Clinical evaluation of an improved cementation technique for implant-supported restorations: a randomized controlled trial

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Key words: abutment design, cement remnants, chamfer, feather-edge abutment, peri-implantitis, shoulderless abutment

Abstract

Background: Cement remnants were frequently associated with peri-implantitis. Recently, a shoulderless abutment was proposed, raising some concern about cement excess removal.

Aim: To compare different cementation techniques for implant-supported restorations assessing the amount of cement remnants in the peri-implant sulcus. Additional aim was to compare the effect of these cementation techniques using two different abutment designs.

Material & methods: Forty-six patients requiring double implant-supported restoration in the posterior maxilla were randomly divided in two groups according to the cementation modality: intraoral and extraoral. According to the abutment finishing line, implants in each patient were randomly assigned to shoulderless or chamfer subgroup. In the intraoral group, crowns were directly seated onto the titanium abutment. In the extraoral group, crowns were firstly seated onto a resin abutment replica and immediately removed, then cleansed of the cement excess and finally seated on the titanium abutment. After cement setting, in both groups, cement excess was carefully tried to remove. Three months later, framework/abutment complexes were disconnected and prepared for microscopic analysis: surface occupied by exposed cement remnants and marginal gaps were measured. Additionally, crown/abutment complexes were grinded, and voids of cement were measured at abutment/crown interface. Related-samples Friedman’s two-way analysis of variance by ranks was used to detect differences between groups and subgroups (P ≤ 0.5).

Results: At the end of the study, a mean value of 0.45 mm² (±0.80), 0.38 mm² (±0.84), and 0.065 mm² (±0.13) and 0.07 mm² (±0.15) described surface occupied by cement remnants in shoulderless and chamfer abutment with intraoral cementation and shoulderless and chamfer abutment with extraoral cementation, respectively. A mean value of 0.40 mm² (±0.37), 0.41 mm² (±0.39) and 0.485 mm² (±0.47) and 0.47 mm² (±0.43) described cement voids at the abutment/crown interface; a mean value of 0.062 mm (±0.03), 0.064 mm (±0.35), 0.055 mm (±0.016) and 0.054 mm (±0.024) described marginal gaps. Statistics showed tendency of intraoral cementation to have significantly higher cement remnants compared with abutments with extraoral cementation groups. At the same time, the presence of voids was significantly higher in case of extraoral cementation. No significant differences between groups for the variable “gap”.

Conclusions: Despite the presence of more voids, extraoral cementation reduces cement excess. However, using low adhesivity cement and careful cement removal, a very limited quantity of cement remnants was observed also in the intraoral cementation.

Implant-supported prostheses can be subdivided into screw-retained or cement-retained. In literature, there is actually no consensus on which of these techniques provide better mechanical or biological performances though advantages and disadvantages have been identified (Wittneben et al. 2014). Screw-retained prostheses are more easily retrievable (for instance, in case of loosening of the retaining screw or chipping of the veneering material) and, due to the reduced vertical amount of space needed, they are more indicated in cases with limited interocclusal distance (Torrado et al. 2004).

Cement-retained reconstructions provide easier passivation on multiple implants.
splinted frameworks, better esthetics (due to the lack of occlusal openings) and lower costs (Michalakis et al. 2003).

On the other hand, literature suggests that, even after a careful removal procedure, some residual cement may remain in the peri-implant sulcus (Chaar et al. 2011; Sailer et al. 2012). The risk of such event increases as the restorations’ margins are located deeper subgingivally (Linkevicius et al. 2011, 2013a,b). Cement remnants have been frequently associated with peri-implant disease (Wilson 2009; Linkevicius et al. 2013a, Korsch et al. 2014), and for this reason, screw-retained restorations have been suggested as a first choice in daily practice by some authors (Brægger et al. 2005).

An original cementation technique for implant-supported restorations has been proposed (Wadhwani et al. 2009) as a mean to reduce cement remnants in peri-implant sulcus: a silicon abutment replica is used as an initial “extraoral” cementation with the purpose to extrude excess cement from the crown, clean it and then place it onto the abutment intraorally to complete setting. An in vitro study (Chee et al. 2013) seemed to confirm the efficacy of the method compared with three other cementation methods. The abutment and crown design may play a role in increasing the risk of cement remnants in the peri-implant sulcus. In fact, to minimize cement remnants, undercuts should be reduced to a minimum (Vindasiate et al. 2013). Recently, a new prosthetic protocol aiming to improve aesthetic outcomes of prosthetic restorations on natural teeth was presented (Loi & Di Felice 2013). This approach is based on a feather-edge preparation of abutment teeth and the gingival adaptation to crowns contours. The same principles and concepts are suggested by the authors for cemented implant restorations through the use of a shoulderless abutment design. However, such geometry presents increased undercuts, raising some concern about the difficulty to completely remove the excess cement.

The aim of the present study was to compare in vivo two different cementation techniques for implant-supported restorations in relation to the amount of cement remnants in the peri-implant sulcus. Additional aim was to compare the effect of these cementation techniques using two different abutment design, chamfer and shoulderless.

The article was written following the CONSORT statement for improving the quality of RCTs.

Material and methods

The present randomized controlled prospective study was performed following the principles outlined in the Declaration of Helsinki on experimentation involving human subjects. All procedures and materials in the present prospective study were approved by the Ethical Committee of the University of Valencia (# H1406287295470).

Patients were required to sign a consent form after being informed about the study. Between Sept 2013 and Sept 2014, according to the power analysis, 46 consecutive patients needing two adjacent implant-supported restorations in the posterior maxilla were selected. Ninety implants (Premium SP, Sweden & Martina, Padua, Italy) were inserted in a two-stage modality.

In all patients, Premium SP implants (Sweden & Martina) were used (Fig. 1).

For every case, after implant osseointegration was achieved (2 months), healing abutments were connected (Fig. 2). After soft tissue healing, a silicon impression was taken at implant level. The working cast was scanned in laboratory (Echo, Sweden & Martina), and prosthetic components were designed and constructed with CAD CAM technology (Echo, Sweden & Martina) (Fig. 3).

Abutment randomization

Every implant in each case was randomly assigned to receive either an abutment with a chamfer finish line or an abutment with a shoulderless [feather edge] design: if the first implant received one kind of abutment design, the second would receive the other design.

Random assignment was performed using a free dedicated software (www.examplerandom.com).
For each implant, two identical titanium abutments and Cr/Co metal frameworks were fabricated: one for the study, the second for the definitive restoration by CAD CAM technology (Echo, Sweden & Martina). The crowns for both the chamfer and the feather-edge abutments were designed to have a subgingival margin of maximum 1.5 mm.

An occlusal opening was made in the first metal framework in order to have access to the abutment screw after cementation. This was necessary to ensure the retrievability of the abutment–restoration complex for the study. However, to prevent venting of luting agent during cementation, the crown was veneered with composite material.

**Cementation technique randomization**

Eugenol-free zinc oxide cement (Temp Bond, Kerr, US) was selected as a luting agent for this study. Before cementation, the screw access of each abutment was filled with polytetrafluoroethylene tape and sealed with provisional restorative material – Cavit (3 M UNITEK, Monrovia, CA, USA).

A thin layer of Vaseline was applied over the external marginal contour of every crown to reduce cement adhesion over the external surface of the crowns and facilitate removal of excess cement. The cement was mixed according to the manufacturer’s instructions; a thin layer was applied to all internal surfaces of the crowns using microbrush (Microbrush International, Waterford, Ireland).

In the subgroup “intraoral cementation”, crown was directly seated without any additional procedures (Fig. 4).

In the subgroup “extraoral cementation”, a custom-made polyurethane resin replica of the abutment had been previously prepared according to ADT technique (Cocchetto et al. 2010). Every crown, after cement application, was fully seated onto the abutment replica, then rapidly removed, cleansed of the extruded excess cement and finally seated on the titanium abutment until cement setting was complete (Fig. 5).

Random assignment was performed using a free dedicated software (www.examplerandom.com).

After final cement setting, in all subgroups, a stainless steel explorer (Dentsply International Inc., Milford, DE, USA), and ultrasound plastic tip were used until the researcher was confident to have removed any eventual excess cement. Thereafter, super floss (Curaprox, Kriens, Switzerland) imbibed of Bio Orange Solvent (Ogna Laboratori Farmaceutici, Milano, Italia) was used to polish the abutment/crown complex (Fig. 6). The cement removal procedure was performed using magnifying loupes.

Three months later, clinical measurements were performed, and implant stability and...
the presence of complications were recorded. Then, the connection screw was accessed, the abutment screw unscrewed and the suprastructure disconnected for assessment. Occlusal photographs of the implants’ platforms and the surrounding soft tissues were taken. The peri-implant sulcus was probed to evaluate depth and BOP.

Immediately after, the second metal ceramic crown/abutment complex was definitively placed [Fig. 7]. Before ceramic veneering, the two metallic frameworks had been laser soldered.

Outcome measures
The trial tested two hypotheses. The first one was that no difference in cement remnants between the use of a traditional “intraoral” and an improved “extraoral” cementation technique would be observed. The second one was that no difference in cement remnants between the use of a traditional “chamfer” and an improved “shoulderless” abutment would be observed.

Outcome measures were as follows:
1. cement remnants at the abutment/crown margin
2. void of cement at the implant/abutment interface
3. gap at the abutment/crown level

Microscopic analysis
Optical light microscope [Stemi DV 4, Carl Zeiss, Oberkochen, Germany] was used to measure the presence of eventual cement remnants or gaps.

For every abutment/crown complex, the following pictures were taken:
1. one picture (10×) of the complex from apical to coronal
2. four pictures (32×) of the abutment/crown finishing line with the abutment laying on the interproximal aspect
3. four pictures (32×) of the abutment/crown finishing line with the abutment inclined at 45° on the occlusal aspect (Figs 8 and 9)

To measure eventual voids of cement at the abutment/crown interface, removed abutment/crown complex, after photographic analysis, was grinded and underwent a microscopic analysis. Two pictures for each sample were taken at 10× and 20× (Fig. 10).

Using a dedicated software [Solidworks Premium 2012; DASSAULT SYSTÈMES, VelizyVillacoublay, France], the surface (squared microns) occupied by exposed cement remnants was measured.

Measurements were performed by other two blinded calibrated examiners (M.C, C.M). The mean value of the two measurements was used for the analysis.

Prosthetic failures (exposed margins and crown decementation] were recorded.

Statistical analysis
Descriptive statistics, including mean values and standard deviations, were calculated.

Statistical analysis of the data was conducted using related-samples Friedman’s two-way analysis of variance by ranks. The level of statistical significance was set at \( P \leq 0.05 \).

Results
Between Sept 2013 and Sept 2014, 62 patients were screened for inclusion and 46 (29 male and 17 females) participated in the study (mean age 60.58 years, SD: 10.91). Reasons for exclusion were as follows: not meeting the inclusion criteria (n.12) and refused to participate (n.4).

All surgical interventions and post-operative healing period were without any serious complication or side effect for all patients.

At the end of the study, four patients dropped out.

After microscopic analysis, the following data were found:
Cement remnants: a mean value of 0.45 mm² (SD: 0.80) was recorded with shoulderless abutment and intraoral cementation;
0.38 mm² (SD: 0.84) with shoulderless abutment and extraoral cementation; 0.065 mm² (SD: 0.13), 0.07 mm² (SD: 0.15) with chamfer abutment and intraoral cementation, 0.072 mm² (SD: 0.14) with chamfer abutment and extraoral cementation. Remnants were mostly located below the IAJ.

Voids: a mean value of 0.40 mm² (SD: 0.38) was recorded with Shoulderless abutment and intraoral cementation; 0.065 mm² (SD: 0.13), 0.07 mm² (SD: 0.15) with chamfer abutment and extraoral cementation, 0.072 mm² (SD: 0.14) with chamfer abutment and extraoral cementation. Remnants were mostly located below the IAJ.

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Table 1. Mean values and SD

<table>
<thead>
<tr>
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<th>Cement remnants (mm²)</th>
<th>Voids (mm²)</th>
<th>Gap (mm)</th>
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<tbody>
<tr>
<td>Shoulderless abutment</td>
<td>0.455 (SD:0.80)</td>
<td>0.404 (SD:0.377)</td>
<td>0.062 (SD:0.033)</td>
</tr>
<tr>
<td>Intraoral Cementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chamfer abutment</td>
<td>0.380 (SD:0.84)</td>
<td>0.413 (SD:0.39)</td>
<td>0.064 (SD:0.035)</td>
</tr>
<tr>
<td>Intraoral Cementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulderless abutment</td>
<td>0.065 (SD:0.13)</td>
<td>0.485 (SD:0.48)</td>
<td>0.055 (SD:0.016)</td>
</tr>
<tr>
<td>Extraoral Cementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chamfer abutment</td>
<td>0.072 (SD:0.14)</td>
<td>0.477 (SD:0.43)</td>
<td>0.054 (SD:0.024)</td>
</tr>
<tr>
<td>Extraoral Cementation</td>
<td></td>
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<td></td>
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</tbody>
</table>

Table 2. (a) Descriptive measures of shoulderless abutment with intraoral cementation; (b) Descriptive measures of shoulderless abutment with extraoral cementation; (c) Descriptive measures of chamfer abutment with intraoral cementation; (d) Descriptive measures of chamfer abutment with extraoral cementation

<table>
<thead>
<tr>
<th>Group</th>
<th>Remnants</th>
<th>Voids</th>
<th>Gap</th>
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<tr>
<td>(a) Shoulderless abutment</td>
<td></td>
<td></td>
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<tr>
<td>Intraoral Cementation</td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
</tr>
<tr>
<td>N</td>
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<td>21</td>
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<tr>
<td>SD</td>
<td>0.800</td>
<td>0.377</td>
<td>0.020</td>
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<tr>
<td>Median</td>
<td>0.200</td>
<td>0.060</td>
<td>0.04</td>
</tr>
<tr>
<td>Minimum</td>
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<td>0</td>
<td>0.04</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.98</td>
<td>0.90</td>
<td>0.18</td>
</tr>
<tr>
<td>(b) Shoulderless abutment</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Extraoral Cementation</td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
</tr>
<tr>
<td>N</td>
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<td>21</td>
<td>0</td>
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<tr>
<td>SD</td>
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<td>0.480</td>
<td>0.090</td>
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<tr>
<td>Median</td>
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<td>Minimum</td>
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<td>0.04</td>
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<tr>
<td>Maximum</td>
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<td>0.90</td>
<td>0.20</td>
</tr>
<tr>
<td>(c) Chamfer abutment</td>
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<tr>
<td>Intraoral Cementation</td>
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<td>SD</td>
<td>Median</td>
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<tr>
<td>N</td>
<td>20</td>
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<tr>
<td>SD</td>
<td>0.840</td>
<td>0.390</td>
<td>0.050</td>
</tr>
<tr>
<td>Median</td>
<td>0.500</td>
<td>0.050</td>
<td>0.04</td>
</tr>
<tr>
<td>Minimum</td>
<td>0</td>
<td>0</td>
<td>0.04</td>
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<tr>
<td>Maximum</td>
<td>2.860</td>
<td>1.000</td>
<td>0.130</td>
</tr>
<tr>
<td>(d) Chamfer abutment</td>
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<td></td>
<td></td>
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<tr>
<td>Extraoral Cementation</td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
</tr>
<tr>
<td>N</td>
<td>21</td>
<td>21</td>
<td>0</td>
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<tr>
<td>SD</td>
<td>0.140</td>
<td>0.430</td>
<td>0.024</td>
</tr>
<tr>
<td>Median</td>
<td>0.900</td>
<td>0.040</td>
<td>0.03</td>
</tr>
<tr>
<td>Minimum</td>
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<td>0</td>
<td>0.03</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.59</td>
<td>1.10</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 3. Related-samples Friedman’s two-way analysis of variance by ranks

<table>
<thead>
<tr>
<th></th>
<th>Remnants</th>
<th>Voids</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test statistic</td>
<td>13.446</td>
<td>11.180</td>
<td>5.607</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Asymptotic Sig (2 sided test)</td>
<td>0.004**</td>
<td>0.11**</td>
<td>0.132</td>
</tr>
</tbody>
</table>

**Statistically significant.

0.47 mm² (SD: 0.43) with chamfer abutment and extraoral cementation. Voids were mostly located at the coronal portion of the abutment/crown interface.

Gap: a mean value of 0.062 mm (SD: 0.033) with Shoulderless abutment and intraoral cementation; 0.064 mm (SD: 0.034) with chamfer abutment and intraoral cementation, 0.055 mm (SD: 0.016) with shoulderless abutment and extraoral cementation; 0.054 mm (SD: 0.024) with chamfer abutment and extraoral cementation groups respectively.

Subgroup data were summarized in Tables 1 and 2.

Related-samples Friedman’s two-way analysis of variance by ranks showed significant differences for only remnants and voids measure (Table 3). Pairwise comparisons (post hoc tests) showed that “chamfer abutment with intraoral cementation” presented significantly more “remnants” versus “shoulderless abutment with extraoral cementation” (0.047). At the same time, “chamfer abutment with extraoral cementation” presented significantly wider “voids” compared with “shoulderless abutment with intraoral cementation” (0.032).

Prosthetic complications: in the subgroup, “extraoral cementation” 2 crowns decemented after 1 week. The crowns were cemented again with the same technique. No further decementation was recorded.

Discussion

The principal aim of the study was to test the efficacy of an “extraoral” cementation technique in reducing the amount of cement remnants in the peri-implant soft tissues. In respect to the original technique proposed by Wadhwani et al. (2009), in the present study, the quality of the abutment replica was improved using a polyurethane resin according to the specifications of the “Abutment duplication technique” (Cocchetto et al. 2010). The precision of the replica allowed to analyze the results, a surprisingly low amount of cement remnants was found in all subgroups (overall mean value of 0.25 mm²), compared with what was expected, considering the data available in literature on the topic so far. On the other hand, data collected in the present study were in agreement with a recently published study by Behr et al. (2014), which demonstrated almost complete removal of ZOE cement.

It must be highlighted that the cement remnants were located only on the abutment/crown complex and no cement was found in the surrounding soft tissues at visual inspection at time of abutment-crown unscrewing. This fact has been interpreted by the authors as the consequence of two main factors: the use of a eugenol-free zinc oxide cement and the particularly accurate removal technique.

In fact, Zinc oxide cement is considered a “temporary cement” for both implant- and tooth-supported prosthesis, but in this study, it has been chosen in alternative to “definitive cements” like glass-ionomers and resin cements used in most studies [Linkevicius et al. 2013a,b; Vindasiute et al. 2013; Korsch et al. 2014].

It must be pointed out that, while polymeric chains of resin cements were supposed to be toxic for soft and hard tissues (Korsch et al. 2014), the ability to reduce biofilm growth by eugenol-free zinc oxide cement was demonstrated by Raval et al. (2014). Remnants of this luting cements, however, seem to represent retentive factor impacting on the composition of the submucosal microbial biofilm, which could represent the first step for a mucositis or even a peri-implantitis.

Eugenol-free zinc oxide cement, in fact, presents some advantages like radiological detectability even in thickness of 1 mm [Wadhwani et al. 2010] and solubility in the oral fluids. This last feature is mostly considered a disadvantage from the biomechanical standpoint [Vindasiute et al. 2013] and has limited its use as a primary choice for cemented implant prostheses for its supposed unpredictable retaining capacity. However, this negative evaluation should be reconsidered. In fact, the retention of an implant-supported crown is depending on several factors: (i) the length and surface of the abutment, (ii) the convergence angle of axial walls, (iii) the roughness of the abutment surface and (iv) the cement characteristics. As demonstrated by Schiessl et al. (2013) which pointed out significant interactions between abutment geometry and luting agents, the modulation of the first three factors can be easily obtained during the laboratory abutment customization procedures (adding retention couplings, reducing the convergence angle, increasing surface roughness through partial

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sandblasting). This could compensate the lack of intrinsic retention capacity of zinc oxide cement, although difference between eugenol-free zinc oxide cement and resin cement still remain controversial (Garg et al. 2014; Rödiger et al. 2014). Following these principles, abutments used in the present study have been designed with a convergence angle of axial walls ranging from 8° to 12° and only two crowns decemented after 1 week which were recemented with no further complication.

The second factor, which may explain the study results, is the cement removal technique. This was obtained firstly applying, using a small brush, a layer of liquid vaseline on the outer margin of the crowns, limiting therefore the adherence of the cement. Then after careful removal of excess cement with explorer and ultrasonic plastic tips, a dental floss with a spongy section impregnated with zinc oxide solvent was used to polish the crown/abutment interface. The entire procedure was done with the aid of a 4x magnification optic system. The combination of these two factors (type of cement and accurate cement cleaning) seemed sufficient to remove almost all the remnants and prevent any peri-implant soft tissue complication.

In the present study, the margin location for both abutment’s design was chosen at 1–1.5 mm below the soft tissue margin. Despite the fact that in literature, there is a consensus indicating ideal margin position to be placed at or even above the gingival margin (Linkevicius et al. 2013a,b) to avoid the excess peri-implant cement, it was deliberately decided to select the 1.5 mm subgingival position to actually create an “average” environment reflecting more or less a real “everyday” clinical setting in which to test the study hypotheses.

For the same reason, it was considered that the crown profiles should reproduce the natural anatomic contours of the teeth to be replaced. Thus, the amount of undercuts, which also has been correlated with an increased difficulty of excess cement removal (Vindasuite et al. 2013), was deliberately not modified.

Focusing on the role of abutment morphology, in the present study, two different designs were analyzed:

1. a “traditional” chamfer abutment produced through CAD CAM technology by the laboratory technician with a 1.5 mm finishing line below the gingival margin, therefore following the gingival architecture. This was considered more in accordance with clinical practice compared with the use of standard abutments with predetermined chamfer finish line used in several studies.

2. a feather-edge abutment (shoulderless and marginless are two other possible definitions). This design is not new and has been proposed by authors as Carl Misch already in 1993. Recently, the idea was mentioned by Loi & Di Felice (2013), which presented a prosthetic protocol for tooth-supported restorations including a feather-edge preparation and a management of gingival architecture through the crown’s contour and profile. The authors claim that improved esthetic results can be obtained in a predictable manner, both in tooth-supported and implant-supported restorations. The key factors would be the better marginal adaptation after crown’s cementation with a minimal microgap and the thickening of soft tissue due to increased space available for the connective tissue when a conical geometry of the abutment is implemented. The concept has gained popularity but has raised controversies. In particular, the possibility of an increased risk of cement remnants in the peri-implant sulcus due to an obvious grater undercut.

Results from the present study have not confirmed this risk: the shoulderless design, together with a careful cement application and removal protocol, presents the same amount of intrasulcular cement remnants compared with traditional design. Additionally, it must be observed that the present study was conducted in posterior quadrants where the undercuts are greater due to the increased difference between the implant platform diameter and the crown’s diameter, particularly in the molar area (Vindasuite et al. 2013). Moreover, there is an increased difficulty for cement removal due to limited access, compared with the esthetic zone.

In these clinical cases, the extraoral cementation technique was demonstrated to significatively minimize the already limited cement remnants amount found after traditional cementation technique.

Due to this limitation, the same study design should be tested in the anterior areas, where crown overcuts are more limited.

Regarding voids, significant differences between extraoral and intraoral subgroups could explain the two decementations happened in extraoral groups.

Regarding gap parameters, no statistically significant difference was found within the groups and subgroups, confirming the absence of clinical differences between the presented abutment designs and cementation techniques.

Clinical limitations of the present study were represented by the small follow-up time. A longer follow-up [5 years at least] could have prospectively demonstrated the soft tissue reaction to eugenol-free zinc oxide cement remnants.

Conclusions

Within the limitation of the present study, the following conclusions can be summarized:

1. Extraoral cementation could minimize the presence of cement remnants. However, from the very limited amount of cement remnants observed also in the intraoral group, a very low possibility of a cement-induced peri-implant pathology may be inferred. These results could probably be associated with the use of a eugenol-free zinc oxide cement and a particularly accurate cement removal protocol.

2. Compared with the abutment design, chamfer cemented with an intraoral technique presented significant higher amount of cement remnants if compared to a shoulderless abutment when extraoral cementation technique is adopted.

3. The presence of significantly wider “voids” was noted in the extraoral group.

4. There is no difference in regard to the “gap” parameters between the two abutment designs and the cementation technique.

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Conflict of interest and sources of funding

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References


Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. CONSORT Checklist of Items to Include When Reporting a Randomized Trial.
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