A Rationale for Retrievability of Fixed, Implant-Supported Prostheses: A Complication-Based Analysis

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Purpose: This article presents a rationale for retrievability of fixed, implant-supported prostheses based on the incidence and variety of biologic and technical complications. The etiologies of these complications are also discussed, emphasizing the unpredictability of implant-based prostheses in the oral environment. ***Materials and Methods:*** Electronic searches of the MEDLINE (Ovid) database were initially conducted to find articles in English relating to the incidences and/or etiologies of dental implant complications up to May 2006. These articles were then manually searched and potential papers investigated. Electronic and manual searches of 11 peer-reviewed dental journals completed the research strategy, with a hierarchy of evidence-based information established to support this complication-based analysis. ***Results:*** Biologic and technical complications appear to be common in all forms of fixed implant-supported dentistry. These complications often jeopardize the functional and/or esthetic features of a given prosthesis, and they occur despite sound prosthetic design and high levels of clinical expertise. Observational studies and systematic reviews dominate this area of the dental literature, leaving the clinician to individually assess the merits of prosthetic retrievability based only on the likelihood of complications and the costs of replacing a permanently cemented prosthesis. These assessments challenge the philosophy of permanent cementation, but there is a need for better, evidence-based information to properly evaluate the costs of prosthetic retrievability against the obvious clinical benefits. ***Conclusion:*** The practice of permanently cementing implant-based prostheses may conflict with the likelihood of biologic and technical failure. The retrievability of fixed, implant-supported prostheses is therefore an important consideration in delivering quality, patient-based treatment outcomes. *Int J Prosthodont 2007;20:13–24.*

Dental implants have provided an alternative for replacing missing teeth. However, researchers do not yet fully understand many of the key elements involved in osseointegration,[1–3] oral force distribution,[4–6] and dental materials science.[7–9] Peri-implantitis is thought to be related to chronic periodontal disease,[10–12] but the complex pathologies of both these conditions are still to be fully established.[12–16] Despite these uncertainties, dental implant companies continue to introduce new products with little evidence supporting their promises of better clinical results.[1,17–20] This presents the clinician with a confusing array of implant surfaces, components, and prosthetic alternatives for tooth replacement. Complications of fixed, implant-supported prostheses have also been widely reported.[21–27] In light of these issues, the decision to permanently cement implant-based prostheses must be questioned.

Many authors have debated the advantages of screw-retained versus cement-retained implant restorations.[28–37] The credibility of these philosophies depends on the benefits of a given implant prosthesis outweighing its biologic and financial costs. These assessments are not straightforward and should not be influenced by implant marketing campaigns that use familiar, tooth-based analogies, such as prosthetic ce-

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mentation, to introduce practitioners to dental implants. Implant-based dentistry provides the clinician with a wider variety of restorative options than tooth-based alternatives, and it is important that each of these options is considered in attempting to meet the prosthetic demands of a given clinical situation.

A major advantage of an implant-based prosthesis is the potential to retrieve the restoration[28,30,34,35,38,39] in the event of a biologic or technical complication. These complications are relatively common,[21,22] even in the hands of experienced clinicians.[40–44] A number of ways of achieving retrievability of fixed, implant-supported restorations have been reported in the dental literature, including gold prosthetic retaining screws,[40,42–47] direct-to-implant screw retention,[33,48] occlusal screws,[49–51] lingual locking screws,[39] lateral fixation screws,[52] lateral set screws,[53] transverse screws,[37,51,54] telescopic prostheses,[55–57] retrieval screws for cemented prostheses,[53] provisional cements,[58–60] and acrylic resin plugs.[61]

Many of the arguments supporting cement-retained prosthetics—better seating of frameworks,[35,62,63] less screw loosening,[34,35] and fewer problems associated with occlusal screw holes such as esthetic,[30,35,36,64] occlusal,[30,35,36,64] and ceramic strength issues[30,65]—lack evidence-based validation. For example, a recent laboratory-based study found that the addition of a luting agent did not compensate for implant stress distributions generated by framework misfit, despite visual evidence to the contrary.[62] Screw-retained crowns have also been shown to produce tighter margins than cemented crowns,[64] with the film thickness of an expressed luting agent leaving a gap between the crown and the implant abutment.[66–68] This discrepancy is a theoretical weak link, given the vastness of marginal gaps relative to microbial dimensions[69] and the risk of the luting agent breaking down in the oral environment.[70–73]

A potential disadvantage of prosthetic retrievability is the increased laboratory cost and complexity that may result from the restoration of dental implants with unfavorable axial alignments. This usually occurs when direct access for the abutment screw compromises the esthetics and/or structural integrity of a prosthesis. In these situations, prosthetic retrievability often comes at the cost of an auxiliary screw system, which must be compared to the potential costs of destroying the prosthesis in the event of a biologic or technical complication. Many factors are involved in these assessments, including the number of dental implants, arch position, costs of remaking a given prosthesis, and the likelihood of complications. Unfortunately, there is insufficient evidence-based information to properly inform clinicians of the likelihood that a particular prosthesis will experience complications during the life of its dental implant. The information that does exist is mainly from observational studies and systematic reviews; these suggest that when experienced clinicians deliver fixed, implant-supported treatments, biologic and technical complications are common.[22–24,27,41,43,44] This casts doubts on the merits of permanently cementing implant-based restorations, but there is a need for randomized controlled clinical trials to properly evaluate the costs of prosthetic retrievability against the obvious clinical benefits.

A few studies have evaluated the costs associated with fixed, implant-supported restorations.[74–76] In a prospective study examining maintenance costs, the majority of adjustments and repairs to fixed, implant-supported prostheses occurred in the first year and were not charged to the patient.[75] The average amounts of time needed for adjustment and repair procedures were 0.84 hours and 1.45 hours, respectively, with an average repair cost of $170 (all figures quoted here are in Canadian dollars).[75]

The maintenance and time costs incurred by 45 mandibular screw-retained, implant-supported complete dentures over 10 years were analyzed recently.[76] Reported maintenance costs were between $208.81 and $4,055.71. Time costs associated with maintenance procedures were calculated using salary rates tied to patient occupations and ranged from $349.99 to $833.08.[76] The proportion of maintenance costs to initial treatment costs could not be calculated from the presented data.

These were the first studies to fiscally quantify implant-related complications, but they involved too few patients for proper evaluation. This level of investigation is commonplace in the dental literature, with many implant-related prosthetic procedures based on untested biomechanical theories[77–79] and flawed mathematical models.[6,8] The scarcity of valid, evidence-based information raises questions regarding the predictability of implant therapy and challenges the merits of permanent cement retention when the option exists for prosthetic retrievability.

The aim of this paper is to present a rationale for the retrievability of fixed, implant-supported prostheses based on the incidence and variety of reported complications. The etiologies of biologic and technical complications are also discussed, emphasizing the unpredictability of fixed, implant-supported prostheses in the oral environment. Until these issues are properly understood by the clinician, 2 key questions of treatment delivery cannot be answered:

1. Does the likelihood of clinical complications validate the decision to permanently cement a given prosthesis?
2. Do the benefits of prosthetic retrievability outweigh the costs of treatment?

Materials and Methods

A 3-part research strategy was conducted to find articles in the dental literature relating to incidences and/or etiologies of dental implant complications. An initial electronic search used the MEDLINE (Ovid) database to find English-language articles published through May 2006 that included combinations of the following terms: "dental implants," "complications," "biologic(al) complications," "technical complications," "mechanical complications," "screw-retained," "cement-retained," "peri-implant mucositis," "peri-implantitis, "periodontal disease," "microbiology," "residual cement," "implant surface roughness," "microgap," "microleakage," "marginal gap," "nonaxial loading," "biomechanical overload," "oral forces," "screw mechanics," "clamping force," "preload," "screw loosening," "prosthesis/prosthetic screw loosening," "abutment screw loosening," "embedment relaxation," "prosthesis/prosthetic screw fracture," "abutment screw fracture," "passive fit," "metal framework fracture," "implant fracture," "acrylic veneer fracture," and "ceramic veneer fracture." This electronic search generated 577 papers, from which 137 papers were selected according to the quality of their information and relevance to the topic. The references from these articles were then manually searched and the potentially relevant papers scrutinized.

To ensure a thorough investigation of the topic, electronic and/or manual searches of the following peer-reviewed journals were also conducted: *Clinical Oral Implants Research*, *Dental Clinics of North America*, *European Journal of Oral Sciences, International Journal of Oral & Maxillofacial Implants*, *International Journal of Prosthodontics*, *Journal of Biomechanics*, *Journal of Dental Research*, *Journal of Dentistry*, *Journal of Oral Rehabilitation*, *Journal of Prosthetic Dentistry*, and *Journal of Prosthodontics*.

A total of 183 scientific studies, review articles, and textbook analyses were eventually selected to support this complication-based analysis of why biologic and technical complications occur despite sound prosthetic design and high levels of clinical expertise.

Clinical Complications of Fixed, Implant-Supported Prostheses

Six categories of complications relating to fixed, implant-supported prostheses have been described: Surgical complications, implant loss, bone loss, peri-implant soft tissue complications, mechanical complications, and esthetic/phonetic complications.[22]

With the exception of surgical complications and the early loss of an implant, all other complications may occur after prosthetic placement, emphasizing the importance of retrievability.

Other authors divide implant complications into biologic and technical factors.[23,27,80,81] Biologic complications involve the tissues supporting implants and include soft tissue disturbances and peri-implantitis, while technical complications involve mechanical damage of implants, implant components, and/or suprastructures.[27]

Biologic Complications

Definition of Biologic Complications

Biologic complications are disturbances of the tissues supporting an implant[23,25,27] and may ultimately lead to implant loss if the disease process is not controlled.[10,13,23] These complications include inflammation of the mucosa (peri-implant mucositis); soft tissue lesions such as gingival proliferation, fenestrations, dehiscences, and fistulas; and inflammatory bone loss (peri-implantitis).[10,11,13,22,82]

Incidence of Biologic Complications

Biologic complications are commonly reported in the dental literature[22,23,26,27,40,41,44,46,83–86] and may threaten the esthetic and/or functional success of a prosthesis, especially when an implant is lost. A systematic review of 217 papers and more than 21,900 implants found that 46% of implant losses occurred after restoration with a fixed prosthesis (187 of 433 lost implants).[22]

The position and type of fixed prostheses appear to influence implant failure, with 9.7% of maxillary, implant-supported, fixed complete denture implants being lost. Maxillary, implant-supported, fixed partial dentures (FPDs) experienced the second highest incidence of implant loss (6.5%), followed by mandibular, implant-supported FPDs, single-unit crowns in either arch, and mandibular, implant-supported, fixed complete dentures at 6.1%, 2.8%, and 2.6%, respectively.[22] Another systematic review reported implant failure rates of 2% to 3% after at least 5 years of function,[23] whereas 4.6% of implants supporting single-unit crowns were lost during a 10-year retrospective study.[60]

Even at the lowest rate, 2 in 100 patients lose a dental implant following restoration. Depending on the clinical circumstances, prostheses retained by more than one implant may survive despite the loss of an implant, and given the high costs of implant dentistry, prosthetic retrievability in these circumstances is an obvious advantage. The option of removal and modification is not available for permanently cemented prostheses, which must be damaged or destroyed in the event of implant failure.[30,38]

Other biologic complications may influence the success of fixed, implant-supported restorations. A systematic review of 51 prospective, longitudinal studies

found that 6.5% of patients with implants experienced soft tissue problems, peri-implantitis, and/or crestal bone loss of 2.5 mm or greater after at least 5 years of function.[23] In another study, progressive bone loss was reported around 12.4% of implants (423 of 3,413 implants), involving only 27.8% of the total number of patients (184 of 662 people).[86] This suggests that some individuals are more susceptible to peri-implantitis than the majority of the population, a finding that agrees with other studies investigating connections to periodontal bone loss.[86–88]

Problems associated with implant-supported, fixed complete dentures appear to be common, with a number of studies reporting gingival proliferation, soft tissue inflammation, and/or bone loss due to impaired cleaning ability.[40,41,44,46] Significant bone loss occurred in 3.8% of 3,373 implants supporting full-arch dentures.[23] A systematic review of the survival of implant FPDs found that 8.6% of 751 prostheses experienced biologic complications after 5 years.[27] Biologic complications reported for single-unit, implant-supported crowns include fistula formation (3.1% of 259 units),[85] gingival recession (0.4% of 677 units),[26] and peri-implantitis (1.0% of 677 units).[26] A systematic review of 8 papers and 387 crowns reported that 1.3% of single-unit, implant-supported crowns experienced biologic complications after 5 years.[23]

The relatively high incidence of tissue-related problems associated with dental implants should concern clinicians who use permanent cement for prosthetic retention. This is especially true when managing multiple-unit complications where treatment involves mechanical debridement, antiseptic cleansing, or surgery.[25,81] Access for these treatments is usually improved after the prosthesis is removed.[89] Prosthetic retrievability is also an advantage when an implant fails and the attached prosthesis must be removed to salvage the implant and modify the framework. This is the major disadvantage of cement-retained prostheses, which must be damaged or destroyed to be removed.[30,38]

Etiology of Biologic Complications

Bacterial infection is a major factor leading to bone loss and implant failure in healthy individuals.[10–12,83,90] Peri-implant mucositis is thought to involve inflammatory processes similar to those of gingivitis,[91,92] and there is evidence that the pathogens implicated in chronic periodontal disease play an important role in the development of peri-implantitis.[10–12]

Subgingival irregularities such as residual cement,[93] implant surface roughness,[94] and/or spaces between implant components[95] assist in the microbial colonization of implants and may lead to peri-implant mucositis, soft tissue lesions, and/or peri-implantitis.[10,12] The effect of cement remnants on peri-implant health is not well documented, but they are likely to facilitate bacterial growth and tissue breakdown based on the destruction caused by subgingival foreign bodies in animal studies.[96,97] The negative periodontal response to subgingival irregularities in natural teeth may also be relevant.[14,98,99] Four patients with residual cement and peri-implant complications all responded to surgical debridement and experienced no further problems.[93]

A study investigating cement removal from cement-retained, implant-supported crowns with subgingival margins found unacceptable amounts of retained cement and abutment scratching following attempts by experienced operators to remove the cement using a variety of instruments.[100] Damage occurred to the implant surfaces, even with the softest cements and instruments; the combination of resin cement and stainless steel explorers produced the deepest scratches and greatest amounts of residual cement.

The gaps between implant components are well suited to plaque formation and may contribute to biologic complications.[12,101] Despite the presence of bacteria[101,102] and detectable microleakage,[95,103] the clinical relevance of these microgaps remains controversial.

Screw-retained, implant-supported crowns produce tighter margins than cement-retained, implant -supported crowns.[64] Regardless of the quality of dentistry, a cement line separating the crown and implant abutment is unavoidable because of the film thickness of the expressed luting agent.[66–68] This discrepancy is a theoretical weak link, given the vastness of marginal gaps relative to microbial dimensions[69] and the risk of the luting agent breaking down in the oral environment.[70–72] The use of an adhesive luting agent may reduce the risk of microleakage,[70,104] but the long-term durability of these materials is yet to be determined[70,73,104] and structural fatigue is a potential problem.[72,73]

There is little scientific evidence to support the notion that forces generated in the mouth disrupt the interface between implant and bone.[12,35] Regardless of an implant's position, the titanium and bony surfaces are subjected to a variety of forces in a number of directions because of the geometry of the interface and the micromechanical nature of the union.[28,105] Experimental testing and clinical reality do not substantiate concerns about off-axis loading of dental implants.[35,106–108]

Technical Complications

Definition of Technical Complications

Technical complications of implant fixed prostheses include acrylic veneer fracture (22% of 663 prosthe-

ses), ceramic veneer fracture (14% of 258 prostheses), esthetic deficiencies (10% of 493 prostheses), phonetic problems (7% of 730 prostheses), prosthesis screw loosening (7% of 312 screws), abutment screw loosening (6% of 6,256 screws), prosthesis screw fracture (4% of 7,094 screws), metal framework fracture (3% of 2,358 prostheses), abutment screw fracture (2% of 13,160 screws), and implant fracture (1% of 12,157 implants).[22]

Incidence of Technical Complications

Many studies have reported technical complications associated with fixed, implant-supported complete dentures.[40–42,44–46,49]

- All of 47 screw-retained, implant-supported complete dentures had all their acrylic resin teeth replaced at least once over 23 years. Prosthetic and abutment screw fractures were also common, and 10 patients fractured their metal frameworks. There were no implant fractures.[40,44]
- Patients with maxillary, screw-retained, implant-supported complete dentures most commonly experienced acrylic resin tooth fractures (21.5% of all reported problems) and speech problems (8.9% of all reported problems) during a 5-year observation period.[42] More than 9% of the patients in this prospective study (7 of 76 people) were seen on more than 10 occasions during the first year, with only 23.7% (18 of 76 people) reporting no technical problems over 5 years.[42]
- Over a 36-month period, 63% of patients with mandibular, screw-retained, implant-supported complete dentures experienced acrylic resin fracture and/or occlusal screw loosening.[49]
- In a 1-year follow-up study of 391 screw-retained implant-supported fixed complete dentures, 14.0% of maxillary prostheses and 1.7% of mandibular prostheses experienced acrylic resin fractures. Speech problems were the most common complication in the maxilla (31.2% of 93 dentures), whereas cheek and/or lip biting was the most common problem in the mandible (6.6% of 287 dentures).[41]

There is also a relatively high incidence of technical complications involving implant-supported FPDs and single-unit crowns, with a number of extensive studies presenting 5- to 10-year data for the first time[22–24,27,43,60,85]:

- A systematic review of 21 papers reported that 13.2% of implant-supported FPDs experienced acrylic or ceramic veneer fracture after 5 years, with screw loosening and screw fracture calculated at 5.8% and 0.4%, respectively, over the same time period.[27] Fracture rates of 0.8% for metal frameworks and 0.4% for implants were also reported after 5 years.
- A prospective multicenter study reported that 86.5% of the original 163 screw-retained, implant-supported FPDs were still in function after 10 years. Technical complications included fractures of the veneering material and screw-related problems, with 21 prostheses either replaced or repaired for these reasons.[43]
- Crown complications appear to be common for single-unit, implant-supported restorations, with 17% of 240 crowns requiring maintenance over a 4-year period, according to a recent meta-analysis.[24] Technical complications reported for implant crowns have included abutment screw loosening,[22,60,85,109] fracture of veneering ceramic,[22,85] and the need for recementation.[22,26,60,85,109]
- A 10-year retrospective study of 126 posterior implants restored with single-unit crowns reported that 7.4% of the prostheses experienced abutment screw loosening, despite undergoing prescribed levels of tightening. The majority of the crowns were cement-retained, with 22.0% requiring recementation on at least one occasion.[60] Provisional cement or direct-to-implant screw retention was used for most crowns to preserve retrievability.

Many of the technical complications of tooth-retained prostheses may also occur in fixed, implant-supported prostheses.[24] For example, ceramic veneer fractures, framework fractures, esthetic deficiencies, and phonetic problems are common complications of both tooth-retained and fixed, implant-supported prosthodontics.[22,24] In the absence of long-term, implant-based data, it is reasonable to consider the incidence of technical complications in conventional prosthodontics as a predictor for implant-related prosthetic problems:

- Meta-analyses of conventional FPDs calculated survival rates of about 90% over 10 years.[110–112] The risk of material fracture was 3.2% over the same period.[110]
- Veneer fracture is a common complication of all metal-ceramic prostheses, with a mean incidence of up to 3% reported for tooth-retained single crowns and FPD restorations.[21] Framework fracture occurred in 2% of tooth-retained FPDs, according to a systematic review of 8 papers and 1,192 prostheses.[21] Most of the fractured frameworks involved long spans and at least 1 cantilevered unit.
- In a longitudinal study of 18 to 23 years, 2.9% of 103 FPDs experienced fractured frameworks.[113]

Technical complications are common in all forms of prosthetic dentistry,[21,22] and they often jeopardize the functional and/or esthetic features of a given prosthe-

sis. When problems such as ceramic and acrylic resin veneer fractures do occur, the ability to remove and repair the prosthesis is a distinct advantage. Implant-based dentistry provides the clinician with the option of retrievability to manage material, esthetic, and phonetic complications without damaging or destroying the prosthesis. The literature suggests that, even in the hands of experienced operators,[40–44,109,114] technical complications occur frequently enough to concern clinicians of lesser experience. In summary, the practice of permanently cementing implant-based prostheses appears to be inconsistent with the high likelihood of technical failure.

Etiology of Technical Complications: Screw-Related Failure

Regardless of their design, implant screw joints are susceptible to screw loosening or fracture, because of the magnitude and direction of oral forces and the strength limitations of the components. Screw-related complications are commonly reported in the dental literature[22,27,43,49,60,85] and may be difficult to manage, especially when the prosthesis has been permanently cemented. This discussion emphasizes the complexities of screw mechanics and the difficulty of maintaining these systems in a hostile oral environment.

It is important to understand the mechanics of screw tightening to appreciate the factors involved in screw loosening.[38] The torque applied to a screw forces the mating screw threads together until the shaft of the screw begins to elongate and produce a clamping force within the system known as *preload*.[115–120] Screw loosening occurs when the clamping force is overcome by forces acting to separate the fastened components.[38,116,121–123] The likelihood of screw loosening is minimized when the screw joint has maximum clamping force and the screw is safely stretched below its elastic limit.[115,117,120,124–127] Unfortunately, the clamping force in a screw joint is very difficult to control owing to a number of factors.[116,118,120,123]

Not all the torque applied to a screw is converted into preload, with both the resistance from misaligned joints[78,110,115,118,128] and frictional resistance[115,120,123,129–132] needing to be overcome before a screw starts to elongate. The greater the misfit and frictional resistance, the less clamping force a given torque is able to generate, and the lower the joint-separating forces necessary to induce screw loosening.[110,115,133–135] For example, when an abutment and an implant do not passively connect, the inserting screw will bend and/or deform to compensate for the misfit.[78,115,128,135] This unpredictably loads the screw joint and increases the risk of screw damage, loss of preload, and/or fatigue failure.[116,118,128]

Screw loosening in fixed, implant-supported prostheses appears to occur through three main mechanisms: embedment relaxation,[117,118,120,121,129] poor component fit,[136–139] and excessive loading of the screw joint.[78,121,140–143] Each of these factors acts to erode the initial preload of the screw. Factors such as operator error,[123,128] torsional relaxation,[118,120,128] and thermal changes[118] may also contribute to screw loosening.

Embedment relaxation, or screw settling, is one reason the torque needed to unscrew a given system is often less than the initial fastening torque.[120,131,140,144] As a screw is being inserted, the surface asperities on the screw threads and opposing flanges are pressed together, preventing complete contact between the surfaces.[117,118,120,121,129,133] Compressing the asperities plastically deforms the contacts and allows the surfaces to settle closer together over time.[117,120,128,129] This settling erodes the initial preload of the screw,[118,121] but it may be counteracted by re-tightening screws after a few minutes[118,123,133,140] and/or avoiding the use of new screws when securing the definitive prosthesis.[120,129]

Studies have attempted to quantify the effects of embedment relaxation on implant screw preload,[120,129,140] with a significant proportion (40.2%) of preload loss in gold prosthetic screws (Nobel Biocare) occurring in the first 10 seconds of tightening.[120] Cantwell and Hobkirk[120] reported an average of 24.9% loss of preload over 15 hours, with no external loads applied to the system. Another study using gold prosthetic screws (Implant Innovations), estimated a preload reduction of 2% after 5 minutes, with about half of this lost immediately after torquing.[129]

Fit discrepancies between implant components are common and may also contribute to screw loosening.[136–139,145] For example, a group of studies considered the effect of component misfit and cyclic loading on abutment screw loosening and reported a direct correlation between machining tolerances and screw joint failure: the greater the rotational freedom of an abutment on an implant, the fewer cycles that were needed to induce screw loosening.[136–138] The implications of abutment casting inaccuracies[139] and geometric variations of interchangeable abutments[146] and abutment screws[145] in screw joint instability are yet to be determined.

The reason that a screw joint with adequate clamping force succumbs to dynamic loading is not fully understood,[132,147–149] but it appears to relate to the potential for movement within the screw joint and the joint's ability to shield the screw from harmful external forces.[143,147,149] A number of studies have investigated the effects of cyclic loading on the performance of implant-related screw joints,[126,140,141,150–155] with nonaxial cyclic loading an identified problem for screw-retained components.[28,38,126,135,138,141]

External forces of greater magnitude than the clamping force of the screw joint will eventually cause screw loosening and/or fracture.[121,123,141,147] These forces include off-axis centric contacts,[36,126,136–138,141] excursive contacts,[36,38,141] cantilevered loading,[78,156,157] and internal stresses created by both component misfit[38,137,138,153,158,159] and framework misfit.[134,158,160,161] It is important to understand that the oral forces acting to loosen and break screws cannot be eliminated, especially in patients with destructive parafunctional behavior.[83,105,162–165]

Etiology of Technical Complications: Prosthetic Failure

These complications are comparable to those experienced in conventional prosthetic dentistry and include ceramic and acrylic resin failures, framework fracture, esthetic deficiencies, and phonetic problems.[21] Failures of fixed prostheses occur when the applied loads exceed a material's proportional limit (in the case of plastic deformation) or a material's breaking strength (in the case of veneer and framework fractures).[166] Fatigue failures occur when microscopic cracks propagate to the point of catastrophic failure[167] and present clinically as wear, fractured margins, delaminations, or bulk fractures.[168]

Ceramic and acrylic resin veneers require sufficient material thickness and support from their underlying frameworks to withstand forces in the oral cavity.[168–171] Veneer fractures may be caused by material failures, design issues, and/or technical errors.[170] Many of these factors can be controlled with technical excellence, but the high incidences of ceramic and acrylic resin veneer failures in prosthodontics[21,22] suggest that the problem cannot be eliminated completely.

Technical errors such as material contamination, casting mistakes, poor alloy surface preparation, and improper ceramic buildup or firing techniques may also result in prosthetic failures.[170,172,173] For example, incompatibilities between an alloy and ceramic greatly affect the mechanism of bonding, often leading to delamination.[172–174] The alloy's grain size and phase structure are also important to clinical performance,[175,176] whereas the cross-sectional dimensions and contours of connectors greatly influence framework strength and stability.[169,171,177]

Framework misfit may also be important in prosthetic and implant fractures.[34,160] It appears that complete passivity of framework fit is not possible in fixed, implant-supported prostheses,[28,31,136,139,160,161,178,179] with evidence suggesting that inaccurately fitting prostheses contribute to implant component loosening and/or fracture.[28,31,137,138,158] The level of misfit beyond which problems arise is yet to be determined[28,158,178,180] and is related to many variables, including the mechanical properties of the prosthetic components, implants, and surrounding tissue structures.[28,158,180]

Implant fractures are not common[23,84] and may be the result of fatigue failure in the presence of heavy occlusal forces and bending overload.[162,181] Posterior-arch cantilevered prostheses retained by a relatively small number of implants appear to be especially susceptible to fracture.[78,182]

Oral forces may contribute to prosthetic and/or implant fracture,[163,164,179] with cantilevered loading of particular concern,[77,78] especially in the presence of parafunctional behavior.[83,162–165] It is important to understand that many cantilevered prosthetic designs are based on biomechanical theories[77,78,156] and have not been clinically validated because of the complexities of oral forces[4,5] and the limitations of in-mouth testing.[4,157,183] Regardless of the prosthetic design, forces acting to break prostheses cannot be eliminated, especially in patients with destructive parafunctional behavior.[105,162–164]

Conclusion

Implant dentistry provides the clinician with the option of retrievability to manage complications without damaging or destroying the attached prosthesis. Biologic and technical complications involving dental implants are widely reported in the dental literature and often jeopardize the functional and/or esthetic integrity of the expensive restoration. These complications often occur despite sound prosthetic design and high levels of clinical expertise, emphasizing the unpredictability of fixed, implant-supported prostheses in the oral environment.

The etiologies of many biologic and technical complications are not fully understood, leaving the clinician to weigh the costs and complexity of treatment against the uncertainty that a given prosthesis will enjoy long-term success. It is important to understand that, whereas the dental literature supports the concept of prosthetic retrievability, much of the evidence is drawn from observational studies. There are currently no randomized, controlled clinical trials dealing with implant-based complications and few meta-analyses. A rationale for retrievability is therefore conditioned on the need for more rigorous, evidence-based investigations with which a clinician may predict complications and determine prognoses.

Despite these uncertainties, the practice of permanently cementing implant-based prostheses often appears to be at odds with the likelihood of biologic and technical failure. The literature suggests that in the hands of experienced operators, complications occur frequently enough to concern clinicians of lesser

experience. The retrievability of fixed, implant-supported prostheses is therefore an important consideration in delivering quality, patient-based treatment outcomes.

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Literature Abstract

The clinical usefulness of surface electromyography in the diagnosis and treatment of temporomandibular disorders

This review on the use of surface electromyography (SEMG) in dentistry looks at recent scientific literature on the use of SEMG in diagnosing and treating temporomandibular disorders (TMDs). This article is not a meta-analysis but a descriptive review. Studies are examined regarding the reliability, validity, sensitivity, and specificity of SEMG as a diagnostic tool. Considering a multitude of biological and technical factors, the authors were not in favor of the reliability and validity of SEMGs. In other words, the diagnosis of TMD is not enhanced by the use of SEMG. The authors conclude that currently, the standard measures used to diagnose TMD remain meritorious. This includes a comprehensive history and examination including determining the range of motion with a millimeter ruler, palpation of the TMJ and masticatory muscles, and when necessary, diagnostic imaging via SEMG may have certain scientific merit in some research, but only under meticulously and adequately controlled conditions.

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