Cement-Retained Versus Screw-Retained Implant Restorations: Selection Criteria: Review

Siman ya da Vida Tutuculu Restorasyonlarda Seçim Kriterleri

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ABSTRACT Implant supported restorations have become widely available for use in dentistry as a result of recent technological advancements. Implant supported fixed partial dentures are retained by means of either screws or luting cements. While there are many studies in the literature investigating advantages and disadvantages of retaining such restorations in place, there is currently no common consensus on which protocol to follow up. Cement retained restorations offer ease of use, tolerance for fixing restorations on unparallel implants up to a certain degree, better passive fit and economical advantages. The disadvantages of (cement retained restorations) are lack of reliable means of retaining and then retrieving the superstructure for routine care and maintenance and risk of causing peri-implantitis where implants placed deeply under the gingival margin due to difficulties of removing the excess cement. Screw retained restorations are mostly used in short crown length cases and allow the operator to remove the restoration when required. On the other hand, esthetic disadvantages especially in the anterior region, difficulties in creating occlusal harmony in the posterior region, complex production procedures and higher cost are some of the drawbacks of this system. Both systems have their own advantages and disadvantages and specific indications for their use. Different aspects of method and indications for cemented implant retained and screw retained restorations will be discussed in this literature review.

Key Words: Dental implant; dental prosthesis, implant supported denture

ÖZET İmplant destekli restorasyonlar teknolojinin ilerlemesine paralel olarak dis hekimliğinde rutin tedavi seçeneği olarak tercih edilmektedir. Sabit protetik uygulama amacıyla yapılan implant restorasyonları implant dayanaklarına simanlarla veya vida tutucular yardımıyla bağlanırlar. Siman tutuculu veya vida tutuculu implant restorasyonları hakkında çok sayıda arastırma yapılmasına rağmen, hangi tip restorasyonun üstün olduğu veya hangi tip restorasyonun kesin olarak kullanılması gerekliliği hakkında kesin bir görüs birliği yoktur. Siman tutuculu restorasyonlar uygulama kolaylığı, belirli dereceye kadar açılı yerlestirilen implantların daha rahat tolere edilmesi, pasif uyumun daha iyi olması ve daha ekonomik olması gibi birtakım avantajlara sahipken bu tip restorasyonlarda rutin kontrollerin yapılamaması, derine yerlestirilen implantlar üzerine yapılan restorasyonlarda simanların temizleme güçlüğünün olması ve sonucunda peri-implantitis olusabilme riski olması dezavantaj olarak sayılabilir. Vida tutuculu restorasyonlar ise özellikle arklar arası mesafenin yeterli olmadığı durumlarda daha rahat kullanılması ve gerektiğinde çıkarılıp rahatlıkla kontrol yapılması gibi avantajlara sahipken, özellikle ön bölgede yapılan vida tutuculu restorasyonlarda vida yerlerinin görünmesinin estetiği olumsuz olarak etkilemesi, posterior bölgede ise yine yapılan restorasyonlarda vida yüzeyleri nedeniyle oklüzal morfolojinin ve yuzey butunluğunun sağlanamaması, yapım islemlerinin daha zor ve pahalı olması gibi bir takım dezavantajlara sahiptir. Her iki sistemin de kendine göre birtakım avantaj ve dezavantajları ve uygulama alanları vardır. Bu derlemede siman tutuculu ve vida tutuculu restorasyonların avantaj, dezavantaj ve uygulama alanları hakkında detaylı bilgi verilecek ve sistemler arasındaki farklılıklar tartısılacaktır.

Anahtar Kelimeler: Diş implantları; diş protezi, implant destekli restorasyonlar

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The choice of cement versus screw retention seems to be based on mainly the clinician's preference. Some authors advocate that the screw-retained prosthesis, as established by Adell et al. offers reversibility and more stability and security at the implant-abutment prosthetic interface.[1-4] Selection of an implant system is another factor in determining the feasibility of cement or screw retention of prosthesis.[5] The use of screw-retained versus cement-retained implant restorations has been the subject of controversy in the literature.[2,6,7]

The factors that influence the choice of retention type of implant supported fixed restorations are:

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

EASE OF FABRICATION AND COST

The fabrication of cement-retained prostheses is easier than that for screw-retained prostheses. The components used for this type of restoration are less expensive than those of the screw type.[2] Restoration of edentulism with a divergence of less than 17 degrees is also easier with cement retained prostheses.[6] 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.[2]

PASSIVITY OF THE FRAMEWORK

Optimization of implant therapy success is directly related to the fabrication of 'passively fitting' implant superstructures. Predictable long term prognosis of implant and the superstructure needs passive fit of the superstructure on the osseointegrated implants abutment. Otherwise, overloading of implant and the abutment will be the cause of mechanical and biologic complications that would even lead to implants loss. Passive fit of a superstructure has an important role in implant biomechanics.[8-12] Absence of a passive-fit may result in prosthetic complications as uneven force distribution, loosening and/or fracture of superstructures or abutment screws. Also, forced tightening of the superstructure may lead to biomechanical complications, such as marginal bone resorption around the neck of implant and even loss of osseointegration.[11-14] 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. 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.[2]

The first step in achieving an accurate, passively fitting prosthesis is to transfer the exact 3 dimensional positioning of the implants on the master cast.[4,15,16] Although, inability to create perfect passive fit of implant superstructures is appreciated to be a fact in dental literature, impression accuracy can be improved by using the correct technique and material science.[11] Many researches were performed to evaluate the effects of different impression techniques and materials on impression accuracy and passive fit. According to the data analyzed, the most important criteria that have effect on implant impression accuracy are classified as, the level of impression making, the technique of impression making, splinting of impression copings, surface modification of impression copings, magnitude of angulations in implant position with respect to the horizontal crestal plane and the type of impression material.[12,13,17-24] When multiple implants are the case, implant level impression permits to choose the most suitable abutment in limited interarch space or in angulated implant positions and to organize the insertion pathway of a multiple implant superstructure. Considering the implants are the case, positioning errors that may occur in analogue placement within the impression, abutment level impression making has been reported to be disadvantageous with respect to implant level impression procedure.[25,26] Many in vitro studies compared the impression accuracies between the direct and indirect methods in which the derived results were reported to be challenging. In recent years, superior chemical and physical properties made polyether and polyvinyl siloxane materials to be used in implant impression making.[25,27,28] To improve accuracy in 3 dimensional transfers, both direct and indirect impression making techniques need an impression material with adequate rigidity to avoid rotational movement of implant impression copings in the impression.[24] To date, many researchers evaluated implant impression accuracies and found better results with polyether and polyvinyl siloxane with respect to condensation silicone, polysulphide, irreversible hydrocolloid and impression plaster materials.[20,21] On the contrary, Holst et al.[29] reported that no exact three dimensional reproductions of implant positions could be performed with polyether and polyvinyl siloxane materials. Evaluating the impression accuracies between polyether and polyvinyl siloxane materials, no significant difference was found in many studies.[24,25,28]

During fabrication of the master cast distortion may occur because different types of dental stone are used for obtaining the cast. 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.[2] Also during fabrication of wax patterns distortion may occur because wax has the highest coefficient of thermal expansion of all dental materials, and its dimensional stability is subjected to 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.[2] Expansion of the investment material may also affect the passive fit of the superstructure: 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).

Shrinkage of the alloy: It has been shown that alloy shrinkage occurs in 3 stages: (1) thermal contraction of the melted alloy between the temperature to which it is heated and the liquids temperature, (2) contraction of the alloy inherent in its change from the melted to the solid state, and (3) thermal contraction of the solid alloy that during cooling to room temperature. Thermal contractions of dental alloys are 1.42% for type III to 1.56% for a type I.[2] Distortion during of the porcelain firing; Distortion occurs within the body of curved, long span fixed partial denture frameworks during the porcelain firing cycle. Distortion pattern in the curved fixed partial denture is a narrowing 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 alloy as well as contraction of the fired porcelain, and it occurs mainly during the degassing and the final glaze stages of porcelain firing cycle.[2] Distortion during delivery of the prosthesis: Tolerance between the abutments and the implants, ability of the clinician to detect and judge the passivity of fit of the framework and mandibular flexure may affect distortion during delivery of the prosthesis. Deformation of the mandible has been studied clinically in the dentate or partially edentulous mandible by a number of researchers. Hobkirk and Schwab, 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.[30] 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 stated that a non-passive fit can cause biologic and prosthetic complications that have not been proved.[31] Research on laboratory animals and limited clinical studies indicate that it is possible that non-passive fit does not necessarily cause biomechanical problems with implant restorations.[32-34] 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 et al.[35] tried to fabricate prostheses with a passive fit by using autopolymerising acrylic resin. Their results indicated that none of the implant restorations had a passive fit. Other techniques of luting abutments to the metal framework, such as the Preci-disc and the KAL system have improved the fit of superstructures to implants, but they have not achieved a completely passive fit.[36,37] Currently, there are no documented published data to support the passive fit of screw-retained implant superstructures. Jemt and Book 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.[34] 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. Further long-term prospective clinical research is needed to evaluate a possible correlation between implant superstructure misfit and prosthetic and/or biomechanical complications. A general consensus on the minimum acceptable marginal fit for implant prostheses would also be valuable. Karl et al.[38] 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.[39] 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. 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 et al.[40] 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 type for cementation of implant supported prostheses. Regarding the microflora that can inhabit the micro gap between abutments and screw-retained superstructures, it was shown by Keller et al.[41] that the mode of fixation (screw-retained or cemented) has little influence on the microbiologic and clinical parameters. These conclusions were drawn by researches done on Straumann implants (Straumann Institute, Waldenburg, Switzerland). Quirynen et al.[42] described 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 with longitudinal clinical studies.[43-46] Another complication attributed to framework misfit is implant fracture. It is an uncommon yet significant complication that represents about 1.5% of restored implants followed for a period of 3 to 15 years.[47,48]

RETENTION

Retention certainly influences the lack of complications as well as the longevity of implant prostheses. The factors that influence the retention of cement-retained restorations are well documented, and they are basically the same as those for natural the teeth such as convergence of axial walls, surface area and height, roughness of the surface, and type of cement. The taper, surface area, and surface texture of preparations affect the retention of castings.[49,50] 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[51] proved that a 6-degree taper is ideal for crown retention. He 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.[2]

Surface Area and Height: Kaufman et al.[52] stated that an increase in surface area and height increases retention and resistance form. Usually implant abutments have longer axial walls than natural teeth because of 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 the 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.[53] 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 where it is similar to that of molars.[2]

Surface Roughness: It has been demonstrated that axial walls with a rough surface[54,55] 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 6-degree taper and long axial walls usually results in unnecessarily over retentive restorations. Mansour et al.[56] examined casting retention using the Straumann solid abutment with 7 cements on the unaltered smooth machined abutment surface. This method could have decreased the cement abutment micromechanical interlocking, leading to comparatively decreased cement retention values but a rougher surface may have resulted in greater retention values and possibly different modalities of cement failure. Surface roughness increases the retention due to resulting micro retentive ridge and groove patterns. Surface roughness enhanced crown retention as much as 31% other factors being equal.

Type of Cement: Regarding this aspect, the type of cement is a relevant and decisive factor for retention. Careful consideration of cement includes reference to abutment and crown specifications, opposing surface characteristic, desired retention, individual properties of preferred cement and ease of excess cement removal.[57-60] Cements used for implant-supported dentures have different properties when compared with those used on teeth.[61] The ideal implant cement should be strong enough to retain the crown, yet weak enough to allow the clinician to retrieve it if necessary. Also, the option to cement crowns to implant abutments may be elected, or contrastingly forced upon the clinician due to implant position and implant number. Studies have demonstrated that resin composite, zinc phosphate, and glass-ionomer luting agents significantly enhance cement failure loads of the prostheses luted to titanium abutments in comparison to provisional luting agents.[7,62,63] The choice of cement is one of the most important factors controlling the amount of retention attained. The cements used in fixed prosthodontics are either permanent or provisional. Definitive cements are used to increase retention and provide good marginal seal. Provisional cements are used primarily for interim restorations to facilitate their removal. Since 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 restorations.[2]

In screw-retained restorations, retention is obtained by a screw, which connects the implant to the abutment. This method of fixation has been validated by the research done on the Brånemark System.[64] However, to avoid future problems of joint failure, it is important that fastening screws should be torque according to the manufacturer's specifications.[65] The primary objective of this tightening is to generate adequate clamping force to maintain unity of the components.[66] Currently, there are numerous abutment screws with different mechanical properties. Screw-retained implant supported prostheses may require additional maintenance because screws may loosen or break. The problem of retaining screw stability has been addressed by the use of gold alloy screws and torque controlling devices.[4,6] In the case of titanium abutment screws, during their joining there can be slight damage of both the implant and the fastening screw threads. This slight damage or discrepancy is called galling.[67] 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 have a soft structure and should be used only for actual seating of the prostheses; not during laboratory procedures to avoid destruction of the threads.[2] When passive and perfect fit of the components obtained, then an optimal preload of the fastening screw can be maintained.[68] A small misfit may alter the preload-torque relationship.[46] Any additional load introduced to the system is called external preload. These preloads result in axial forces and bending moments that constantly loads the implant and the surrounding bone.[66] Furthermore, when an external preload is used to bring ill-fitting parts together causing tension on the screw which can ultimately lead to screw loosening or fracture. A certain advantage of screw-retained restorations is evident where there is limited interarch space and therefore a limit to the desired height of axial walls for retention for a cement-retained denture.[2]

OCCLUSION

Another important factor affecting the selection of the restoration type, screw- or cement retained, is occlusion. Ideally, an implant should be placed in the central fossae of the posterior teeth for an axial loading. The bucco-lingual dimension of a maxillary premolar is about 9 mm, while that of maxillary first and second molars are 11 mm. The bucco-lingual intercusp dimensions of the aforementioned teeth is about 4.5 mm for the premolars and 5 to 6 mm for the molars.[2] Screw heads have a diameter of about 3 mm, thus requiring a screw access hole diameter at least 3 mm. 3 mm represent 50% of the occlusal table of the molars and more than 50% of the occlusal table of the premolars.[53] 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. Composite material is used to cover the screw holes, however, these contacts are not be stable in the long term. Ekfeldt and Øilo[69] stated that composite material had been worn especially when the opposing restorative material had been porcelain. On the contrary, with cement-retained prostheses, ideal occlusal contacts can be Established and remain stable over a long period of time.[2]

AESTHETICS

Aesthetics can influence the selection of prosthesis type. It is true 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. As a result occlusal contacts, this should be done on composite material, which is usually used to cover the screw holes. access hole is highly unaesthetic; in addition, the aesthetics of screw-retained prostheses may be compromised if the access opening is positioned near the facial surface.[58] Modern opaque composite materials can certainly decrease the gray color of the screw hole, but they can hardly be eliminated. Obviously, this problem does not exist with cemented restorations.[2]

RETRIEVABILITY

The greatest disadvantage of cement retained restorations is lack of reliable retention and irretrievability of the superstructure for routine care and maintenance.[39,70,71] Selection of retention method is a challenge for the clinician that involves recognition of the drivers of the desired treatment option. Also, aspects of retrievability versus aesthetic have largely been considered in deciding whether restorations should be screw-retained or cement retained.[72]

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