, GC) and left to sit for 5 hours to allow the elastic return of the impression material. The impressions were poured using an extra-stone plaster type IV (Fuji Rock, GC) and left to sit for 5 hours to allow the elastic return of the impression material. The composite resin temporary crowns were relined intraorally, then polished and cemented as previously described.

In order to standardize the shape of the experimental copings as much as possible, each framework was waxed-up by the same experienced dental technician, who achieved a minimum thickness of 0.5 mm; then, the copings were scanned by a computer-aided design/computer-assisted manufacturing (CAD/CAM) software (Aadva IOS, GC) and the zirconia cores were fabricated. The porcelain veneering was performed using a ceramic material dedicated to zirconia (Initial Zr-FS, GC), characterized by a special adaptation to the coefficient of thermal expansion of the zirconia frameworks ($9.4 \times 10^{-6} \text{K}^{-1}$). Slow cooling was made in order to dissipate the residual stresses within the bilayered restorations. The pressure layering technique was adopted following the manufacturer’s instructions.

At the intraoral try-in of the bisque bake crown, slight occlusal adjustments were made by a diamond bur when needed, carefully checking the occlusal contacts. The final restorations were finally glazed and then cemented using a glass-ionomer cement (FujiCEM, GC) following the manufacturer’s instructions. The luting agent was inserted into the crowns, and the patients were requested to hold them under occlusal compression until the cement set; after, excess cement was carefully removed.

Follow-up Examinations

Crown cementation time was considered the baseline for data collection. The patients were recalled for follow-up visits after 1 month, 6 months, and 1, 2, 3, and 4 years of clinical service. Function and the esthetics were checked and calibrated at follow-up appointments by two independent examiners (E.F.C. and M.F.) blinded to the group assignment. In order to collect and classify the clinical outcomes, success was defined as the percentage of restorations that remained in situ without any modification; survival was defined as the percentage of restorations that remained in situ with modifications but still under clinical acceptability; and failure was defined as the percentage of restorations that needed to be replaced.22,23

Statistical Analyses

Patient characteristics and clinical variables were balanced between groups. Chi-square test was applied to assess the statistical significance of between-group differences in the 4-year success rate. The level of statistical significance was set at $P < .05$.

A logistic regression analysis was applied to verify whether 4-year BoP at the interproximal level was significantly influenced by tooth type, preparation type, and distance of preparation margin from bone crest level. A separate logistic regression analysis was performed to assess whether 4-year BoP at the buccal site was significantly influenced by tooth type and preparation type.

Data Collection

Data collection included clinical and radiographic measurements and photographs (horizontal format 1:1). An individual x-ray tray was made for each sample tooth of each patient in order to ensure the radio-
Statistical analyses were performed using a statistical package software (SPSS Statistics for Windows, version 21.0, IBM).

Results

The following results were collected at the final follow-up, after the period of clinical service: Group 1 had an 80% success rate (21/25 crowns; 1 had irreparable fractures of ceramic the layer) and a 96% survival rate (24/25 crowns). Group 2 had a 76% success rate (20/25 crowns) and a 100% survival rate (25/25 crowns). Four chippings were noticed in Group 1, but only 1 crown needed replacement after 4 years. In Group 2, five chippings were noted but none needed replacement after 4 years of clinical service (Table 1). All chippings took place at the coronal aspect of sample crowns in patients with evident clinical signs of occlusal wear. One chipping (the catastrophic one) was recorded during the first year of clinical service, two were noted during the second year, two during the third year, and the other four during the fourth year of clinical service. No chipping at the margins was noted in either group.

Statistical analyses of survival and success rates did not show any statistically significant difference (Table 1).

Regarding the periodontal parameters, BoP was present at 4 years in 12 of 25 crowns (48%) in Group 1 and at 18 of 25 crowns (55.5%) in Group 2 (Table 2). A statistically significant correlation was found between BoP and the distance of the margin to the bone crest. When the bone crest was less than 3 mm, a higher probability of BoP was detected. According to the regression analysis, BoP at the interproximal level was significantly dependent on the preparation type \( (P = .004) \) and the distance between the bone crest and the crown margin \( (P < .001) \), while tooth type did not have a significant influence \( (P = .821) \). Conversely, for BoP at buccal sites, neither preparation type \( (P = .721) \), nor tooth type \( (P = .399) \) were statistically significant.

Figures 2 and 3 show the finish line procedures for both feather-edge and chamfer preparations, respectively.

Discussion

The results of this study support acceptance of the first null hypothesis: The fracture resistance of the zirconia crowns made with feather-edge or chamfer margins did not show statistically significant differences between survival and success rates after 4 years of clinical service. Within the limitations of this in vivo study, due to the limited number of specimens tested, it was concluded that all zirconia crowns layered with dedicated ceramics and created with a feather-edge or chamfer finish line demonstrated a similar and acceptable behavior regarding fracture resistance and periodontal response. Despite these similarities, a feather-edge line would allow the use of precise zirconia restorations in abutments for fixed prostheses. Further, preserving a maximum amount of sound tooth structure during tooth preparation for fixed abutments, as is commonly done in feather-edge preparations, might be a less-invasive alternative to a chamfer margin. This would be true not only for periodontally treated teeth\(^{16–18}\) but also in other clinical conditions.

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**Table 1 Four-Year Success and Survival Rates of the Experimental Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Outcome</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Success</td>
<td>Survival</td>
<td>Failure</td>
<td>Total</td>
<td>Significance(^a) ( (P &lt; .05) )</td>
</tr>
<tr>
<td>Group 1</td>
<td>21</td>
<td>24</td>
<td>1</td>
<td>25</td>
<td>A</td>
</tr>
<tr>
<td>Group 2</td>
<td>20</td>
<td>25</td>
<td>0</td>
<td>25</td>
<td>A</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>49</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

\( \text{Group 1} = \text{feather-edge preparation}; \) \( \text{Group 2} = \text{chamfer preparation}. \) Different letters indicate statistically significant differences. \(^a\)Chi-square test.

**Table 2 Four-Year Bleeding on Probing of the Experimental Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Outcome</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BoP Yes</td>
<td>BoP No</td>
<td>Total</td>
<td>Significance(^a) ( (P &lt; .05) )</td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>12</td>
<td>24</td>
<td>24</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>18</td>
<td>25</td>
<td>25</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>49</td>
<td>49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BoP = bleeding on probing; \( \text{Group 1} = \text{feather-edge preparation}; \) \( \text{Group 2} = \text{chamfer preparation}. \) Different letters indicate statistically significant differences. \(^a\)Chi-square test.
such as endodontically treated teeth, vital teeth in young individuals, and teeth affected by caries at the cervical third of the clinical crown.  

There were certain limitations to this study. Only one specific zirconium-oxide–based ceramic CAD/CAM system was evaluated with only one ceramic material dedicated to zirconia. Further clinical investigation is necessary to evaluate the influence of different tooth preparation designs with different total occlusal convergence (TOC) angles on clinical behavior. It would be also necessary to undertake additional studies to determine the clinical risk of delamination of the veneering porcelain if different types of preparation are carried out.  

Though glass-ionomer cement is a very well-known luting material, it was the only one used, and it can be speculated that other cements can reach clinical results similar to this study. It should also be noted that all the crowns included in this study had 360-degree zirconium-oxide margins: the zirconia margins when a feather-edge was used are thinner than the margins obtained when a chamfer was performed, and therefore it might be supposed that these thinner margins can be more easily altered during various clinical phases, such as during scaling procedures at oral hygiene recalls. Further studies should be performed to verify if these small irregularities may influence the BoP of the two types of finish line. On the other hand, a previous study showed that zirconia is unlikely to be altered during cementation and can be the material of choice to make esthetic crowns with a feather-edge finish line.  

The second null hypothesis tested in this study, that there was no difference between two different finish lines on periodontal tissue health, was rejected. Evaluation of the recorded BoP values showed statistically significant differences between the two groups, favoring the chamfer finish line; higher BoP scores were recorded on abutments with a feather-edge line.  

However, it should be noted that the deep position of this finish line into the sulcus and, consequently, its close position to bone crest may result in increased BoP. Because of the revealed statistically significant correlation between BoP and the distance of the margin to the bone crest, it should be clinically advocated that the margins are placed ≥ 3 mm away from the bone crest independently from the type of finish.
line. For that reason, the third null hypothesis tested—that there was a direct influence of the distance of the margin to the bone crest on the periodontal parameters, independently from the type of finish line—was accepted. Differences in patients’ home oral hygiene, which cannot be completely controlled in a study, could be another factor influencing the BoP scores of the two groups.

In accordance with a previous article, CAD/CAM systems were used to achieve good in vivo marginal fit for single-unit crowns made with chamfer and feather-edge finish lines with the advantages of homogeneous standardized materials.31

Within the limitations of this study, it can be stated that clinicians can decide to use either type of finish line for zirconia single crowns, but clinicians should also pay attention to periodontal parameters, as BoP can be correlated with the distance of the finish line from the bone crest, as already demonstrated.32–37

Recently, Ercoli and Caton10 evaluated the literature for evidence that factors related to teeth and dental prostheses play a role in the initiation and progression of gingivitis and periodontitis. In their narrative review, Ercoli and Caton summarized the current evidence regarding the role that the fabrication and presence of dental prostheses and tooth-related factors have on the initiation and progression of gingivitis and periodontitis.10 They pointed out once more that the placement of margins within the supracrestal tissue attachment causes gingival inflammation and possibly recession or pocket formation, and that the intraoral procedures to fabricate fixed prostheses can traumatize periodontal supporting tissue. However, it was evident that despite the existence of many clinical factors that can affect the periodontal tissue health, adequate periodontal assessment and treatment, appropriate instructions and motivation in self-performed plaque control, and compliance to maintenance protocols appeared to be the most important factors to limit or avoid potential negative effects on the periodontium caused by fixed and removable prostheses.10 Given the limited available evidence in humans, it was not possible to determine if the negative effects on the periodontium associated with a violation of the supracrestal tissue attachment by restorative margins are caused by bacterial plaque, trauma, or a combination of these factors,10 as both factors can play an important role.

Fig 3  Group 2. (a) The patient radiograph shows a need for removal of an old crown made with a cantilever on the second premolar. (b) The patient was treated with an implant to replace the missing first premolar, and the single crown was prepared with a chamfer finishing line. (c) Try-in of the two copings. (d) Buccal view and (e) radiograph at the final follow-up.
The high rate of BoP recorded in the present study can be related to the fact that when a margin is located slightly (0.5 mm) into the sulcus, in the interproximal area of posterior teeth and independent from the type of finish line used, the maintenance of healthy periodontal condition is mainly in the hands of the patient and their home plaque control. The clinician must design the margin to make plaque control procedures easier for the patient, and patients should be motivated to properly and regularly perform his/her oral hygiene, including interproximal regions.

Another limitation of this study is that, though a marginal gap of up to 100 to 120 microns can be expected with a higher number of abutments, the presence of a marginal overhang can act as a plaque-retentive factor and cause a qualitative shift toward a subgingival cultivable microflora more characteristic of periodontitis.

In both groups, 10% of patients reported chipping of the crowns, a failure percentage higher than expected. Only porcelain-fused-to-zirconia crowns were used in this study, and all chippings were recorded in patients with signs of occlusal wear. Crown chipping may be correlated with different factors, such as the presence of natural opposing teeth and type of occlusal loading, coping/framework design, surface finishing, thermal misfit of veneering ceramic/zirconia composites, slow heating and cooling of porcelain on zirconia coping, internal surface treatment of coping, type of luting material and marginal gap, hydrothermal degradation, and different clinical conditions and operators.

However, considering the multiple possible causes of chipping, the partial failures in patients of this study might be due to a combination of the mentioned factors. However, more clinical information is needed to point out the use of porcelain-fused-to-zirconia crowns on patients with different occlusal patterns and types of loading.

Indeed, further research must be carried out; for example, concerning the clinical outcomes of chamfer and feather-edge finishing lines in the case of multiple dental restorations, different results can be achieved in multiple abutments due to the insertion method and because less precision can be expected with a higher number of abutments.

Conclusions

According to the results of the present in vivo study and within its limitations, the following conclusions were drawn:

The clinical performances of the zirconia crowns made with feather-edge or chamfer margins showed no differences in survival and success rates after 4 years of clinical service.

A statistically significant correlation between BoP and the distance of the margin to the bone crest was found; thus, both feather-edge and chamfer margins should be placed a minimum of 3 mm away from the bone crest.

A higher probability of BoP can be expected in cases with a feather-edge preparation.

The results of the present clinical study suggest clinicians may use either a feather-edge (vertical) or a chamfer (horizontal) finish line when using zirconia single crowns. However, clinicians must focus their attention on the periodontal parameters, as the type of preparation and its distance from the bone crest are key clinical factors.

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References