Chapter 07

Cement-Retained Implant Restorations

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Abstract

Screw-retained prostheses were the first restorations used over implants by the Branemark group at the early stages of osseointegration. Later the cement-retained implant restorations were introduced and widely used in the clinical practice. Each retention mode has advantages and disadvantages that should be evaluated according to the demands of each clinical case. The aim of this chapter is to present a short overview of the cement-retained restorations with clinical cases and analyze the characteristic for each type of retention.

Keywords

Cement-Retained; Implant Restorations

Introduction

The first restorations used on implants by the Branemark group at the early stages of osseointegration (going back to 1965) were the so called "tissue integrated prosthesis". These prostheses were strictly screw-retained, had a metal framework and were veneered with acrylic resin that supported denture teeth. At that time dental implants were used only for the treatment of the edentulous mandible and 5-6 implants were considered as absolutely necessary for this prosthetic treatment. The prosthetic restorations were fixed on a transmucosal (or also called transgingival) abutment which was secured by screw on the implant [1].

At the following years the spectrum of restorations on implants was enlarged from total edentulism to single tooth implants. The available materials for the fabrication of implant restorations nowadays include porcelain-fused-to metal (which is the most widely used type of restoration), polymer-to-metal restoration and all-ceramic restorations. The techniques for the fabrication have also been improved and the use of CAD/CAM restorations deriving from intraoral scanning or laboratory scanning expands rapidly.

Cement-retained prostheses were introduced at the beginning of the 90's as fixed restorations. The first abutments were the UCLA abutments that allowed fabrication of customized abutments by overcastting of a prefabricated basis [2,3]. The prefabricated Titanium abutments were also introduced either as straight or as angulated and at that time a great change occurred in the field of implant restorations. Cement-retained restorations are supported by abutments fixed by screw in the implants and the axis of the crown can be different or divergent from the implant axis. Non-parallel or divergent implants can also be combined in the same restoration as the path of insertion for the Fixed Dental Prosthesis (FDP) is independent from the direction of the retention screws of the abutments. This characteristic offers great versatility in the fabrication of implant prostheses allowing the restorations of all implants, even with non-favorable inclinations. For these reasons cement-retained restorations were immediately received and adopted from the clinicians. The use of angulated abutments that made possible the fabrication of crowns without access hole for the retaining screw was a solution, especially in cases of anterior maxillary implants where the implant inclination usually has severe diversion to the implant axis.

Despite the evolution of materials and techniques there is always the issue of fixing the prosthesis on the dental implant. The two existing available options for implant-supported restorations remain the screw- or the cement- retention.

Aim

The aim of this chapter is to present a short overview of the cement-retained restorations with clinical cases and analyze the advantages, disadvantages and characteristic for each type of retention.

Screw- or Cement-Retained?

A fixed implant restoration can be fabricated either by fixing the prosthetic directly to the implant head using a screw for retention,

or can be achieved by cementing the final prosthetic on to an abutment, which, in turn, has been fixed by screw to the implant . There is also the possibility to secure a transmucosal abutment on the implant (also called "multi-purpose abutment") and then fix the prosthesis by a retention screw on the abutment. These abutments are prefabricated titanium abutments with diameter analogue to the implant diameter and available in different heights to fit to the clinical demands of each case. Each method has specific advantages and disadvantages, thus the retention mode should be selected individually after taking under consideration the characteristics of each clinical case.

Advantages, Disadvantages and Indications of the Cement -Retention

Cement-retained restoration offer a better esthetic result and are often the clinical choice in anterior maxillary restorations, when the implant axis does not allow the placement of the access hole on the palatal surface. In some cases however, it may be difficult to remove the excess cement from a deep sub-gingival abutment margin. If excess cement remains under the abutment margin, it may cause infection to periimplant tissues. For this reason the margin line of the cemented crown should be placed to an adequate depth from the soft tissue margin (2-3mm) so that the excess cement can be safely removed.

Screw retained restorations offer easy retrievability which is important to allow repair and maintenance. Retrievability can be difficult in cement retention even if temporary cement has been used. There is no clear documented guideline about the type or the way the cement should be used. The loosening of the fixing screw in an abutment for a cemented implant crown -while the crown remains cemented on the abutment- is a common clinical problem and may lead to severe prosthetic complication [4].

In screw-retained restorations, absolutely passive fit of the crown on the implant head or the transmucosal abutment is needed.

In cement-retained restorations the passive fit is considered easier to achieve, as the use of cement may be a compensating factor for minor misfits. On this issue however there are so far no published data to support scientifically this consideration.

The passive fit of the cement-retained restorations on the abutments should be checked carefully in the same way it is performed on natural teeth. In cases of implants with thick periimplant tissues, radiographic control may be necessary.

The abutments for cemented restorations should be fixed by applying the final torque, as indicated by the manufacturer prior to cementation of the prosthesis. The use of a torque measuring device is recommended, in order to exert and control the tightening torque on the fixing screws upon final fixation. The recommended torque of more than 20Ncm, -which is standard in most manufacturers- cannot be achieved by the majority of the clinicians with wet gloves. If the abutments screws are not fixed with the recommended force, screw loosening may occur during clinical function resulting in prosthetic complications [4].

Cement-retained restorations have their main indication in esthetically demanding cases where the existence of the access hole on the labial surface may compromise the final esthetic result. They are also a clinical solution for implants with divergent axes in the same restoration or mall-aligned implants. In cases of implants where a fully customized abutment in the cervical area is needed, cement-retained restorations offer increased possibilities for the creation of the emergence profile on the abutment.

Materials for Implant Abutments

Various materials have been used over the last decades for the industrial fabrication of implant abutments including titanium, alumina oxide, zirconium oxide, gold alloys and lately PEEK (Poly-Ether- Ketone). Titanium is still the most widely used material for prefabricated abutments (Figure 1 and 2) either as commercially pure Titanium Grade 5 or as Titanium alloys (Ti-6Al-4V, Ti6Al4V, or Ti-

6-4). Titanium has adequate mechanical strength to withstand the forces applied on the abutment and has been used extensively by most implant manufacturers.

Figure 1: Prefabricated titanium abutments (straight) for cement retained restorations in different diameters (Xive implants, Dentsply/ Sirona Co).

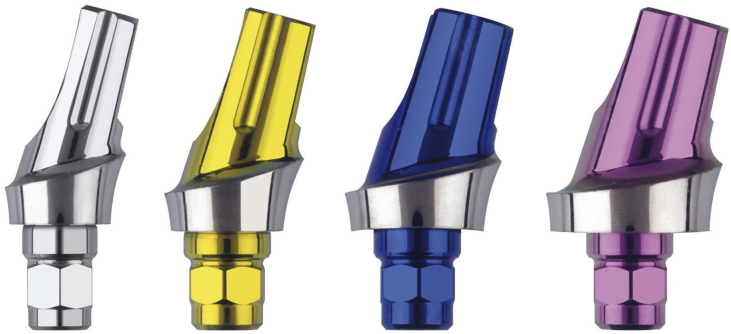

Figure 2: Prefabricated titanium abutments (angulated) for cement retained restorations in different diameters (Xive implants, Dentsply/ Sirona Co).

Figure 3: UCLA type abutment (Aurobase abutments) with prefabricated gold base for overcastting (Xive implants, Dentsply/Sirona Co).

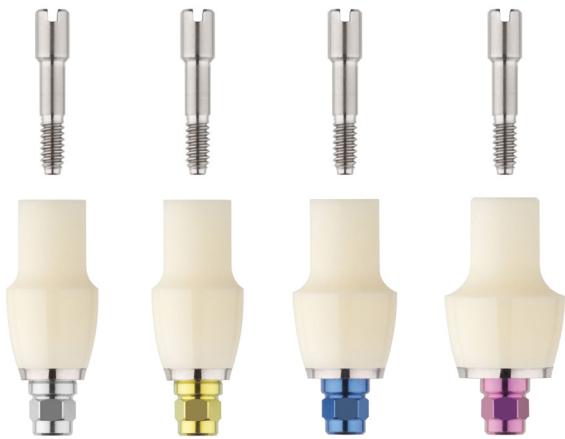

Figure 4: Prefabricated ceramic abutments with titanium base (Cerabase abutments, Xive implants, Dentsply/Sirona Co).The cervical area can be modified individually.

Figure 5: Prefabricated ceramic abutments (Cerkon abutments, Xive implants, Dentsply/Sirona Co).The cervical area is designed to support the soft tissues and can be customized.

Figure 6: Fully customized abutments for cement-retained restorations (Atlantis, Dentsply/Sirona Co).

Gold has been used for the fabrication of custom abutments on UCLA basis by overcastting (Figure 3). It allows complete customization of the abutment directly from the implant head and can compensate any unfavorable implant axis. Generally, a plastic UCLA abutment is waxed up and customized to shape and then overcast with alloy compatible to the prefabricated base which fits the implant accurately [5].

Aluminum oxide has been used in the past on prefabricated ceramic abutments, usually with a prefabricated titanium base (Figure 4) due to its improved esthetic performance and was indicated mainly for anterior maxillary implants [6,7]. Ceramic abutments nowadays are fabricated almost exclusively from Zirkonium oxide (Figure 5) that has similar esthetic properties and excellent biocompatibility combined with increased strength [8-12]. The PEEK abutments have been used mainly as temporary abutments and there are no published data concerning their use in final restorations [13].

Beside the prefabricated abutments many implant manufacturers offer the possibility of completely customized abutments fabricated on demand by CAD/CAM technology (Figure 6) , as for example the Atlantis System (Dentsply/ Sirona Co). Titanium and Zirkonium oxide are the most widely used materials nowadays. CAD/CAM abutments offer increased possibilities in cases of implants demanding an individually shaped emergence profile or if increased angulation is needed. Ceramic materials have shown adequate mechanical strength to be considered as a safe option for implant restorations [14].

Luting Cements for Cement-Retained Restorations

The choice of the luting cement is an important factor to ensure adequate retention of the implant prosthesis with the feasibility of removal, and thereby improving the longevity of implant prostheses. Temporary luting cements are the most commonly used means for the retention of implant prosthesis. The factors that influence the re-

tention of the cement-retained restorations are well documented, and are basically the same as those for natural teeth [15,16]. Various authors have shown that the type of cement, amount of cement space or internal relief, occlusal forces, and type of luting agent can also affect the retentiveness of final restorations. The ideal cement should be strong enough to retain the crown indefinitely, yet weak enough to allow the clinician to retrieve it if necessary [17-19]. Methacrylic-based urethane cements and elastomeric resin-based zink-oxide cements have also been used for the fixation of implant restoration but their efficacy has not been documented with long-term clinical trials [20]. The highest retention however is achieved with resin cements [21].

Ideally, adequate strength of the luting agent is required for retention of prosthesis yet should allow professional removal of restorations by simple clinical procedure. However, literature regarding the ideal cement has revealed disagreements. Owing to varied cement, implants, components, and treatment protocols being used in different studies, a standardized cementation protocol was difficult to obtain. Most of the studies used zinc phosphate as definitive cement and zinc oxide-eugenol as temporary cement. Of these, zinc phosphate luting agent can be advantageous as mechanical bonding of the cement and substructure exists. This benefits the clinician if the prosthesis has to be removed in case need arises. Zinc oxide eugenol on the other hand, being a temporary luting agent, guarantees theoretically easy removal. It can thus be assumed that cement that performs well a temporary luting agent for tooth-supported restorations may or may not be a definitive luting agent for implant supported prosthesis. Hence, in these cases, easy removal still remains a controversial issue [22].

In all clinical cases radio-opaque cement is of advantage as the excess of the cement can be detected by an oral radiography. The cement should be applied on a very thin layer in the inside of the implant crown while on the outer surfaces vaseline should be applied to facilitate cement removal after setting [23].

Fabrication of Cement-Retained Restorations

For the fabrication of cement-retained crowns it is essential to select an abutment with proper dimensions to support the final restoration. The important factors that have to be taken under consideration are the implant diameter, the height of the transmucosal part (Gingival Height), the height of the abutment over the cervical area and the contour of the cervical area lying under the soft tissue level. The height of the abutment is important to ensure adequate mechanical retention to the prosthesis. The height of the transmucosal part and its contour are crucial for the support of the soft tissues and the depth of the marginal line of the prosthesis. In cases where angulated abutments are needed, the abutment with the right inclination should be selected to allow thickness for the metal framework and the ceramic materials.

For all these reasons a full wax-up of the planned restoration offers significant help before the abutment selection and has been suggested several years ago [24]. Silicon partial impressions from the wax-up can be applied on the working cast and the selected abutment can be checked before the fabrication of the prosthesis. The wax-up can be also used as guide for the individual modification of prefabricated abutments concerning the height or inclination. The wax-up (conventional, scanned or digitally designed) is also essential for the design of custom fabricated CAD/CAM abutments in order to achieve the needed form in all aspects [25].

The fabrication and the clinical stages of cement retained restorations is presented in Clinical Cases A to D.

Case A: 3-Unit Maxillary FDP with Cantilever on Prefabricated Titanium Abutments (Figure A1-A8)

In this case two internal hexagon implants (Xive implants, Densply/Sirona Co) were inserted in regions 13 and 14 (Figure A1). The

height of the alveolar crest under sinus floor did not allowed the placement of additional implants more distally and the patient denied any surgical treatment involving the sinus. He wished a simple and low-cost restoration. For these reasons a cement retained restoration was planned as the implants had severe diversion from the axis of the crowns (Figure A2). An impression was taken at implant level and prefabricated titanium abutments were selected that allowed the fabrication of the crowns to the planned shape (Figure A3). Minimal modification was needed and the abutments were tried intraorally to verify that the margin was slightly under the soft tissue margin (Figure A4). The final restoration was a 3-unit FDP with a distal cantilever shaped as premolar (Figure A5-A7). Before final cementation a radiographic control was necessary to verify the precision of fit (Figure A8).

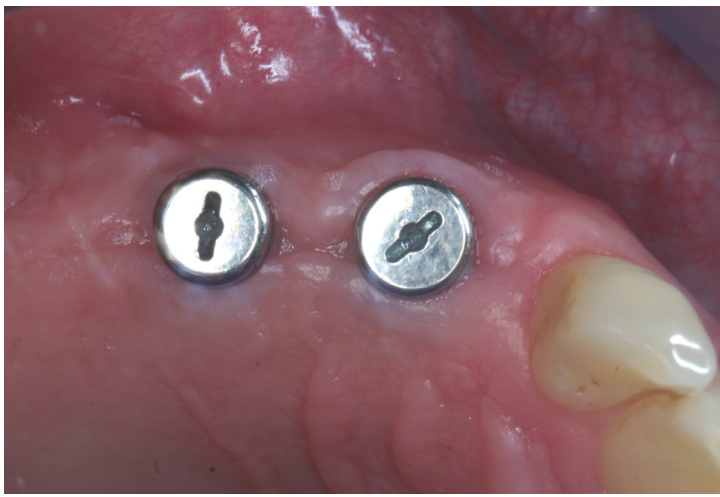

Figure A1: Case A: Initial clinical situation.

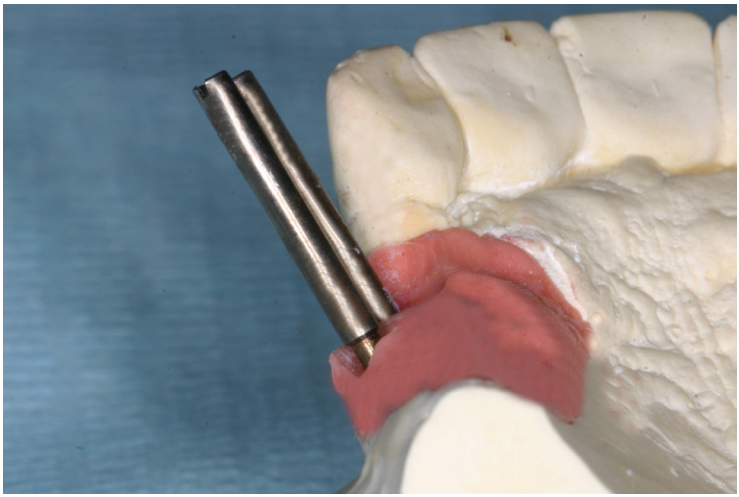

Figure A2: The working cast with long screws in the implants indicating severe diversion of the implant axis to the prosthetic restoration.

Figure A3: Prefabricated titanium abutments (angulated) for cement retained restorations. The abutments can be modified individually.

Figure A4: Try-in of the abutments intraorally.

Figure A5: The 3-init cantilever FDP on the working cast.

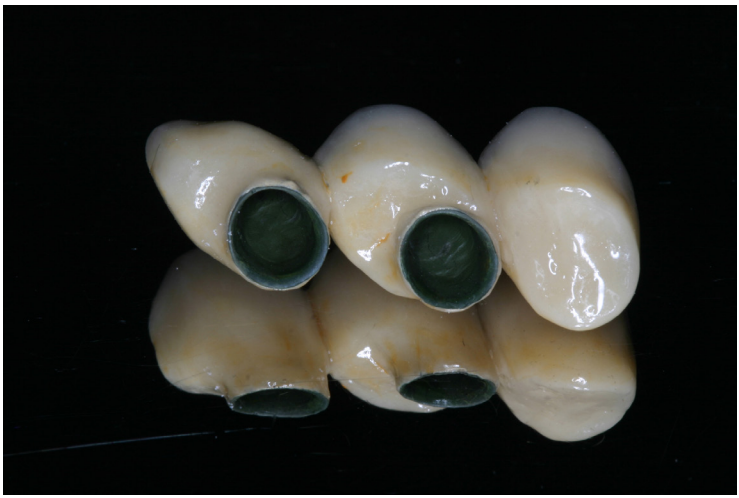

Figure A6: The restoration before cementation.

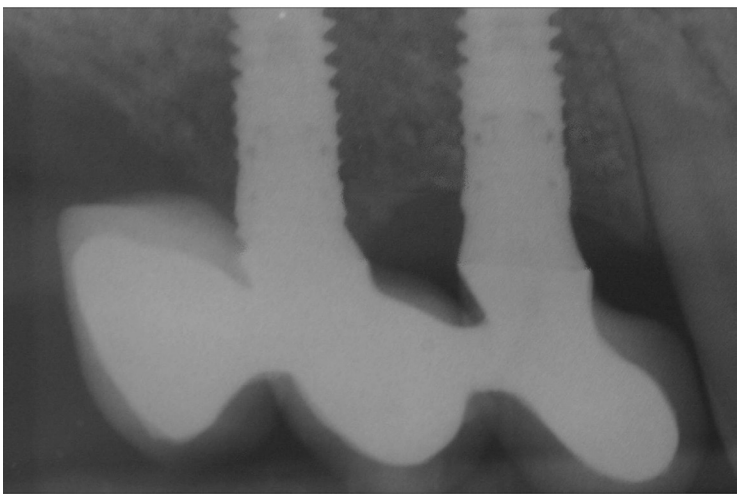

Figure A7: Radiographic control before cementation.

Figure A8: The final clinical result.

Case B: 3-Unit Mandibular FDP on on Prefabricated Titanium Abutments (Figure B1-B6)

Two implants (Astra implants, Densply/Sirona Co) were inserted in regions 34 and 36 for the restoration of partial edentulism in the posterior left mandibular area (Figure B1). The implants had slightly divergent axes and a screw-retained restoration with direct fixation on the implants would be difficult. There was adequate vertical space with the antagonists and a cement-retained FDP was fabricated on prefabricated Titanium abutments that required minimal modification (Figure B2 and B3). The final restoration was checked radiographically and cemented with temporary cement (Figure B4-B6).

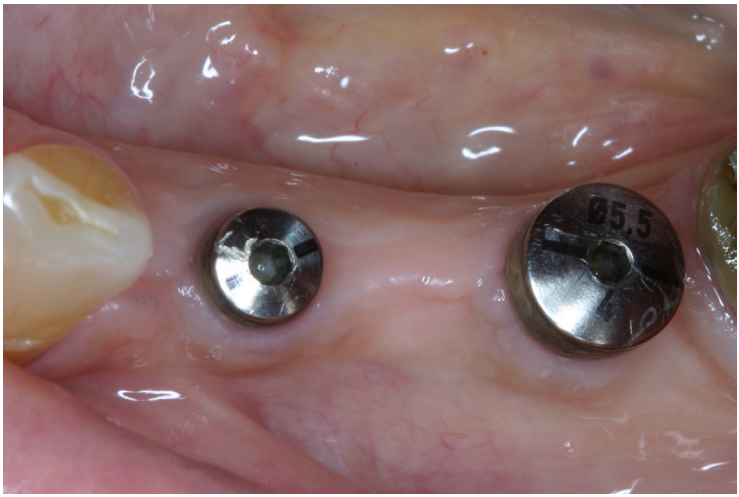

Figure B1: Case B: Initial clinical situation.

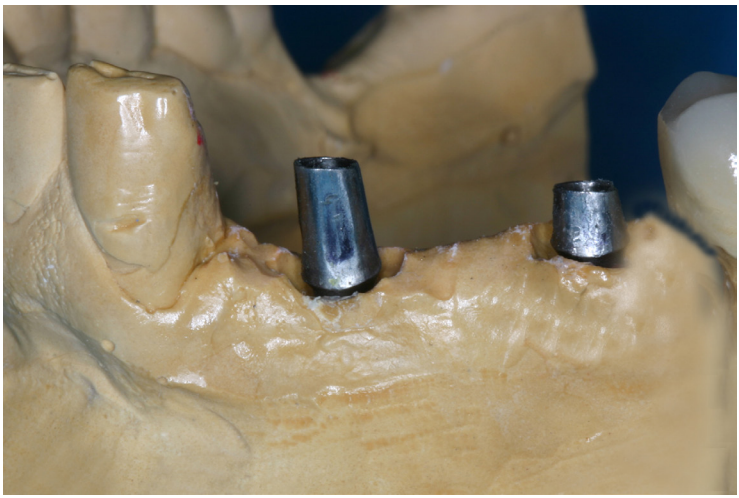

Figure B2 and B3: The working cast with prefabricated titanium abutments. The soft tissue mask has been removed.

Figure B4: The 3-init FDP on the working cast.

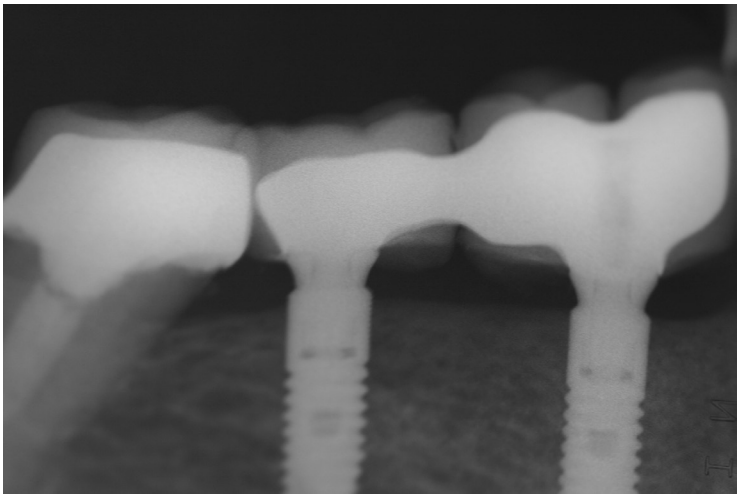

Figure B5: Radiographic control before cementation.

Figure B6: The final clinical result

Case C: Anterior Maxillary Single Tooth Implants with Ceramic Abutments (Figure C1-C10)

In a young female patient two external hexagon implants had been inserted upon completion of growth for the restoration of congenitally missing lateral incisors (Figure C1-C3). The implants were external hexagon type and two metal-ceramic screw-retained crowns had been fabricated by direct fixation on the implants (Figure C4). The implant crowns supported the soft tissues and the papillae (Figure C5) but the patient was not satisfied with the esthetic result. She also complained for a gray discoloration at the marginal area resulting from the metal finishing of the crowns. An impression was taken at implant level with customized impression posts and a working cast was fabricated (Figure C6 and C7). As the patient had high esthetic demands two cement-retained restorations on customized all-ceramic zirconium abutments were fabricated. The use of ceramic abutments eliminated the shining of the metal collar and by cement retention the labial inclination of the previous crowns (necessary for the screw hole) could be avoided (Figure C8-C10).

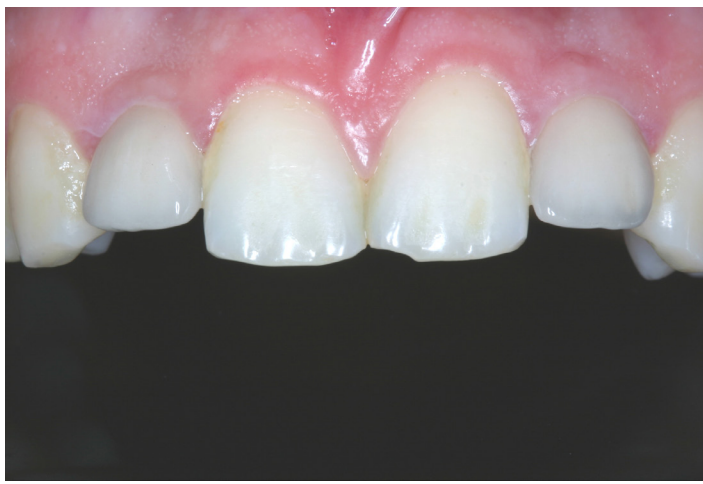

Figure C1: Case C: Initial clinical situation.

Figure C2 and C3: Side views of the existing crowns. Labial inclination of the incisal edge was necessary to place the access hole on the palatal surface. Gray discoloration was caused by the metal collar of the crowns.

Figure C4: The existing screw-retained metal ceramic restorations.

Figure C5: The soft tissue profile.

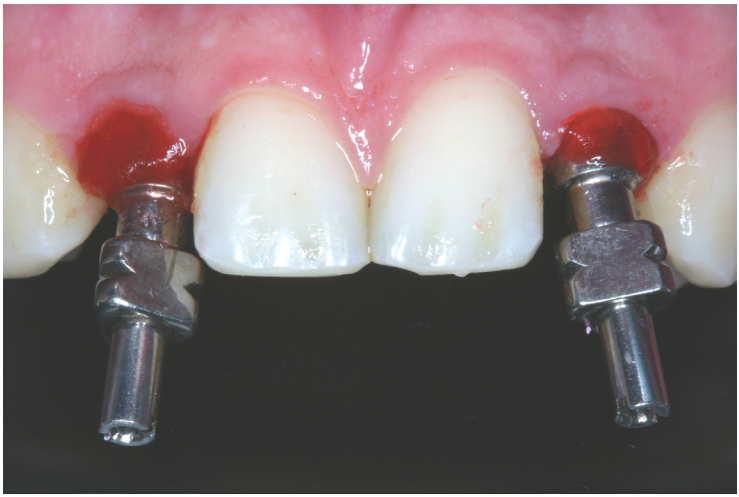

Figure C6: Open tray impression with customized impression posts.

Figure C7: The working cast.

Figure C8: All-ceramic abutments on the cast.

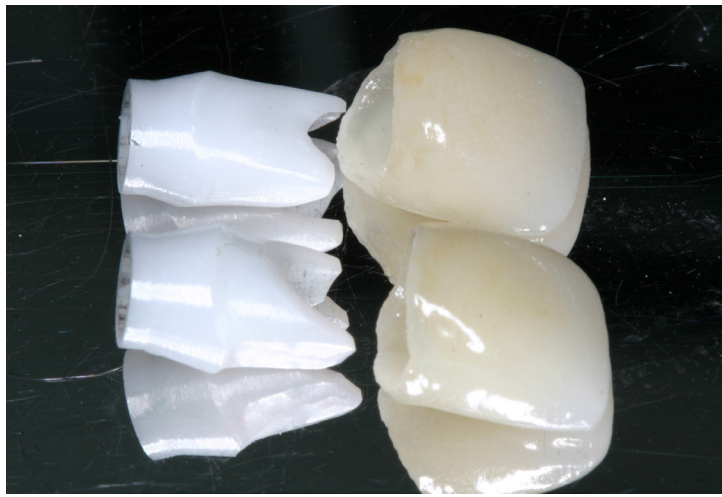

Figure C9: All ceramic abutment and crown.

Figure C10: The final clinical result.

Case D: Anterior Maxillary Single Tooth Implant with CAD/CAM Ceramic Abutment (Figure D1-D14)

An internal hexagon implant (Xive implants, Densply/Sirona Co) was inserted in region 23 of a young female patient for the restoration of the congenitally missing lateral incisor #22. The canine had been moved orthodontically in the place of # 22 and had been reshaped to mimic the morphology of a lateral incisor (Figure D1). For the creation of a proper emergence profile, a screw-retained provisional restoration was initially fixed on the implant, based on a prefabricated titanium abutment. The soft tissues were shaped following the stage approach procedure by adding composite resin on the cervical areas and applying selective pressure (Figure D2). The access hole of the retaining screw was placed on the incisal edge of the crown, thus making necessary the addition of composite resin on the incisal area (Figure D3,D4). For this reason a cement-retained crown was

decided as final restoration. The fit of the temporary abutment and crown was checked radiographically (Figure D5).

Figure D1: Case D: Initial clinical situation.

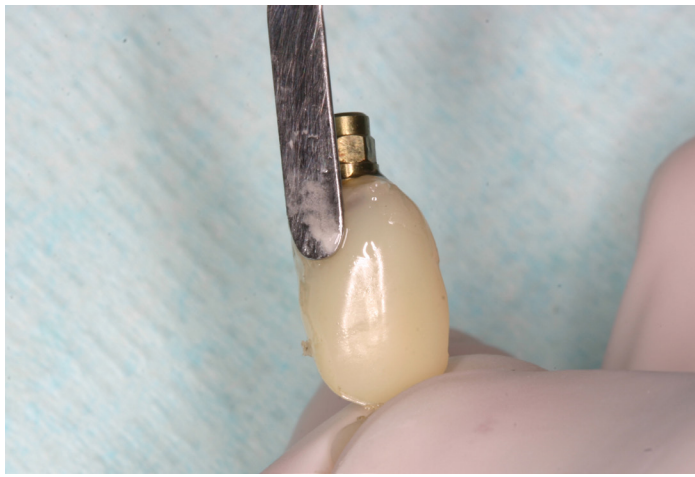

Figure D2: Modification of the provisional screw-retained crown for selective pressure.

Figure D3 and D4: The provisional crown.

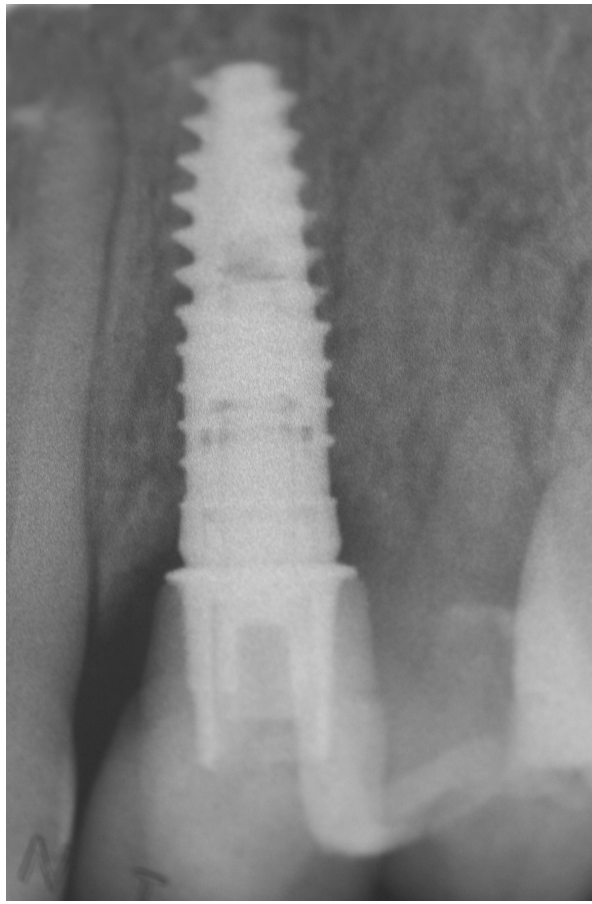

Figure D5: Radiographic control of the provisional crown.

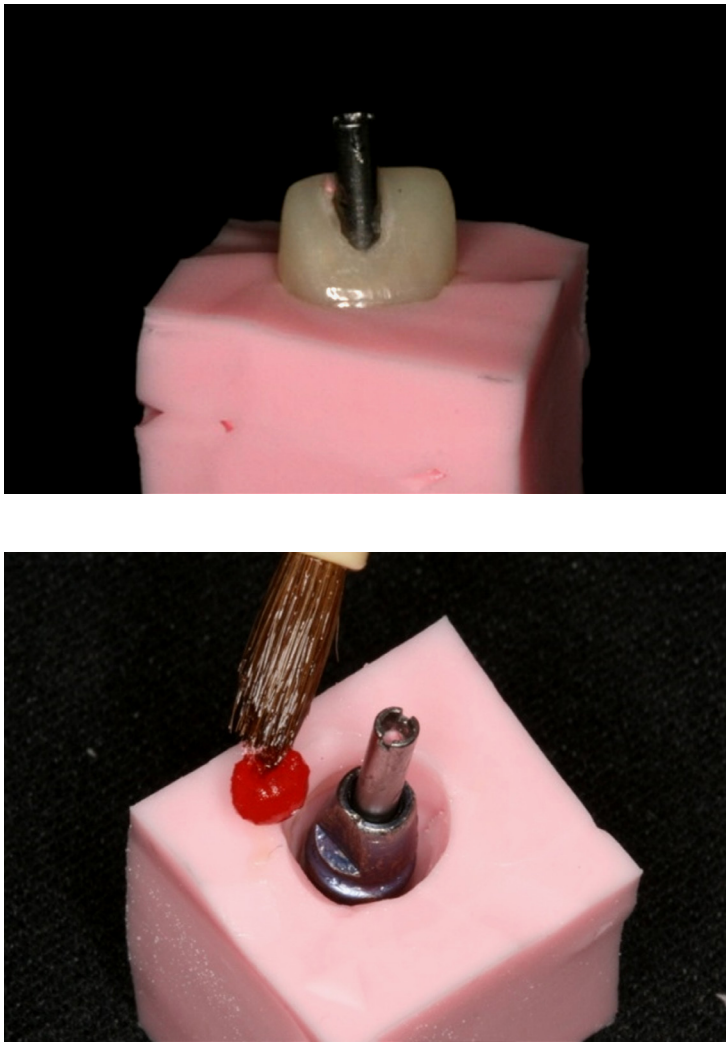

Figure D6 and D7: Impression of the provisional crown for the modification of the impression post (from Papadopoulos et al 2014).

Figure D8: The customized impression post,

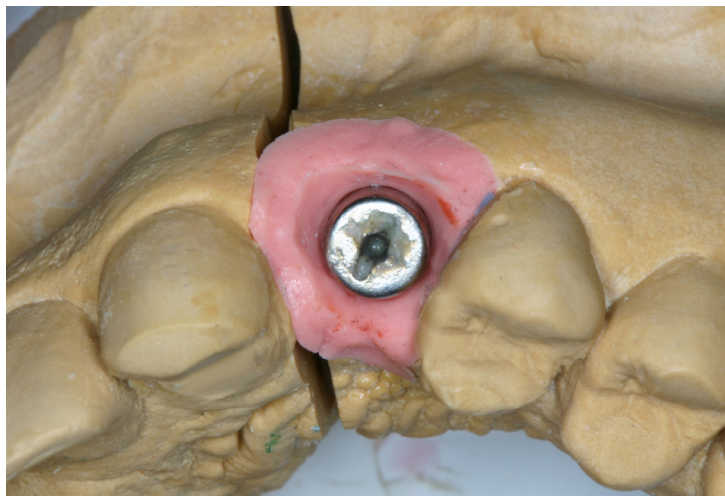

Figure D9: Working cast with soft tissue mask. The created emergence profile differs from the prefabricated healing screw.

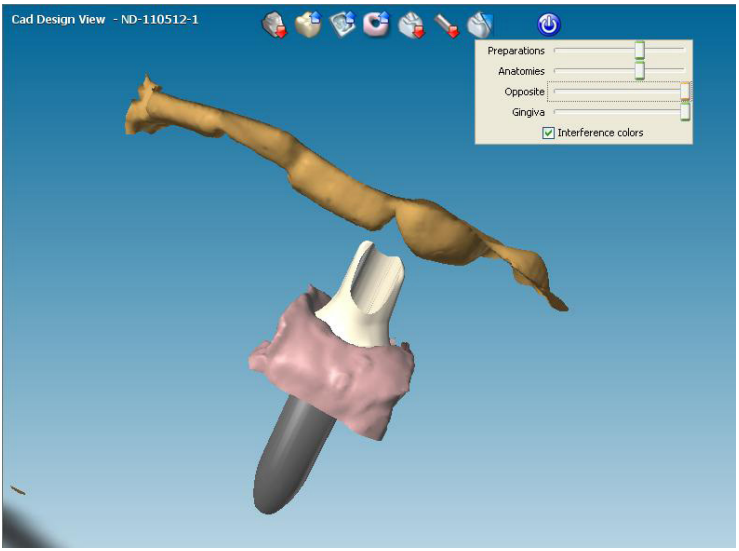

Figure D10: CAD design for a ceramic abutment.

Figure D11 and D12: The ceramic abutment on the cast and in intra-oral try-in.

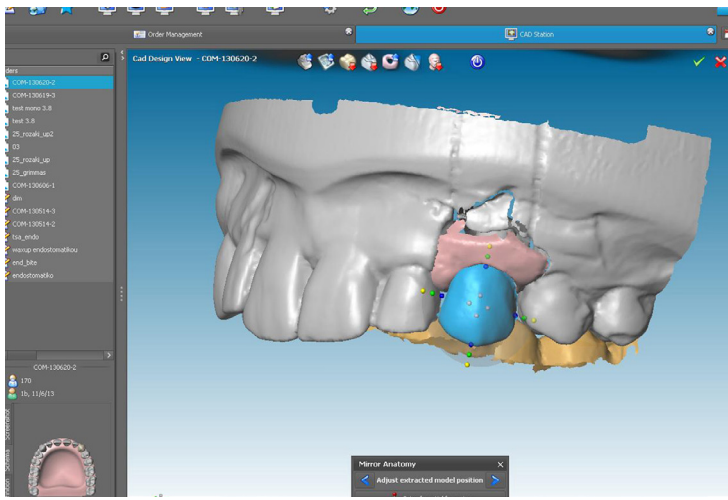

Figure D13: CAD design of an all-ceramic cemented crown.

Figure D14: The final clinical result.

After creation of the desired soft tissue contour, an impression was taken at implant level using a customized impression post to support the soft tissue. For the customization of the impression post an impression was taken extraorally from the provisional restoration and autopolymerizing resin was added around the impression post to support the soft tissues during impression (Figure D6-D8). The final working cast reproduced accurately the shape and the individually formed emergence profile (Figure D9). The clinical procedure has been published previously and is strongly indicated in anterior maxillary implants in order to achieve the best possible esthetic result [26].

As the patient had a high smile line and was concerned extremely about the esthetic result, a cement-retained all-ceramic crown was selected as the definite restoration based on a CAD/CAM ceramic abutment (Figure D 10). The customized abutment supported the contour of the soft tissues adequately and was tried intraorraly to verify the depth of the margin (Figure D 11, D12). The try-in of the abutment is recommended as the soft tissue mask on the model does not always

reproduce the shape the soft tissue precisely. A CAD/CAM ceramic crown was fabricated on the ceramic abutment that fullfilled the patient's expectation (Figure D13, D14).

Survival of Implants in Screw- and Cement Retained Restorations

The 5-years survival rate and the frequency of complications for all kinds of fixed restorations was examined in a systematic review based on 59 clinical studies [27]. For cemented single crowns and cemented FDPs the estimated 5-year reconstruction survival was similar for screw-and cement-retained restorations for cemented full-arch FDPs the 5-year survival was 100%, which was somewhat higher than that for screw-retained FDPs with 95.8%.

The authors concluded that both types of reconstructions influenced the clinical outcomes in different ways but none of the fixation methods was clearly advantageous over the other. Cemented reconstructions exhibited more serious biological complications (implant loss, bone loss >2 mm) while screw-retained reconstructions exhibited technical problems more frequently. Screw-retained reconstructions are more easily retrievable than cemented reconstructions and, therefore, technical and eventually biological complications can be treated more easily. For this reason and for their apparently higher biological compatibility, these reconstructions seem to be preferable.

Restorations

The 5-years survival rate and the frequency of complications for all kinds of fixed restorations was examined in a systematic review based on 59 clinical studies [27]. For cemented single crowns and cemented FDPs the estimated 5-year reconstruction survival was similar for screw-and cement-retained restorations for cemented full-arch FDPs the 5-year survival was 100%, which was somewhat higher than that for screw-retained FDPs with 95.8%.

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Clinical Performance of Screw- and Cement-Retained Restorations

The clinical performance of screw- and cement-retained restorations was examined in an extended systematic review based on 73 publications [28]. The authors found the 5-year survival rates of 96.03% and 95.55% for cemented and screw-retained reconstructions, respectively. Comparison of cement and screw retention showed no difference when grouped as Single Crowns or Fixed Dental Prosthesis (FDPs). Technical and biologic complications demonstrating a statistically significant difference included loss of retention, abutment loosening, porcelain fracture and/or chipping and presence of fistula/suppuration.

Although no statistical difference was found between cement- and screw-retained reconstructions for survival or failure rates, screw-retained reconstructions exhibited fewer technical and biologic complications overall. There were no statistically significant differences between the failure rates of the different reconstruction types or abutment materials (titanium, gold, ceramic). The failure rate of cemented reconstructions was not influenced by the choice of a specific cement, though cement type did influence loss of retention.

Complications in Cement-Retained Restorations

Frequency of Complications

In a recent systematic review based on 29 papers [29] cement-retained reconstructions exhibited more biological complications (implant loss, bone loss > 2 mm) and screw-retained prostheses exhibited more technical problems. Clinical outcomes were influenced by both fixations in different ways. The screw-retained restorations were more easily retrievable than cemented ones, therefore, technical and eventually biological complications could be treated more easily. For this reason, and for their higher biological compatibility, these reconstructions are preferable.

Similar findings were also reported to a previous extended systematic review based on 59 publications [27]. The estimated 5-year cumulative incidence of technical complications at cemented single crowns was 11.9% and 24.4% at screw-retained crowns. At the partial and full-arch FDPs, in contrast, a trend to less complication at the screw-retained was found than at the cemented ones (partial FDPs cemented 24.5%, screw-retained 22.1%; full-arch FDPs cemented 62.9%, screw-retained 54.1%). Biological complications like marginal bone loss >2 mm occurred more frequently at cemented crowns (5-year incidence: 2.8%) than at screw-retained ones (5-year incidence: 0%).

The authors concluded that none of the fixation methods was clearly advantageous over the other. Cemented reconstructions exhibited more serious biological complications (implant loss, bone loss >2 mm), screw-retained reconstructions exhibited more technical problems. Screw-retained reconstructions are more easily retrievable than cemented reconstructions and, therefore, technical and eventually biological complications can be treated more easily.

The influence of the type of restoration on the prosthetic complication was also investigated in a systematic review based on 73 pa-

pers [30]. Screw-retained prostheses showed a tendency toward and significantly more technical complications than cemented prostheses with single crowns and fixed partial prostheses, respectively. For "all fixed prostheses" (prosthesis type not reported or not known), significantly fewer biologic and technical complications were seen with screw retention. Multivariate analysis revealed a significantly greater incidence of technical complications with cemented prostheses. A significantly greater incidence of technical and biologic complications was seen with cemented prostheses.

In the same review screw-retained fixed partial prostheses demonstrated a significantly higher rate of technical complications and screw-retained full-arch prostheses demonstrated a notably high rate of veneer chipping. When "all fixed prostheses" were considered, significantly higher rates of technical and biologic complications were seen for cement-retained prostheses. The incidence of technical complications was more dependent upon prosthesis and retention type than prosthesis or abutment material.

The most common prosthetic complication in screw retained restorations is the loosening of the fixing screw. In a clinical trial with follow-up to 3,5 years the prevalence of reconstruction loosening was significantly lower for cement-retained FDPs when a temporary cement (10%) was used than it was for screw-retained FDPs (29%). The survival rate of the reconstructions within the observation period was 97% for screw-retained FDPs and 100% for cement-retained FDPs (not significant [31].

The influence of the implant-abutment connection on the frequency of screw loosening was investigated in a systematic review with meta-analysis based on 60 papers [32]. Meta-analysis of these studies indicated an estimated 5-year survival rate of 97.6% for Single Crowns and 97.0% for FDPs supported by implants with internal implant-abutment connection and 95.7% for Single Crowns and 95.8% for FDPs supported by implants with external connection. The 5-year abutment failure rate ranged from 0.7% to 2.8% for different connec-

tions with no differences between the types of connections. The total number of complications was similar between the two connections, yet, at external connections, abutment or occlusal screw loosening was more predominant. Ceramic abutments, both internally and externally connected, demonstrated a significantly higher incidence of abutment fractures compared with metal abutments. The authors concluded that for implant-supported Single Crowns, both metal and ceramic abutments with internal and external connections exhibited high survival rates. Moreover, implant-supported FDPs with metal abutments with internal and external connections for also showed high survival rates.

Screw Loosening

Screw loosening is a major problem with screw-retained restorations. The incidence of screw loosening was 65% for single tooth implant restorations in one study [33] whereas the incidence of unretained cemented implant restorations was reported to be less than 5% in other studies [34]. However, the improvements in implant systems, including the advent of internal implant-abutment connections, enhancement of torque drivers, and screw materials and design, led to reduction in the incidence of screw loosening. The incidence of screw loosening was more frequent in the older types of external hex-implants that used titanium and gold screws with slot-head screws. In the majority of the implant systems nowadays, screws with hexagon-heads are used, that allow higher tightening torque without damage to the head [5].

On the other hand, the screw loosening of screw-retained restorations can be considered as an important advantage since the weakest component within the implant-supported restoration will be the prosthetic screw; this will allow for assessing the implant-supported restoration before more serious complications develop, such as implant fracture at screw level especially in implant systems using internal connections. Using screw-retained restorations will enable assessing the preload of implant abutment screws over time, since the

preload is not constant with ongoing application of forces associated with occlusion [35].

The gingival response is found to be better when using screw-retained crowns since no cement is used. However, if prosthetic retaining screws and abutment screws become loose, granulation tissue accumulates between the prosthesis and the abutment and also between implant and abutment leading to fistulae formation, plaque deposition, and screw fracture. Therefore, it is recommended to retighten the screws in full arch fixed prosthesis every 5 years [36].

Loss of Retention

In an extensive systematic review based on 33 articles [22] less retention failures were found with cement-retained prostheses when compared to screw-retained prostheses. The retention failure rate in short term studies (<5 years) ranged from 0% to 15.74% for cement retained prosthesis and 0% to 46.66% for screw retained prosthesis. For long term observation of more than 5 years, the retention failure ranged from 0% to 23.72% for cement retained prosthesis and 0% to 50% for screw retained prosthesis.

In an earlier systematic review [37] -where all complications were included and not only the loss of retention- the prosthetic success rates of cement and screw retained implant prosthesis was 93.2% and 83.4%, respectively with a follow-up of more than 6 years.

It must be underlined however that detachment of a cement-retained implant restoration can be a disturbing event both for the patient and the clinician. It is the simplest prosthetic complication and can be treated without major procedures. On the other side de-cementation of a prosthesis can be a helpful warning sign in case of occlusal overloading or misfit to avoid further complication. If additional retention is needed, grooves or sandblasting of the abutment surfaces can increase the retention of the crown and the efficacy of the lutting cement.

Marginal Bone Loss

The findings concerning marginal bone loss around dental implants with screw- and cement-retained restorations are controversial. In a retrospective clinical trial with follow-up of 15 years the mean marginal bone loss was statistically significantly higher ($P < .001$) for screw-retained (1.4 ± 0.6 mm) than for cemented (0.69 ± 0.5 mm) restorations [38]. These results were also confirmed by another similar clinical study [39].

On the other side screw-retained restorations showed reduced marginal bone loss compared to cemented in other clinical trials [40]. In a systematic review screw-retained restorations also showed better results in marginal bone loss compared to cemented [27].

In an extended systematic review based on 9 clinical studies comparing marginal bone loss on screw- and cement retained restorations, no difference was found between the two types (Brandau 2013). These results were also confirmed by another systematic review focusing on the same clinical topic [41].

Clinical Relevance

Cement-retained restorations have been used for decades on dental implants with high survival rates and reduced frequency of complications. Their main advantage is the excellent esthetic result without limitations from the fixing screw. Their main restriction however is that retrievability cannot always be predictable, thus reducing the possibility for professional hygiene, modification and/or repair. Additionally cements remnants may induce infection in the peri-implant tissues. The type of the prosthetic retention should be selected individually for each case, based on the specific characteristic and the demands of the patients.

References

1. Hobkirk JA, Watson RM, Searson LJ. Chapter 2 in Introducing Dental Implants. London: Churchill and Livingstone Publ. 2003; 3-19.
2. Lewis S, Beumer J, Hornburg W, Moy P. The UCLA abutment. International Journal of Oral and Maxillofacial Implants. 1988; 3: 183–189.
3. Lewis SG, Liamas D, Avera S. The UCLA abutment: a four-year review. Journal of Prosthetic Dentistry. 1992; 67: 509–515.
4. Kourtis S, Damanaki M, Kaitatzidou S, Kaitatzidou K, Roussou V. Loosening of the fixing screw in single implant crowns: predisposing factors, prevention and treatment options. J Esthet Restor Dent. 2017; 00: 000–000.
5. Shafie HR, White BA. Implant abutment materials, Chapter 1 in in Shafie HR Clinical and laboratory manual of Dental Implant Abutments. USA: Wiley Publ Co. 2014; 1-19.
6. Andreiotelli M, Wenz HJ, Kohal R. Are ceramic implants a viable alternative to titanium implants? A systematic literature review. Clinical Oral Implants Research. 2009; 20: 32–47.
7. Anderson B, Glauser R, Maglione M, Taylor A. Ceramic implant abutments for short-span FPDs: a prospective 5-year multicenter study. International Journal of Prosthodontics. 2003; 16: 640–646.
8. Myshin H, Wiens J. Factors affecting soft tissue around dental implants: a review of the literature. Journal of Prosthetic Dentistry. 2005; 94: 440–444.
9. Manicone P, Rossiiommetti P, Raffaelli L. An overview of zirconia ceramics: basic properties and clinical applications. Journal of Dentistry. 2007; 35: 819–826.

10. Linkevicius T, Apse P, Pros D. Influence of abutment material on stability of peri-implant tissues: a systematic review. International Journal of Oral and Maxillofacial Implants. 2008; 23: 449–456.

11. Koutouzis T, Richardson J, Lundgren T. Comparative soft and hard tissue responses to titanium and polymer healing abutments. Journal of Oral Implantology. 2011; 37: 174–182.

12. Butz F, Heydecke G, Okutan M, Strub JR. Survival rate, fracture strength and failure mode of ceramic implant abutments after chewing simulation. Journal of Oral Rehabilitation. 2005; 32: 838–843.

13. Alexakou E, Damanaki M, Zoidis P, Bakiri E, Moutzis M, et al. PEEK High Performance Polymers: A Review of Properties and Clinical Applications in Prosthodontics and Restorative Dentistry. European Journal of Prosthodontics and Restorative Dentistry. 2019; 27: 113–121.

14. Silva NR, Sailer I, Zhang Y, Coelho PG, Guess PC, et al. Performance of Zirconia for Dental Healthcare Materials (Basel). 2010; 3: 863–896.

15. Hebel KS, Gajjar RC. Cement-retained versus screw-retained implant restorations: Achieving optimal occlusion and esthetics in implant dentistry. J Prosthet Dent. 1997; 77: 28.

16. Tarica DY, Alvarado VM, Truong ST. Survey of United States dental schools on cementation protocols for implant crown restorations. J Prosthet Dent. 2010; 103: 68–79.

17. Kapoor R, Singh K, Kaur S, Arora A. Retention of implant supported metal crowns cemented with different luting agents: A comparative in vitro study. J Clin Diagn Res. 2016; 10: ZC61–64.

18. Garg P, Gupta G, Prithviraj DR, Pujari M. Retentiveness of various luting agents used with implant-supported prostheses: A preliminary in-vitro study. Int J Prosthodont. 2013; 26: 82–84.

19. Bernal G, Okamura M, Muñoz CA. The effects of abutment taper, length and cement type on resistance to dislodgement of cement-retained, implant-supported restorations. J Prosthodont. 2003; 12: 111–115.

20. Sarfaraz H, Hassan A, Shenoy KK, Shetty M. An in vitro study to compare the influence of newer luting cements on retention of cement-retained implant-supported prosthesis. J Indian Prosthodont Soc. 2019; 19: 166-172.

21. Gultekin P, Gultekin A, Aydin M, Yalcin S. Cement selection for implant-supported crowns fabricated with different luting space settings. J Prosthodont. 2013; 22: 112-119.

22. Jatin J, Sethuraman R, Chauhan S, Javiya P, Srivastava S, et al. Retention failures in cement- and screw-retained fixed restorations on dental implants in partially edentulous arches: A systematic review with meta-analysis J Indian Prosthodont Soc. 2018; 18: 201–211.

23. Canullo L, Cocchetto R, Marinotti F, Oltra DP, et al. Clinical evaluation of an improved cementation technique for implant-supported restorations: a randomized controlled trial. Clin. Oral Impl. Res. 2015; 2015: 1–8.

24. Kourtis S. Selection and modification of prefabricated implant abutments according to the desired restoration contour. Quintessence Int. 2002; 32: 383-388.

25. Osorio J, Kerstein RB. Use of CAD/CAM technology in custom abutment manufacturing. Chapter 6 in Shafie HR Clinical and laboratory manual of Dental Implant Abutments. USA: Wiley Publ Co. 2014; 65-101.

26. Papadopoulos I, Pozidi G, Goussias H, Kourtis S. Transferring the Emergence Profile from the Provisional to the Final Restoration J Esthet Restor Dent. 2014; 26: 154-161.

27. Sailer I, Mühlemann S, Zwahlen M, Hämmerle CH, Schneider D. Cemented and screw-retained implant reconstructions: a systematic review of the survival and complication rates. Clin Oral Implants Res. 2012; 23: 163-201

28. Wittneben JG, Millen C, Brägger U. Clinical performance of screw- versus cement-retained fixed implant-supported reconstructions--a systematic review. Int J Oral Maxillofac Implants. 2014; 29: 84-98.

29. Gaddale R, Mishra SK, Chowdhary R. Complications of screw- and cement-retained implant-supported full-arch restorations: a systematic review and meta-analysis. Int J Oral Implantol (Berl). 2020; 13: 11-40.

30. Millen C, Brägger U, Wittneben JG. Influence of prosthesis type and retention mechanism on complications with fixed implant-supported prostheses: a systematic review applying multivariate analyses. Int J Oral Maxillofac Implants. 2015; 30: 110-124.

31. Korsch M, Walther W. Retrospective analysis of loosening of cement-retained vs screw-retained fixed implant-supported reconstructions. Quintessence Int. 2015; 46: 583-589.

32. Pjeturson BE, Zarauz C, Strasding M, Sailer I, Zwahlen M, et al. A systematic review of the influence of the implant-abutment connection on the clinical outcomes of ceramic and metal implant abutments supporting fixed implant reconstructions. Clin Oral Implants Res. 2018; 29: 160-183.

33. Jemt T, Linden B, Lekholm U. Failures and complications in 127 consecutively placed fixed partial prostheses supported by Branemark implants: from prosthetic treatment to first

annual check-up. Int J Oral Maxillofac Implants 1992; 7: 40-44.

34. Mish CE. Screw-retained versus cement-retained implant supported prostheses Pract Periodontics Aesthet Dent. 1995; 7: 15-18.

35. Shadid R, Sadaqa N. A Comparison between Screw- and Cement-Retained Implant Prostheses. A Literature Review. J Oral Implantol. 2012; 38: 298–307.

36. Kallus T, Bessing C. Loose gold screws frequently occur in full-arch prostheses supported by osseointegrated implants after 5 years. Int J Oral Maxillofac Implants. 1994; 9: 169-178.

37. Weber HP, Sukotjo C. Does the type of implant prosthesis affect outcomes in the partially edentulous patient? Int J Oral Maxillofac Implants. 2007; 22: 140–172.

38. Nissan J, Narobai D, Gross O, Ghelfan O, Chaushu G. Long-term outcome of cemented versus screw-retained implant-supported partial restorations. Int J Oral Maxillofac Implants. 2011; 26): 1102-1107.

39. Lemos CA, de Souza Batista VE, Almeida DA, Santiago Junior JF, Verri FR, et al. Evaluation of cement-retained versus screw-retained implant-supported restorations for marginal bone loss: A systematic review and meta-analysis. J Prosthet Dent. 2016; 115: 419–427.

40. Koller CD, Pereira-Cenci T, Boscato N. Parameters Associated with Marginal Bone Loss around Implant after Prosthetic Loading. Braz Dent J. 2016; 27: 292-297.

41. Sherif S, Susarla HK, Kapos T, Munoz D, Chang BM, et al. A systematic review of screw- versus cement-retained implant-supported fixed restorations. J Prosthodont. 2014; 23: 1-9.