Cement-Retained Versus Screw-Retained Implant Restorations: A Critical Review

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This article presents a comparison of screw-retained and cement-retained implant prostheses based on the literature. The advantages, disadvantages, and limitations of the 2 different types of restorations are discussed, because it is important to understand the influence of the attachment mechanism on many clinical aspects of implant dentistry. Several factors essential to the long-term success of any implant prosthesis were reviewed with regard to both methods of fixation. These factors include: (1) ease of fabrication and cost, (2) passivity of the framework, (3) retention, (4) occlusion, (5) esthetics, (6) delivery, and (7) retrievability. (More thatn 50 references) INT J ORAL MAXILLOFAC IMPLANTS 2003;18:719–728

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Implant dentistry has seen rapid and remarkable progress in recent years. The quest for predictable long-term results has raised several questions concerning the materials used as well as the techniques followed in clinical practice. One of these questions concerns the type of connection between the restoration and the implant. Implant restorations can be screw-retained, cement-retained, or a combination of both, eg, cemented prostheses with lingual or palatal fastening screws. Screw-retained prostheses have a well-documented history of successful application in completely edentulous patients.[1–4] However, with the increase in treatment of partially edentulous patients, new restorative concepts have evolved in the field of implant prosthodontics, including cement-retained prostheses. It is a fact that, in comparison to screw-retained restorations, cement-retained, implant-supported prostheses have limited scientific documentation.[5,6]

Cement-retained prostheses have become, in many cases, the restoration of choice for the treatment of implant patients. This evolution started after a modification of the UCLA abutment, which led to a new philosophy in restorative solutions, ie, fabrication of customized abutments to overcome esthetic and angulation problems, which implant manufacturers had not foreseen. Lewis and coworkers in 1988 were the first to describe a new technique for the fabrication of implant-supported restorations made directly on Brånemark System implants (Nobel Biocare, Göteborg, Sweden), without the use of traditional transmucosal abutment cylinders, so as to overcome limited interocclusal space problems.[7] In 1989, going one step further, Lewis and associates described the fabrication of telescopic crowns on customized abutments

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made from UCLA abutments to solve problems with implant angulation.[8] Currently, there are numerous premachined cement-retained abutments,[9] as well as preparable titanium and ceramic abutments. Some vendors also provide computer-generated custom abutments for cement-retained restorations.[10] These abutments can be further modified in the mouth to accommodate soft tissue changes. The preparation of these abutments should always be done with copious amounts of water and intermittent contact to prevent heat generation.[11]

In screw-retained restorations, the fastening screw provides a solid joint between the restoration and the implant abutment or between the restoration and the implant itself, for example, with UCLA abutments. With cement-retained prostheses, this restorative screw is eliminated for many reasons cited by different authors; esthetics, occlusal stability, and fabrication of passively fitting restorations appear to be the primary factors for elimination of the retaining screws.[12–14] It has also been advocated that the intervening cement layer can act as a shock absorber and enhance the transfer of load throughout the prosthesis-implant-bone system.[15,16]

There have been very few articles comparing the 2 types of retention of the prostheses to the implants. The purpose of this article was to discuss the advantages and disadvantages of cemented and screw-retained restorations, because it is important for every practitioner to understand the influence of the attachment mechanism in implant dentistry.

The factors that are influenced by different methods of fixation of the prostheses to the implants are:

1. Ease of fabrication and cost
2. Passivity of the framework
3. Retention
4. Occlusion
5. Esthetics
6. Delivery
7. Retrievability

EASE OF FABRICATION AND COST

The fabrication of cement-retained prostheses is easier than that for screw-retained prostheses, because traditional prosthetic techniques are followed and there is no need for special training of the laboratory technicians. The components used for this type of restoration are less expensive than those of the screw type. In addition, there usually is no extra fee charged by the commercial laboratories. Restoration of implants with a divergence of less than 17 degrees is also easier with cement-retained prostheses.[17] The reason for this is that the manufacturers do not yet provide preangled abutments for screw-type restorations with divergence of the screw path of less than 17 degrees. In these instances, the use of screw-retained prostheses is not simple. It requires the fabrication of customized abutments, a procedure that is technique-sensitive and demanding.

PASSIVITY OF THE FRAMEWORK

The possible complications of non-passively fitting frameworks can be categorized into 2 groups:

1. Biologic complications: increased transfer of load to the bone, bone loss, and development of microflora at the gap between the implant and the abutment, and
2. Prosthetic complications: loosening or fracture of the fastening screw and implant fracture

The fabrication of implant-supported restorations requires many clinical and laboratory procedures that must be very precise.[18,19] Each stage in the fabrication procedure can incorporate a small error, which will contribute to a positional distortion of the prosthesis relative to the implants. In a series of articles, Nicholls[20–22] defined the distortion that can occur during framework fabrication as "the relative movement of a single point, or a group of points, away from some originally specified reference position such that permanent deformation is apparent." This distortion can occur 3-dimensionally in both the rotational ($d\theta_x$, $d\theta_y$, $d\theta_z$) and the translational (x,y,z) axes. It can occur at any stage from impression to delivery of the prosthesis and is expressed by the "distortion equation," which is the summation of all the small distortions that happen during the fabrication procedure. When the total of these distortions is zero, then a passive fit is achieved. The question that arises is whether passivity of the fit of the framework is obtainable. Possible distortion of the restoration can occur during the impression procedure, during fabrication of the master cast, during fabrication of wax patterns, during investing and casting procedures, during firing of the porcelain, or during delivery of the prosthesis.

During the Impression Procedure

- Direct or indirect transfer method: The pickup technique provides more consistent results than the repositioning method, which has shown

greater variations in the laboratory analog position. The errors usually produced by the indirect method are both rotational and vertical (z axis).[23–25]
- Splinted or non-splinted impression copings with acrylic resin: There is some controversy on this point. Assif and coworkers[26] found that splinted copings produce the least amount of error, which is statistically significantly different from that of the non-splinting method. Conversely, Phillips and associates[27] did not find any significant difference between the 2 impression methods.
- Dimensional stability of the impression material: Both polyvinylsiloxane and polyether impression materials are appropriate for implant impression procedures.[23,24]
- Tolerance between the implant and the transfer coping: Though there are no data available concerning specific components, Binon[28] has stated that tolerance in critical areas ranges from ± 3.0 to ± 101.6 µm. Several companies do not provide any data on this issue.

During Fabrication of the Master Cast

- Setting expansion of the dental stone: Type IV dental stone, usually used for fabrication of master casts, has a setting expansion of 0.1%, while type V dental stone has a setting expansion of 0.3% to compensate for the greater casting shrinkage of base metal alloys.[29]
- Tolerance between the transfer coping and the laboratory analog

During Fabrication of Wax Patterns

- Distortion of the wax: Wax has the highest coefficient of thermal expansion of all dental materials, and its dimensional stability is subjected to air temperature changes. Resultant dimensional changes may result in poor fitting castings if not balanced by compensating factors of mold expansion. Wax shrinkage on cooling from liquid to solid can be as great as 0.4%. In addition, the patterns tend to release strains that were incorporated during wax handling, because of nonuniform heating.[30]
- Tolerance between the laboratory analog and the abutment

During Investing and Casting Procedures

- Expansion of the investment: High-heat, phosphate-bonded investments present a setting expansion that ranges between 0.23% and 0.50%. Their hygroscopic expansion is 0.35% to 1.20% and the thermal expansion is 1.33% to 1.58% (700°C).[30]
- Shrinkage of the metal: It has been shown that metal shrinkage occurs in 3 stages: *(1)* thermal contraction of the liquid metal between the temperature to which it is heated and the liquidus temperature, *(2)* contraction of the metal inherent in its change from the liquid to the solid state, and *(3)* thermal contraction of the solid metal that occurs down to room temperature. Thermal contraction of dental alloys can be from 1.42% for a type III to 1.56% for a type I.[31]

During Firing of the Porcelain

Distortion occurs in the body of curved, long-span fixed partial denture frameworks during the porcelain firing cycle. The distortion pattern in the curved fixed partial denture is a closing of the posterior or lingual dimensions and labial movement in the anterior dimension. It has been shown that this distortion is a result of changes in the metal as well as contraction of the fired porcelain, and it occurs mainly during the degassing and the final glaze stages of the porcelain firing cycle.[32]

During Delivery of the Prosthesis

- Tolerance between the abutments and the implants
- Ability of the clinician to detect and judge passivity of fit of the framework
- Mandibular flexure: Deformation of the mandible has been studied clinically in the dentate or partially edentulous mandible by a number of workers.[33–39] Hobkirk and Schwab,[40] in a pilot study, showed that in subjects with edentulous mandibles containing osseointegrated implants, jaw movement from the rest position results in relative displacement between the implants of up to 420 µm and force transmission between the linked implants of up to 16 N. It was also noted that forces and displacements were much smaller in lateral excursions than when opening and protruding. The authors also stated that there were wide variations between subjects and that there may be an increased tendency for relative displacement where implants are widely spaced in thin mandibles.

It can be assumed that the distortion caused by each of the aforementioned factors is probably very small and therefore clinically insignificant. However, the summation of all distortions can cause significant internal stresses in the implant-prosthesis complex. Skalak's theory[41] that a non-passive fit can cause biologic and prosthetic complications has not been proved. Research on laboratory animals[42,43] and limited clinical studies[44–47] indicate that it is possible that non-passive fit does not necessarily cause biomechanical problems with implant restorations. These findings should not affect the efforts of clinicians for the quest of a passive fit of implant prostheses.

A review of different proposed methods over time, seeking to achieve a passive fit with screw-retained restorations, has showed that this is not feasible. Ness and coworkers[48] tried to fabricate prostheses with a passive fit by using autopolymerizing acrylic resin. Their results indicated that none of the implant restorations had a passive fit. Jemt and associates[49,50] tested in 2 different studies the fit of laser-welded frameworks at the implant-prosthetic interface and concluded that this method does not contribute to a passive fit. Van Roekel[51] in 1992, Schmitt and Chance[52] in 1995, and LaBarge[53] in 1997 reported on "electric discharge machining," which is also known as "spark erosion." This method consists of the use of high-intensity electric discharges that machine a metal or an alloy to a desired configuration. An in vitro study of Linehan and Windeler[54] demonstrated that this procedure can significantly improve the fit of frameworks. However, a passive fit was not obtained. Fabrication of wax patterns and casting, cutting, and soldering of the frameworks do not assure a passive fit either, as has been shown by Klineberg and Murray[55] and Waskewitz and colleagues.[56]

Other techniques of luting abutments to the metal framework, such as the Preci-disc[57] (Ceka-Vertrieb, Hannover, Germany) and the KAL (Kulzer Abutment Luting; Heraeus Kulzer, Wehrheim, Germany)[58–60] have improved the fit of superstructures to implants, but they have not achieved a completely passive fit.[61,62] Currently, there are no documented published data to support the passive fit of screw-retained implant superstructures. Jemt and Book[47] studied the association between implant prosthesis misfit and marginal bone loss for a period of 5 years, but a significant statistical correlation was not found. However, the authors are concerned about fatigue of the prosthetic parts, as well as about areas with poor quantity of bone and about those areas in which a bone graft has been placed. Results of other studies have indicated that there is also a biologic tolerance for prosthesis misfit.[63,64] There is also an animal study suggesting that prosthesis misfit could promote bone growth.[65] Further long-term prospective clinical research is needed to evaluate a possible correlation between implant superstructure misfit and prosthetic and/or biologic complications. A general consensus on the minimum acceptable marginal fit for implant prostheses would also be valuable.

In a review article, Taylor and coworkers[66] stated that cement-retained implant superstructures have the potential for being completely passive. They believe that the absence of a screw connecting the superstructure to the abutment or to the implant tends to eliminate the strain that is introduced into the prosthesis/implant system during tightening of this screw. Cement-retained restorations can be passive because of the 25- to 30-μm space provided for the cement, a concept that has been utilized for many decades in traditional fixed prosthodontics. In a similar way, if a restoration can be fabricated to fit passively on multiple implant abutments, it would be unlikely that the introduction of cement would create any stresses to the system. A recent laboratory study has demonstrated a significant improvement in passive fit of cement-retained prostheses in comparison to wax, cast, and soldered screw-retained frameworks. This improvement regards both the z-axis and angular distortion.[67]

The absence of passivity of fit of screw-retained superstructures results in greater stress concentrations around the implants in comparison to cement-retained prostheses. However, screw-retained prostheses have exhibited significantly smaller marginal opening than cement-retained restorations.[68] The marginal opening is not associated with decay of the abutments, but there is always a risk of colonization of this space with microflora. With cement-retained restorations, there is an additional concern for dissolution of the temporary cement. Keith and coworkers[69] tested the marginal openings in screw- and cement-retained prostheses and concluded that these were 8.8 ± 5.7 μm for screw-retained restorations. The values for cement-retained restorations were 57.4 ± 20.2 μm for those cemented with glass ionomer and 67.4 ± 15.9 μm for those cemented with zinc phosphate. However, in that study no provisional cements were used, which are the most commonly used for cementation of implant-supported prostheses.[70]

Regarding the microflora that can inhabit the microgap between abutments and screw-retained superstructures, it was shown by Keller and associates[71] that the mode of fixation (screw-retained or cemented) has little influence on the microbiologic and clinical parameters. These conclusions were drawn by research done on ITI implants (Straumann Institut, Waldenburg, Switzerland). Quirynen and van Steenberghe[72] came to the same conclusions involving the Brånemark System, although they pointed out that the internal implant gaps might act as a reservoir for microorganisms, which can leak into a pocket and interfere with the treatment of peri-implantitis.

Regarding prosthetic complications, poorly fitting screw-retained superstructures can be one of the primary causes for screw loosening and/or fractures, as has been stated by many researchers who did longitudinal clinical studies.[73–82] Another complication attributed to framework misfit is implant fracture.[83] It is an uncommon yet significant complication that represents about 1.5% of restored implants followed for a period of 3 to 15 years.[84–87] Most of the fractures occur between the third and the fourth implant thread, which corresponds to the last thread of the fastening screw.[88]

RETENTION

Retention certainly influences the lack of complications as well as the longevity of implant prostheses. The factors that influence retention of the cement-retained restorations are well documented, and they are basically the same as those for natural teeth[89–92]: convergence of axial walls, surface area and height, roughness of the surface, and type of cement.

Convergence of Axial Walls

Taper is a factor that greatly affects the amount of retention that can be produced in a cement-retained prosthesis. Jorgensen[93] proved that a 6-degree taper is ideal for crown preparations. His study showed that a 15-degree taper provides approximately one third of the retention of the ideal 6-degree taper, and a 25-degree taper reduces retention by 75%. Most manufacturers machine their abutments to approximately a 6-degree taper. Thus, the retention achieved with cement-retained prostheses is about 3 times greater than the retention of natural teeth, since most practitioners prepare tooth abutments with between 15 and 25 degrees of taper.[94]

Surface Area and Height

Surface area and height are closely related. It has been documented by Kaufman and coworkers[95] that an increase in surface area and height increases retention and resistance form. Usually implant abutments possess longer axial walls than natural teeth because of the subgingival placement of implants. As a result, the margins of machined or customized cemented abutments are subgingival and in this way offer longer walls. An exception is implants placed in the molar area. They may have higher walls, but the total surface area of the implant abutments is smaller than that of natural teeth.[13] This is true only for prefabricated machined abutments. Customized abutments can be made to resemble natural tooth morphology and thus increase the total surface area to where it is similar to that of molars.

Roughness of the Surface

It has been demonstrated that axial walls with a rough surface[96,97] can offer greater retention. Implant abutments can be roughened if more retention is required. This can be done with either a diamond bur or with airborne particle abrasion, which has been shown to increase in vitro retention. However, the increased retention provided by the 6-degree taper and the long axial walls usually makes the need for more retention unnecessary.

Type of Cement

The cements used in fixed prosthodontics are either definitive or provisional. The definitive cements are used to increase retention and provide good marginal seal for the restorations. Provisional cements are used primarily for interim restorations to facilitate their removal. Since there is no risk of decay for the abutments, provisional cements can also be used for the cementation of implant restorations, as they are much weaker than the definitive cements and permit retrievability of the restorations. Regarding the use of cements for implant restorations, studies have demonstrated that resin composite, zinc phosphate, and glass-ionomer luting agents significantly enhance the cement failure loads of the prostheses luted to titanium abutments in comparison to provisional luting agents.[98–100] For cement-retained implant restorations, the choice of cement is one of the most important factors controlling the amount of retention attained.[101]

For screw-retained restorations, retention is obtained by the fastening screw, which connects the implant with the abutment and the abutment with the prosthesis. This method of fixation has been validated by the research done on the Brånemark System.[102,103] However, to avoid future problems of joint failure, it is important that fastening screws be torqued to the manufacturer's specifications.[104,105] The primary objective of this tightening is to generate adequate clamping force to maintain unity of the components.[106] Currently, there are numerous abutment screws with different mechanical properties. These differences are the result of different size, design, and alloy composition.

The screws most commonly used are the gold and the titanium. Retention is obtained by the friction resistance developed between the internal threads of the implant and those of the fastening screw. In the case of titanium abutment screws, there can be slight damage of both the implant and the fastening screw threads, which results in their joining. This phenomenon is called *galling*.[107] Conversely, gold abutment screws have a smaller coefficient of friction, allowing them to be tightened more effectively than the titanium without risking galling between the threads. However, gold screws should be used only for the actual seating of the prostheses and not for any laboratory procedures because of the soft structure of the material, because such use may result in destruction of the threads.

When there is passive fit of the prosthesis and perfect fit of the component, then an optimal preload of the fastening screw can be obtained.[108] Yet if there is even small misfit, deformation can result that alters the preload-torque relationship.[109] The additional load introduced in the prosthesis-implant system is called external preload. This preload results in axial forces and bending moments that are constantly loading the implants and the surrounding bone.[106] Furthermore, when external preload is used to bring the ill-fitting parts together, screw tension results, which can ultimately lead to screw loosening or fracture.[110]

A certain advantage of screw-retained restorations presents in the situation where there is limited interarch space and therefore a limit to the desired height of axial walls for retention of a cement-retained prosthesis.

OCCLUSION

Occlusion is another factor affecting the selection of the restoration type—screw- or cement-retained. Ideally, in the case of posterior teeth, an implant should be placed in the central fossa for an axial loading to be generated.

The buccolingual dimension of maxillary premolars is about 9 mm, while that of the maxillary first and second molars is 11 mm.[111,112] The occlusal table of the aforementioned teeth is about 4.5 mm for the premolars and 5 to 6 mm for the molars. The heads of fastening screws have a diameter of about 3 mm, thus requiring the screw access hole diameter to be at least 3 mm. These 3 mm represent 50% of the occlusal table of the molars and more than 50% of the occlusal table of the premolars.[13] This area that the screw access hole occupies can be very critical for the establishment of an ideal occlusion in all occlusal relationships (Angle I, II, III), especially for the molars.[113] As a result, the establishment of ideal occlusal contacts in screw-retained prostheses may not be possible, because the screw access hole occupies a significant portion of the occlusal table. To establish proper occlusal contacts, this should be done on composite material, which is usually used to cover the screw holes. However, these contacts will not be stable long term, because, as has been documented by Ekfeldt and Øilo,[114] composite material wears, especially when the opposing restorative material is porcelain. On the contrary, with cement-retained prostheses, ideal occlusal contacts can be established and remain stable over a long period of time.

ESTHETICS

Esthetics can influence the selection of prosthesis type. It is true that the screw access hole is highly unesthetic, but this problem is limited to only the areas of mandibular premolars and molars. Modern opaque composite materials can certainly decrease the gray color of the screw hole, but they can very rarely eliminate it. Obviously, this problem does not exist with cemented restorations.

DELIVERY

For screw-retained restorations, only a radiographic examination is required to verify the precise fit of the prostheses to the implants before proceeding to the final torquing of the fastening screws. However, for cemented restorations, there is a need for careful removal of the cement remnants in addition to the radiographic examination. Removal of cement residues is critical for peri-implant health. It has been documented by Waerhaug[115] that in natural dentition, subgingival cement roughness enhances plaque accumulation in the gingival sulcus. In a similar way, cement residues can cause peri-implant inflammation associated with swelling, soreness, deeper probing depths, bleeding and/or exudation on probing, and radiographic evidence of peri-implant bone loss.[116] Thus, it is very important to eliminate all cement remnants to avoid any iatrogenic inflammation. Removal of excess cement is not an easy procedure, especially when the margins of the restorations are subgingival. This was demonstrated clearly by Agar and coworkers,[117] who demonstrated that there is a distinct possibility for excess cement to remain, especially when the margins are placed 1.5 to 3 mm subgingival. In the same study, it was concluded that resin cement was the most difficult to remove, followed by glass-ionomer and zinc phosphate cements. Provisional cements were not included in this study. Other interesting findings of the same research were that stainless steel explorers appeared to produce the deepest scratches, while gold and plastic scalers created multiple shallower scratches. Scratches produced during the removal of cement residues can cause plaque accumulation,[118] which is difficult to remove and can lead to compromised soft tissue compatibility, as shown previously by Dmytryk and associates.[119]

Modifications of the components may reduce either the risk of extrusion of excess cement at crown margins or reduce the inability to detect and remove these residues. The clinician should always use prefabricated or customized abutments that place the crown margin at the level of the gingiva. Another solution to this problem is the lingual venting of metal-ceramic crowns to allow excess cement to escape to an area where it can be easily removed. However, placement of a vent hole cannot be performed on all ceramic crowns because of the increased risk of inducing fracture lines.

Because of the difficulty in removing cement remnants, patients should be scheduled for their first postoperative visit 1 week after prosthesis delivery. In this way the clinician can detect early changes or reactions of the peri-implant tissues, which can indicate the existence of cement residues subgingivally.

RETRIEVABILITY

Retrievability is advantageous for reservicing, replacement, or salvaging of the restorations and implants necessitated by *(1)* the need for periodic replacement of prosthodontic components; *(2)* loosening or fracture of the fastening screws; *(3)* fracture of abutments; *(4)* modification of the prosthesis after loss of an implant; and *(5)* surgical reintervention.[70] Therefore, retrievability of implant prosthetic components can be a significant safety factor. It should also be noted that removal of implant-supported fixed partial dentures (FPDs) is sometimes needed for better evaluation of oral hygiene. Peri-implant probing can also be more accurate when the prosthesis has been removed.

The main disadvantage of cemented prostheses is the difficulty of their retrievability. Although retrieval is needed less often because of the dramatically increased survival rates for dental implants, the need for future removal of FPDs should not be overlooked. For this reason, provisional luting agents are widely used for the cementation of cement-retained restorations. Many researchers[98,101,120,121] have studied the tensile as well as the compressive strength of provisional luting agents and zinc phosphate cements for implant restorations. From these laboratory studies it may be concluded that single implant restorations cemented with provisional luting agents can be retrieved. In another study,[122] the cement failure loads of different provisional luting agents used for the cementation of multiple implant abutments were tested. From this laboratory research it was concluded that there is a statistically significant difference in the tensile strengths of provisional cements. Clinicians are encouraged to use the least retentive cements so that prostheses can be retrieved if necessary.

CONCLUSION

It has not been the intention of the authors to defend one type of restoration over the other, as both types of prostheses—screw-retained and cemented—present certain advantages and disadvantages. Clinicians should be aware of the limitations and disadvantages of each type of prosthesis so as to select the one that is most appropriate for a given clinical situation.

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