CLINICAL ORAL IMPLANTS RESEARCH

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Incidence of undetected cement on CAD/CAM monolithic zirconia crowns and customized CAD/CAM implant abutments. A prospective case series

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Abstract

Objective: The aim of this study was to assess the frequency of cement residues after cementation of CAD/CAM monolithic zirconia crowns on customized CAD/CAM titanium abutments.

Materials and methods: Sixty premolars and molars were restored on Astra Tech Osseospeed TX™ implants using single monolithic zirconia crowns fixed on two types of custom-made abutments: Atlantis™ titanium or Atlantis™ Gold Hue. Occlusal openings providing access to the abutment screws were designed for retrievability of the crown/abutment connection. After fixation with glass ionomer cement, the crown/abutment units were unscrewed to evaluate the presence of residual cement. Dichotomous assessment of the presence or absence of cement at the crown/abutment unit and peri-implant tissues was performed.

Results: Clinically undetected cement excess was visible on 44 of 60 restorations (73.3%). There was no interdependency between residual cement presence and implant location or diameter. However, a dependency between the presence of residual cement and the aspect of the abutment/crown connection could be noted. The majority of the residues were observed on the distal (17.9%) and mesial (15%) aspects. While on the palatal/lingual aspect, the cement was visible in 8.8%; only 3.4% of all surfaces displayed cement residues.

Conclusions: Within the limitations of the study, it can be concluded that the use of customized CAD/CAM abutments do not guarantee avoidance of subgingival cement residues after crown cementation.

There are several options to clinically retain restorations on implants. The retention of fixed dental prostheses (FDPs) can be accomplished either via screws or cement both on pre-fabricated as well as on customized abutments. Both cemented and screw-retained solutions seem to have their benefits and shortcomings and are equally often applied (Michalakis et al. 2003; Chee & Jivraj 2006; Sherif et al. 2011). The decision in favor of one of the retaining options involves many aspects of consideration, including the clinician's personal preference and the particular clinical situation (Hebel & Gajjar 1997; Sailer et al. 2012; Wittneben et al. 2014).

Screw-retained implant reconstructions allow for a predictable retrievability, require a minimal amount of interocclusal space and are easier to remove when hygiene maintenance, repairs or surgical interventions are necessary (Zarb & Schmitt 1990; Chee et al. 1998). Biological problems are rather unlikely to occur, provided that the reconstruction exhibits an accurate fit (Keith et al. 1999). However, screw-retained implant reconstructions require a precise, prosthetically driven placement of the implant due to the position of the screw access hole. If the choice of a screw-retained restoration is questionable because of the implant position or other reasons, a cement-retained restoration would be the treatment of choice. Cemented implant restorations are, however, impaired due to the frequent occurrence of undetected cement residues below the soft tissue margin (Linkevicius et al. 2013a). As a result, an inflammation of the peri-implant tissues can develop (Renvert & Quirynen 2015). As cement remnants after fixation of the restoration have been associated with clinical and radiographic signs of peri-implantitis, there is a call for search of enhanced methods which

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could reduce the probability of leaving subgingival cement excess. Besides changing clinical procedures, new technologies might lead to improvement in this clinical matter. One of the novelties in cement-retained restorations is the application of computer-aided design and computer-aided manufacturing (CAD/CAM) to produce custom implant abutments and frameworks from different materials. It has been claimed that custom abutments facilitate the formation of anatomical gingival topography with a natural emergence anatomy and proper spatial design at the cervical margin. High flexibility in designing the subgingival part of the abutment and the positioning of the shoulder finish line may eliminate the problem of undetected cement residues. However, so far there are no data available to support this hypothesis.

The majority of data available refers to stock abutments or individually cast abutments. Consequently, the aim of this clinical study was to assess the frequency of undetected cement residues after fixation of single CAD/CAM monolithic zirconia crowns on CAD/CAM titanium abutments.

Materials and methods

The study was designed as a case series clinical trial and was carried out in accordance with the Helsinki Declaration of 1975, as revised in 2008. The protocol of the study was approved by the regional ethical committee in Gdańsk (No. NKBB/233/2014). Thirty-four adults (mean age 52.5), generally healthy patients with at least one single missing tooth in the premolar or molar region, were included into the study (17 males, 17 females). The total number of missing teeth was 60 including 18 premolars and 42 molars. They were replaced with single-implant restorations (Osseospeed TX™, Dentsply Implants, Mölndal, Sweden) using monolithic zirconia crowns (Prettau®, ZirkonZahn, Brunico, Italy) fixed on two types of CAD/CAM abutments (Atlantis™ titanium or Atlantis™ Gold Hue, Dentsply Implants, Mölndal, Sweden). Twenty-one missing teeth were replaced by 3.5-mm-diameter implants, while the diameters of the remaining implants were the following: 4.0 mm(22 implants), 4.5 mm (10 implants) and 5.0 mm (7 implants).

Prosthetic procedure

Implant-level impression with an open tray and impression of the opposing arch as well as bite registration were performed after implant uncovery and soft tissue healing. Resulting master casts were sent to Atlantis™ center for abutment milling in Mölndal (Sweden) where CAD/CAM abutments were virtually designed using the Atlantis™ 3D Editor software (Dentsply Implants, Mölndal, Sweden). The virtual design process of the abutments considered the location of the soft tissue margins by creating the abutment shoulder 1 mm subgingivally. A concave emergence profile with a chamfer margin design was selected. After central manufacturing, each CAD/CAM abutment was clinically checked in a try-in procedure and screwed into the corresponding implant. Subsequently, the interface between abutment and soft tissue, the shoulder position and the relation to adjacent and opposing teeth were controlled. X-rays were taken to evaluate the correct seating of the abutments in the implants. After positive verification of the above parameters, abutments and master casts were sent to the laboratory to digitally design (Modellier software, ZirkonZahn, Brunico, Italy) and manufacture the zirconia crowns (Prettau®, ZirkonZahn, Brunico, Italy). To ensure retrievability of the crown/abutment connection, occlusal openings providing access to the abutment screws were designed (Fig. 1). The protocol described previously by Linkevicius et al. was used (Linkevicius et al. 2011, 2013b). At delivery, the abutments were screw-retained and the crowns were cemented with glass ionomer cement (GC Fuji Plus, GC Corporation, Tokyo, Japan). Cement excess was thoroughly removed with a dental explorer and dental floss. The crown/abutment units were unscrewed to evaluate the occurrence of undetected cement residues. Afterward, the crown/abutment units were cleaned, polished (if necessary) and re-screwed in final position using a defined torque of 25 Ncm. The occlusal openings of the ceramic crowns were filled with polytetrafluoroethylene tape and closed with a composite material (GC Corporation, Tokyo, Japan) (Fig 2–5).

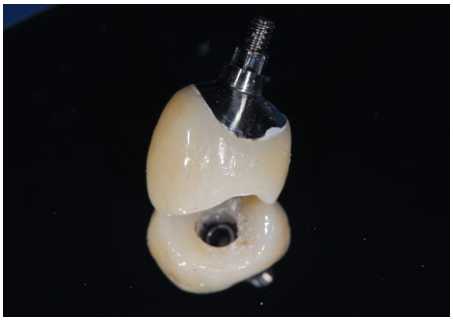

Fig. 1. Small cement residues on the abutment on which a crown restoring the bicuspid was cemented. The occlusal opening allowing post-cementation unscrewing of the abutment/crown connection is visible in the mirror reflection.

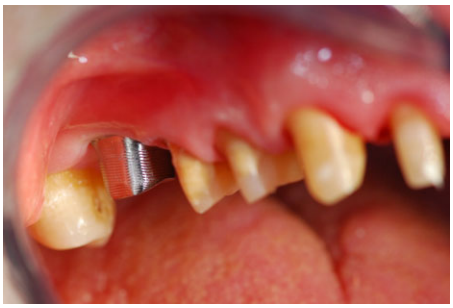

Fig. 2. CAD/CAM abutment screwed into implant before cementation procedure.

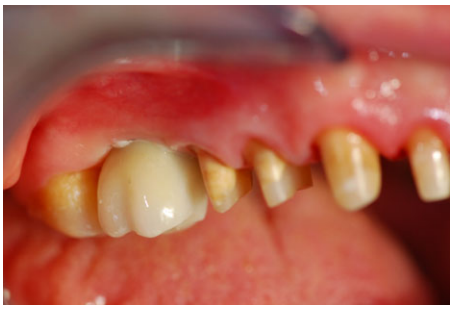

Fig. 3. Monolithic zirconia crown after cementation before cleaning.

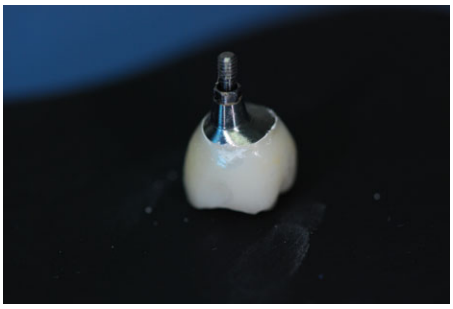

Fig. 4. Crown/abutment unit unscrewed after cementation. Cement excess visible on the surfaces of abutment and crown.

Measurements

The clinical cementation procedure and assessment of undetected cement residues were performed by an experienced clinician (GW). The examination included the following:

A dichotomous evaluation of the cement presence/absence on the crown/abutment unit and the peri-implant soft tissue. In case residual cement excess was visible on the

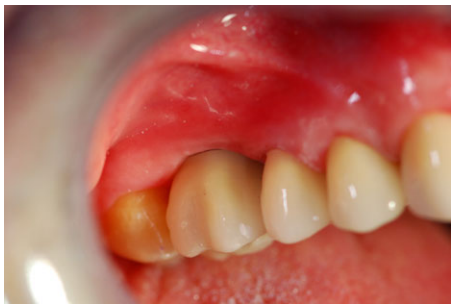

Fig. 5. Crown/abutment unit re-screwed after cleaning and polishing.

surface, the specimen was deemed as contaminated (+). If no cement remnants were detected, the specimen was considered to be clean (−).

A linear assessment of the cement residues extending coronally and/or apically from the abutment shoulder. The size of the residues was classified as small (extension from the shoulder<2 mm) or large (extension from the shoulder>2 mm).

The assessment was performed on four aspects of the crown/abutment connection (mesial, distal, buccal and palatal/lingual).

Statistical analysis

To compare the categorical variables, a chi-square (χ^2) test was used. Statistical significance was determined at $P < 0.05$. All calculations were performed using Statistica 10.0 software (StatSoft, Tulsa, OK, USA).

Results

No cement remnants could be found at the surrounding peri-implant tissues, whereas clinically undetected cement excess was visible on 44 of 60 restorations (73.3%). No cement was noticed on 16 restorations (26.7%). The cement residues were located along the shoulder line of the abutment or/and crown. Linear assessment has shown that the cement residues were not expansive. Only in one case, they extended beyond the threshold of 2 mm distance from the shoulder toward the implant/abutment connection (Fig. 6, 7).

The analysis of the implant positions has demonstrated that cement was present in 19 of 27 (70.4%) implants located in the maxilla and in 25 of 33 (75.8%) implants placed in the mandible. Cement excess was evident on 11 of 18 (61.1%) implants placed in the premolar and 33 of 42 (78.6%) in the molar region. Considering the diameter of the implants, it was found that cement residues were present in 16 of 21 (76.2%) 3.5-mm implants, 15 of 22 (68.2%) 4-mm implants, 9 of 10 (90%) 4.5-mm implants and 4 of 7 (57.1%) 5-mm implants (Table 1). There was no interdependency between the presence of residual cement and implant region or diameter.

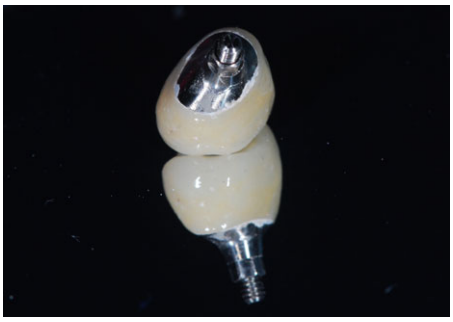

Fig. 6. Prosthetic reconstruction of the bicuspid. Typical linear shape of cement residues located along the abutment shoulder.

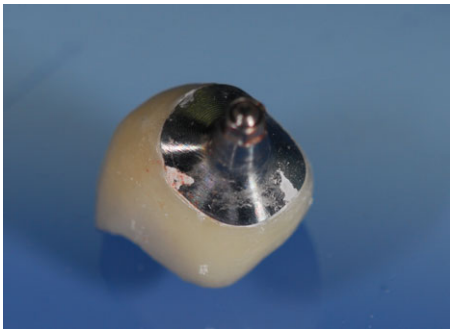

Fig. 7. Prosthetic reconstruction of the molar with the largest cement residues exceeding a 2 mm distance from the crown/abutment connection.

However, there was a dependency between the presence of cement and the aspect of the abutment/crown unit. The majority of remnants were observed at the distal (17.9%) and mesial (15%) aspects. At the palatal/lingual aspect, cement was visible in 8.8% while buccally only in 3.4% of all surfaces (Table 2).

Discussion

After unscrewing the crown/abutment connection, cement residues were identified on the submucosal surface of the abutments and/or crowns in 73.3% of the cases (44 of 60). These findings demonstrate evident differences in comparison with previous outcomes, where cement was located on all retrieved superstructures and peri-implant tissues (Linkevicius et al. 2013a; Vindasiute et al. 2013). This difference may result from differently employed abutment types. While previous studies focused on the frequency of cement remnants around stock abutments, the current clinical investigation utilized solely custom-made CAD/CAM abutments.

There were slight differences between the incidence of residual cement according to the region of the implant. In the present study, cement residues were found more often in the lower jaw (75%) than in the upper one (70.4%) and in the region of molars (78.6%) more often than in the region of bicuspids (61.1%). The incidence of cement residues in correlation to the region of the implant was, however, not statistically significant. These findings are pursuant to previous studies. Similar statistical analyses failed to show significant differences in the presence of cement residues according to the implant diameter. Cement was found in 76.2% of the 3.5-mm, 68.2% of the 4.0-mm, 90.0% of the 4.5-mm and 57.1% of the 5.0-mm implants. Contrary to the above findings, a correlation was found between the presence of cement and the aspect of the crown/abutment connection. Cement was observed to a lesser extent on the buccal aspect of the crown/abutment connection, that is, only in 3.4% of all surfaces. Nevertheless, it was present, respectively, in 8.8% palatally/lingually, 15% mesially and 17.9% distally. The clearly lower incidence of cement present at the buccal aspect is probably due to its better access from the vestibular side. This result cannot be compared to other studies, because cement presence at this aspect has not been evaluated. In addition, some of the studies were performed *in vitro* where access from a certain aspect was irrelevant (Agar et al. 1997; Linkevicius et al. 2011).

Table 1. **Occurrence of cement with reference to implant position (maxilla/mandible; premolar/molar) and diameter**

Variable		Lack of cement – n (%)	Presence of cement – n (%)	*p*
Jaw	Maxilla	8 (29.6%)	19 (70.4%)	0.639
	Mandible	8 (24.2%)	25 (75.8%)	
Position	Premolars	7 (38.9%)	11 (61.1%)	0.161
	Molars	9 (21.4%)	33 (78.6%)	
Diameter	3.5	5 (23.8%)	16 (76.2%)	0.433
	4.0	7 (31.8%)	15 (68.2%)	
	4.5	1 (10%)	9 (90%)	
	5.0	3 (42.9%)	4 (57.1%)	

Table 2. **Occurrence of cement with reference to the aspect of crown/abutment connection**

Variable (aspect)	Lack of cement – *n* (%)	Presence of cement – *n* (%)	*P*
Buccal	52 (86.7)	8 (13.3)	
Palatal/Lingual	39 (65)	21 (35)	<0.001
Mesial	24 (40)	36 (60)	
Distal	17 (28.3)	43 (71.7)	

The aim of the present study was to solely evaluate the presence or absence of cement in the submucosal area, not its quantity. Several studies have demonstrated that cement residues should be considered as one critical factor in the etiology of peri-implant soft tissue inflammation and continued loss of supporting bone, which can result in implant failure. (Wilson 2009; Renvert & Polyzois 2014; Burbano et al. 2015; Renvert & Quirynen 2015).

According to these publications, there could be two mechanisms of developing inflammation related to the submucosal presence of cement. First, it can act as a foreign body provoking an inflammatory response leading to a peri-implant disease. Secondly, increased bacteria accumulation on rough cement surfaces may also aggravate the tissue status, as it is known that there is an association between plaque accumulation and the development of peri-implant mucositis (Serino & Ström 2009). In this context, it should be noted that pathological signs of soft tissue inflammation can manifest themselves a few weeks or even years after delivery of the restoration (Pauletto et al. 1999). In the current study, cement residues were positioned linearly, close to the line of the abutment/crown connection and rarely exceeded a distance of more than 2 mm below the crown margin. Obviously most of the cement excess had been removed during the cleansing procedure. This fact was possibly facilitated by the customized design of the CAD/CAM abutments with anatomical emergence profile, only slightly subgingivally positioned shoulders, no pronounced undercuts, but simultaneously moderately concave surfaces. Linkevicius et al. have stated that the deeper the position of the margin, the greater amount of cement can be found. Undercuts should be ideally reduced to a minimum for better removal of cement excess (Linkevicius et al. 2011, 2013b; Vindasiute et al. 2013). Due to the narrow diameter of stock abutments, their shoulders are often localized deeper than 2 mm below the gingival margin. This makes a reliable inspection and cleansing of the margin more difficult. The study demonstrated the presence of subgingival cement residues in 73,3% of fixed single crowns on customized abutments, which indicates some advantage over standard abutments. However, using individual CAD/CAM abutments still cannot be considered as a completely safe method for cement-retained restorations in the molar and premolar regions. These findings underline that crown cementation on CAD/CAM abutment remains a procedure which has to be performed very carefully due to the high probability of undetected cement residues present even at the buccal aspect of the restoration. This becomes particularly important in periodontal patients. As it was stated by Linkievicius et al., cement remnants should be considered as an additional predisposing factor in the development of chronic peri-implant disease especially in patients with history of periodontitis (Linkevicius et al. 2013a). That is why in such cases, screw-retained implant restorations should be considered as the treatment of choice even if it slightly compromises the esthetic outcome by the presence of screw access hole. Furthermore, there is a need for additional studies evaluating the presence of subgingival cement residues, especially in the esthetic region.

Conclusion

Within the limitations of the study, it can be concluded that use of customized CAD/CAM abutments do not guarantee avoidance of subgingival cement residues after crown cementation.

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Conflict of interests

The authors declare no conflict of interests.

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