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Evidenced-Based Criteria for Differential Treatment Planning of Implant Restorations for the Partially Edentulous Patient

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Abstract

Evidence-based criteria for differential implant planning for the partially edentulous patient have been lacking despite the exponential use of implant reconstructions. Anecdotal reports are often the basis for training of dental students and the continuing education of dentists and specialists. Decision-making metrics for optimal dental treatment are best predicated on a comprehensive assessment of the systemic, local, and patient-mediated factors evaluated through the lens of the best available evidence. The purpose of this article is to delineate the benefits/risks/alternatives calculus for patients considering implant restorations.

As we celebrate the 30th anniversary of the introduction of the endosseous concept to North America, a number of significant advances in the surgical and prosthodontic arena have enhanced not only implant survival, but also patient satisfaction; however, there remains a robust controversy as to the optimal restorative plan. In accordance with the Commission on Dental Accreditation, which has mandated that graduates must be competent to assess, critically appraise, apply, and communicate scientific and lay literature as it relates to providing evidence-based patient care, the teaching staff at the University of the Pacific Arthur A. Dugoni School of Dentistry (San Francisco, CA) has reviewed these guidelines for student clinical decision making, faculty cross-training, and calibration. The practice of evidence-based dentistry means integrating individual clinical expertise with the best available external clinical evidence.[1] Treatment planning decisions can only be framed in light of the specific patient profile and level of operator expertise, which will define the external validity of pertinent literature. On the basis of internal validity, research methodologies can be placed on the hierarchy of evidence ladder.[2] Clinical experimental research (randomized controlled trials, cross-over designs, and split-mouth studies), in which the investigator introduces changes and keeps the other factors constant, has the highest level of internal validity.[3] Observational research (cohort, case-control, cross-sectional, and case studies) in which groups are described and compared without controls can introduce bias and lead to a lower level of evidence.[3] With this in mind, this article will discuss the indications for (1) implant therapy versus endodontic treatment, (2) single implant crowns vs. tooth-supported fixed dental prostheses (FDPs), (3) implant FDPs, implant cantilevered FDPs, (4) tooth-implant FDPs, (5) splinting multiple implants, cement-retained versus screw-retained implant restorations, (6) implant therapy in patients with a history of periodontitis, (7) the use of short implants, (8) immediate implant placement versus delayed placement with or without immediate restoration.

For each section, the levels of evidence outlined by Sackett et al[4] were designated to stratify the category of scientific rigor available for documentation. They are outlined as follows:

Level IA: Systematic Review of Randomized Controlled Trials; Level 1B: RCTs with Narrow Confidence Interval; Level 1C: All or None Case Series; 2A: Systematic Review Cohort Studies; 2B: Cohort Study/Low Quality RCT; 2C: Outcomes Research; 3A: Systematic Review of Case-Controlled Study; 3B: Case-Controlled Study; 4: Case Series, Poor Cohort Case-Controlled Study; 5: Expert Opinion

A MEDLINE Search was conducted along with a hand search for articles published over the last 20 years on implant restorative treatment for the partially edentulous patient. Both authors independently reviewed the culled articles.

General considerations for implant therapy

Three factors need to be addressed when considering dental rehabilitation. They are the patient's systemic condition, prevailing local factors, and patient-mediated concerns. Specific to implant therapy, a number of systemic conditions, such as acute infections, severe anemia or emphysema, uncontrolled diabetes, uncontrolled hypertension, abnormal kidney or liver function, severe risk of hemorrhage, severe immunocompromize, or the use of IV bisphosphonates, have been considered to be contraindications.[5] Incomplete growth[6] and pregnancy require delay of treatment. Local factors such as quantity and quality of bone, gingival biotype, interarch space, periodontal and restorative status of teeth, anatomic limitations, and need for adjunctive care may influence whether conventional or implant-borne restorations will be preferable.[7] Patient-related factors include finances, time of treatment, anticipated morbidity, surgical exposure, esthetics, hygiene access, and maintenance.[8,9]

Systemic risks for implant therapy

As controlled studies are lacking for most conditions, the level of evidence indicative of absolute and relative contraindications for implant therapy due to systemic conditions is low.[5] Lack of standardized populations and methodologies render these strict delineations unreliable. For example, several factors may influence success rates of implants in irradiated patients. They include source, dose, fractionation of irradiation, concomitant therapies (chemotherapy, hyperbaric oxygen), the timing of the medical and dental intervention, and the anatomic region of implantation.[10,11] The risk of osteonecrosis is always present, but has not been quantified.[12] Regarding the incidence of bisphosphonate-related osteonecrosis of the jaw after implant placement in patients taking oral bisphosphonates, the recent evidence points to a low risk, but the duration, dosage, and type of antiresorptive therapy are reported to play an important role.[13-16] Implant treatment in HIV-positive patients is appropriate, given their immune status is stable (CD4+ cell counts >250 per ml and viral load below 50 per ml).[17] The use of active antiretroviral therapy for HIV infection has significantly reduced the rate of opportunistic infections and extended the life expectancy of these patients.[18] The density of peripheral bone (bone density level 2.5 standard deviations below that of a mean young population) as an index of osteoporosis showed only a weak association with the risk of implant failure, suggesting that simple visual assessment of bone quality at the proposed implant site may be more informative.[5] The assumption that controlled diabetics (Hb1AC < 7%) tend to have higher implant failure rates is equivocal.[19,20] Regarding implant failure rates in patients with recent myocardial infarctions, diagnosis of congestive heart failure, atherosclerosis, and/or hypertension, limited literature is available, pointing to no significant association.[21] A current consensus found smoking to be a factor in higher implant failure and postoperative complications.[22] A literature review found an increased risk of periimplantitis in smokers compared to nonsmokers (odds ratios from 3.6 to 4.6) while the combination of a history of periodontitis and smoking increases the risk of implant failure and periimplant bone loss.[23] Finally, there have been attempts to jointly evaluate several factors that may lead to implant failure. Age, gender, smoking habits, alcohol, diabetes, radiotherapy, osteoporosis, impaired immune defense, psychological disorders, and bruxism were analyzed in patients with multiple implant failures in the maxillae compared to matched controls.[24] The significant variables, aside from less favorable bone volume, were bruxism and addiction to alcohol and tobacco. Moy et al[20] completed a multiple regression analysis to assess gender, implant location, hypertension, smoking, chemotherapy, diabetes, coronary artery disease, steroids, asthma, head and neck radiation, and postmenopausal hormone replacement therapy in over 1000 implant patients. The only variables having a significant predictive index were location in the maxillary arch, diabetes, smoking, and head and neck radiation. In general, the investigations on potential systemic risk factors are restricted to retrospective cohort studies or case reports and case series or Level 3/4 Evidence, and more definitive assessments serving as the basis of consensus statements will rely on future controlled studies.[5,25] For example, a controlled study on antibiotic prophylaxis before implant placement may demonstrate a protective effect in patients with assumed systemic preclusions.[26]

Local factors influencing implant therapy

The location of the tooth may influence the probability of a successful outcome with an implant restoration. The anterior maxillary region often is an esthetic challenge with implant replacement of teeth, which can be complicated with thin biotype and a high lip line.[27] The esthetic success of the implant restoration is predicated on the correct 3D position of the implant in bone. The implant should be in a position with at least 2 mm of buccal bone, approximately 3 mm apical to the mid-buccal cementoenamel junction of the adjacent teeth and 1.5 mm from the adjacent tooth.[28] Thin biotype has been reported to be associated with 1.8 mm marginal mucosal recession as opposed to thick biotype with 0.6 mm recession.[29] In regard to the influence of biotype on implant esthetics, Fu et al[27] recommended a management triad for thin biotype with a concave abutment and crown profile, more palatal and apical implant placement with a straight-walled platform using platform switching. Implant survival in the posterior maxilla has been reported lower in the presence of inadequate residual crestal bone height requiring sinus augmentation.[30] The need for interceptive intervention with orthodontics[31] (e.g., space management, extrusion, optimization of occlusal scheme), periodontics[32] (e.g., subepithelial connective tissue grafting), and/or surgical grafting[33] all involve additional risk factors and are both operator- and technique-sensitive. The presence of chronic periodontitis is also a significant risk factor for late implant failure.[34,35] Finally, if a patient has had an implant failure, the odds of having a second implant removed has been reported as 1.3 times greater.[36] The link between periodontitis and implant failure is supported by Level 2A evidence. The implant site development by orthodontic extrusion is documented with Level 2A evidence, and the other local factors influencing implant therapy are supported by Level 3B and 4 evidence. At this juncture, there is no definitive data on platform switching to preserve marginal bone levels[37] or the importance of a keratinized gingival zone for long-term maintenance of periimplant health.[38] Split-mouth designs will assist in higher levels of evidence for clinical decision making and prognosis.

Indications for endodontic therapy versus implant treatment

A meta-analysis addressed the relative survival rates of single-tooth implants versus endodontically treated and restored natural teeth (approx. 12,000 implants/23,000 teeth) and reported equivalent outcomes.[39] Although these two treatment regimens have demonstrated similar survival rates, the implant group has shown a greater incidence of postoperative complications (e.g., prosthetic repairs, soft tissue maintenance),[40] and consideration of multiple risk factors are needed to determine the most predictable and satisfactory restoration.[41] Therefore, the decision to treat a tooth endodontically or to place a single-tooth implant should be based on other criteria such as prosthetic restorability of the tooth, esthetic demands, cost-benefit ratio, potential for adverse effects, and patient preferences. The evidence comparing the survival rates of single-tooth implants to endodontically treated and restored teeth is Level 3A, and the comparison of aftercare burden is Level 3B. Although the level of evidence is not of the strongest rigor, it is reasonable to strategize from the meta-analysis[39] that survival rates are comparable, and decision-making rubrics will need to be based on clinician- and patient-related factors.

Local factors influencing endodontic therapy

Specific tooth factors will affect prognosis for endodontic success: The root anatomy/presence of calcification, remaining coronal structure (1.5–2 mm available ferrule and adequate dentin thickness), need for orthodontic extrusion, periodontal condition including furcation involvement, history of endodontic failure and quality of treatment, presence of periapical radiolucency, tooth position in the arch, absence of tooth/root perforation, the absence of sinus root-filling extrusion, cleaning canal as close to the apical terminus as possible, presence of satisfactory coronal restoration, and caries index.[41] When endodontic retreatment is indicated, either conventionally or surgically, the use of dental operating microscopes and hand instrumentation combined with nickel titanium rotary instruments, advanced electronic apex locators, microsurgical/ultrasonic instruments, thermoplastic gutta-percha delivery devices for root canal obturation, and CT-guided surgery have made this strategy the second line of defense before extraction and implant placement.[42-47] The evidence evaluating local factors influencing endodontic versus implant therapy is characterized by Level 3B and 4. Results of a number of earlier investigations suffer from a modest level of evidence and dated techniques. Recent material and technical advances in both implant and endodontic treatment need to be reflected in well-designed studies. Specifically, controlled studies are needed to assess prognoses when periapical radiolucencies exceed 5 mm in diameter and when there is presence of internal or external resorption.[48]

Patient-mediated factors

Insurance data from a 2005 analysis estimated that a restored single-tooth implant (without adjunctive interdisciplinary care) is about 75% to 90% more costly than a similarly restored endodontically treated tooth.[49] Informed consents should include differences in treatment cost, time, and maintenance, as implant restorations require a longer average time to function (up to 250 vs. 67 days) and have a higher incidence of technical postoperative complications requiring subsequent treatment intervention (18% vs. 4% over 6 years).[38] However, reports of technical complications are rarely divided into major (implant fracture, loss of superstructure), medium (veneer or framework fractures), and minor (screw loosening, loss of screw hole restoration) problems.[50] The decision to endodontically retreat or extract a tooth will also be predicated on the strategic position of the tooth in a restored prosthesis, which will impact cost, time, and maintenance projections for the patient. The evidence documenting patient-related considerations in implant therapy ranges from Level 3B to 4. Medical ethics preempt performing controlled studies on the influence of patient-mediated factors in treatment selection.

Indications for tooth-supported FDPs vs. single implant crowns

When comparing the long-term survival of metal ceramic FDPs to single implant crowns (SC), Pjetursson et al[50] reported a surprisingly scant difference in the 10-year survival rate (89.2% vs. 89.4%, respectively); however, a 10-year prospective study assessing the clinical outcomes of adhesively placed FDPs with zirconia frameworks reported only a 67% survival rate, due to biologic and technical complications.[51] Survival was defined as the reconstruction remaining in situ with or without modification over the observation period, as opposed to success, which was defined as free of all complications over the entire observation period. Conventional metal ceramic FDPs have been shown to have a 10-year success rate of 71%.[52] Causes for restoration loss include caries (2.6%), abutment fracture (2.1%), and periodontitis (0.5%), while restorable complications include loss of vitality (10%), caries (9.5%), loss of retention (6.4%), and risk of material fracture (3.2%).[52]

Ten-year success rates for SCs have not been published, but a 5-year success rate for SCs was documented at 76.1%.[53] However, esthetic problems were not included in this analysis, which was reported in another study to be as high as 9%.[54] Soft-tissue inflammation/periimplantitis occurred adjacent to 9.7% of the SCs (6.3% of the implants had bone loss exceeding 2 mm). The cumulative incidence of implant fractures was 0.14%. Screw or abutment loosening was 12.7% and 0.35% for screw or abutment fracture. Loss of retention was 5.5%. For suprastructure-related complications, ceramic fractures and framework fractures were 3.5% and 3%, respectively.[55] Statistical analysis revealed no significant differences between the cement- and screw-retained SCs with respect to periimplant marginal bone levels and soft tissue parameters, when careful protocols were followed for cement removal.[56] As with conventional FDPs, failure and complication rates have been reported to be higher with all-ceramic SCs, with veneer fracturing the predominant problem.[57] While there is an insignificant difference in the survival rate of FDPs and SCs, biologic and technical complications for SCs may be underestimated because of underreporting in as many as 60% of studies.[58] Notwithstanding this observation, optimal prosthetic design will again be predicated on systemic,[59] local,[60] and patient-related factors.[61] Local factors include both the need for restoration and restorability of the teeth bounding the prospective implant site, the quality/quantity of bone, periodontal condition of the teeth,[62] the indication for interdisciplinary care to optimize the implant site, caries index, and the esthetic predictability of the two regimens.[63,64] The evidence characterized by the studies used to compare conventional FDPs with implant therapy is Level 2A. While the level of evidence is relatively high with prospective studies comparing these two treatment modalities, a 10-year follow-up on the maintenance of implant single crowns would be helpful for a more meaningful comparison of success rate.

Indications for implant FDPs (IFDPs) and implant cantilevered FDPs (ICFDPs)

A systematic review reported the 10-year survival of IFDPs to be 86.7%, which is only 2.7% lower than SCs. Biologic and technical complications were reported at 31.4% after 5 years.[50,65] Esthetic problems were not included in this analysis. The distribution of these complications was as follows: periimplantitis (8.6%), ceramic fracture (8.8%), loss of retention (5.7%), abutment or occlusal screw loosening (5.6%), fracture of abutment/occlusal screws (1.5%), framework fracture (0.7%), fracture of implants (0.5%).[50,65] A major difference in the comparative cumulative complications of IFDPs and SCs is the incidence of ceramic fracture. Therefore, parafunction is a potential contraindication to the use of the IFDP, particularly in the posterior arch, unless the patient can acquiesce to metal occlusal design or/and the use of an orthotic.[65] However, in a study of 379 patients who had worn implant restorations for many years, occlusal wear had no statistical impact on periimplant bone loss.[66] Other authors have concluded that nonaxial loading has not been shown to be detrimental to osseointegration.[67,68] To avoid technical complications, occlusal recommendations for implant restorations should include light centric occlusal contact (shimstock should pass through the teeth when the patient is not clenching and be grasped only when the patient fully activates the masticatory muscles). Posterior implant restorations should have no or shared excursive contact (when anterior guidance is absent) and anterior restorations should have shared excursive contact.[69]

In summary, indications for IFDPs include space considerations, preservation of papillae, avoidance of anatomic barriers and cost considerations. For example, given that 1.5 to 2 mm is required between implant and adjacent tooth, and 3 mm is the optimal space between implants,[70] an IFDP offers a viable alternative when the mesial-distal space will not allow for appropriately sized individual implant/crowns. Esthetic zone considerations may also favor an IFDP. It has been demonstrated that only 3 to 4 mm of soft tissue forms coronal to the interimplant crestal bone, but at least 50% more papillary fill can be expected between the implant crown and pontic.[71,72] In addition, by eliminating the middle implant, surgical risks may be reduced when anatomic limitations are present. On the other hand, if patients have a premium on hygiene access, and a nonsplinted design is biomechanically sound for the patient, one crown per implant may be preferable. One advantage of placing one implant per crown in a splinted three-tooth array is that if there is a failure of one implant, a ready-made prosthesis can be converted. Drawing a comparison between the implant survival of an SC and an IFDP is not the same as comparing three implants supporting three crowns versus an IFDP; however, a 5-year study by Vigolo and Zaccaria[73] evaluated 44 patients with three consecutively placed adjacent implants in the posterior maxillae of diverse bone qualities (both splinted and nonsplinted designs) and demonstrated a 92.7% implant survival rate, which is similar to that for SCs. The evidence evaluating the survival and maintenance of IFDPs is Level 2A, while the evidence culled for functional, occlusal, esthetic, space, and cost considerations ranges from Level 2B (Vigolo and Zaccaria) to Level 5. Controlled studies with specific inclusion criteria would be especially useful in determining when to place one implant per tooth or design an FDP in patients with parafunction, opposing implant prostheses, short implants, and grafted bone.

The 10-year survival of ICFDPs was similar to IFDPs, at 88.9%.[74] However, the 5-year cumulative technical and biologic complications were reported at 37%, not including esthetic problems. Technical complications include veneer fractures (10.3%), followed by screw loosening (8.2%), loss of retention (5.7%), abutment/screw fracture (2.1%), and implant fracture (1.3%). The incidence of periimplantitis at the prosthetic level was 9.4%, but no detrimental effects or bone loss have been attributed to this design around implants proximal to the cantilever.[74,75] This observation is in accordance with Blanes et al, who documented the lack of influence of the mesial and distal cantilever extensions on periimplant bone-level changes.[76] Nonetheless, the incorporation of cantilevers into implant-borne prostheses may be associated with a higher incidence of minor technical complications.[77] To date, there is a paucity of evidence on the superiority of designing the cantilever on the mesial or distal end and number of implants supporting the prosthesis on the incidence of complications.[74,75] It should be noted, however, that investigations on ICFDPs with two- or three-implant support[78] performed better than those with one-implant support.[79] There is sound rationale for planning infra-occlusion on the cantilevered segment with no lateral guidance contact.[69]

In summary, ICFDPs are to be used with caution because of their higher incidence of technical complications (bruxers should be excluded) and the need for a mechanically sound crown-to-abutment ratio, if cement-retained restorations are planned. With inadequate space or anatomic limitations (requiring higher risk augmentation procedures) for the placement of one implant per tooth in a multiple array in the anterior sextant, and/or in thin biotypes with high smile lines,[80] a cantilevered implant prosthesis offers an alternative treatment modality.[81]

The evidence evaluating the implant survival and maintenance of ICFDPs is Level 2A. Although the scientific rigor of the evidence is relatively high to support implant cantilever designs, mechanical limitations are not reflected in the documentation. For example, if the interarch space is minimal (6–7 mm), and the implant axis demands a cement-retained design, a short abutment height may not retain the suprastructure predictably.

Indications for combined tooth/implant FDPs (TIFDP)

A systematic review reported the 10-year survival rate at 77.8%.[82] Failure rates of the abutment teeth and implant abutments were not significantly different.[83] The 5-year cumulative biologic and technical complication rate was estimated at 32.9%. These were distributed as follows: biological complications (11.7%), veneer fractures (9.8%), loss of retention (6.2%), abutment/screw loosening (3.6%), abutment/screw fractures (0.7%), and implant fractures (0.9%), with an intrusion rate of 5.2%.[82] Fugazzotto et al[84] examined over 3000 sites with implant/tooth connections after a follow-up period of 3 to 14 years and detected intrusion in only nine cases. Their finding was consistent with others: that intrusion in TIFDPs is found almost exclusively in designs with nonrigid connections.[85] In a systematic review comparing the prosthetic success rates of SCs, IFDPs, and TIFDPs over a 6-year follow-up period, none of the differences were statistically significant.[86] The evidence supporting the implant survival and maintenance of TIFDPs is Level 2A. The intrusion studies are characterized by Level 3B. In summary, the indication for the TIFDP design would be only in highly selected cases when anatomic structures or patient-centered needs would necessitate higher risks in executing a totally implant-supported design.[82]

Indications for splinting multiple implants

Several in vitro studies have reported conflicting results for splinting implant units as far as minimizing the stress transfer to restoration and supporting bone.[87-91] The concept of splinting implants has been extrapolated from splinting teeth where the assumption that joined linear and noncollinear units improve the resistance to forces and alter the center of rotation of the joined units.[92] However, clinical implant studies may not replicate the natural tooth model.[93] For example, Glantz et al[94] documented unexpectedly high functional bending moments on implants on maximum biting and chewing in a conventional cross-arch splinted restoration. Finally, Vigolo and Zaccaria[73] evaluated 144 splinted and nonsplinted implants in 32 patients using a split-mouth design in the posterior maxilla with a 5-year observation period. They found no difference in marginal bone loss between the two designs. It is of note that only external hexagon implants were used, and similar conclusions were reported with internal-connection implants.[95]

In summary, the indications for splinting may include short or narrow implants, crown-to-implant ratios >1:1, angled implants, high loading forces, and immediate function.[73,91] An advantage of nonsplinted implants is the elimination of large prostheses with large quantities of ceramic and metal, which may reduce the risk of veneer and framework fracture.[73] In addition, multiple screw-retained units are easier to achieve passive fit when nonsplinted, reducing static preload forces on implants, and are easier to repair than splinted units.[88] Further, patients appreciate the hygiene access and natural appearance of nonsplinted crowns.[95]

The in vivo evidence comparing splinted and nonsplinted designs is Level 2B. Only in vitro studies are available to evaluate risk factors such as crown-to-implant ratios, short/narrow implants, presence or absence of a terminal natural tooth abutment, and high loading forces. Controlled clinical studies are needed to assist in treatment planning.

Indications for cement-retained versus screw-retained implant restorations

A number of articles have compared the clinical performance of cement- and screw-retained implant-supported restorations, demonstrating similar success rates.[56,96-98] However, Nissan et al, using a split-mouth design with up to a 15-year follow-up, found increased complications with the screw-retained restoration.[99] Ceramic fracture (38% vs. 4%) and abutment screw loosening (32% vs. 9%) were found to be significantly higher. In screw-retained restorations, the presence of an occlusal access hole may disrupt the structural continuity of the porcelain.[100] Metal occlusal designs for screw-retained restorations have been recommended in bruxers to minimize porcelain fracture. Regarding screw loosening, more recent techniques of torque control (50% to 75% of yield strength) with gold screws and retorquing the screw 5 minutes after initial torque to achieve an increased preload, have reduced screw loosening.[101,102] Given these data and evolving technologies, the decision to use either screw- or cement-retained restorations will be best dictated by clinician- and patient-mediated factors.[103-105] The evidence comparing the clinical performance of cement-retained versus screw-retained designs is Level 2B. Despite the relatively strong evidence of higher complications with screw-retained designs, cited by Nissan et al's investigation,[99] the results must be evaluated through the lens of dated materials. Use of textured implants has eclipsed machined surfaced fixtures and are not reflected in longitudinal studies (up to 15 years). Implementation of resin cements has also become more common over recent years. Perhaps the soft tissue indices found to be more favorable for cement-retained crowns would be negated by the incidence of cement extrusion on highly retentive rough-surface implants using radiolucent cements, preventing radiographic evaluation. Regardless, when cement-retained implant designs are selected, internal venting, use of a radiopaque cement, careful debridement, and radiographic verification are all recommended.[106]

In summary, the following recommendations have been offered in the literature. When the implant is not placed in the ideal position, a custom cast or CAD/CAM abutment can often reconcile divergent angulation.[107] Cement-retained restorations may also be indicated for patients with limited jaw opening, but require 6 to 7 mm interach space as opposed to 4 mm for a screw-retained design.[108] Ideal cement retention will be contingent on factors such as taper, reciprocating walls, surface area and height, surface roughness, and type of cement.[109-111] The choice of cement is limited to radiopaque compositions and may be dependent on intended retrievability and mechanical retention and resistance of the abutment.[106] However, predictable retrievability can best be achieved with a screw-retained restoration. A technique for locating the abutment screw under a cement-retained crown with a well-placed ceramic stain may offer some reversibility when crown debonding is not feasible in cement-retained designs.[112] Combining screw- and (temporarily) cement-retained restorations in the same multi-unit prosthesis allows for flexibility of design and retrievability.[113,114] Esthetic demands by patients may dictate a cemented restoration in the posterior quadrants, although opaquers can disguise the access opening.[115] In the anterior sextants, thin biotypes may favor a cement-retained design with a zirconium abutment, which also may have less attraction to biofilms than titanium does.[116]

History of periodontitis as a risk factor for implant failure/marginal bone loss

There is a moderate level of evidence that periodontitis patients carry a significantly higher risk for implant failure and progressive bone loss around implants.[117-119] Most reported patients had advanced or aggressive periodontitis, suggesting increased susceptibility in more progressive forms of the disease.[117] In a long-term study by Anner et al,[120] evaluating patients with periodontitis and cofactors, the effects of smoking, diabetes mellitus, and supportive periodontal treatment on implant survival were investigated. Smoking, not diabetes, was statistically associated with implant failure rates, which was consistent with other studies.[121,122] On the other hand, periodontitis patients had statistically favorable implant survival rates, if they were under a high level of maintenance care and had very good plaque control.[123] Therefore, implant therapy should be pursued in patients with a history of periodontitis only after successful adjunctive surgical or nonsurgical care followed by a commitment to long-term periodontal maintenance. The evidence discussing the link between periodontitis and implant failure ranges from Level 2A to 3B. While the level of evidence to link periodontitis to implant failure is not weak, periodontitis is one of a group of multifactorial diseases in which pathogens trigger host chronic inflammatory and immune responses. As genetic typing becomes more mainstream, controlled studies may in fact be able to predict which subset of periodontal patients may be most at risk for implant failure.[124]

Indications for the use of short implants

The development of new surface treatments and implant designs has facilitated the use of short implants as an alternative to the choice of advanced surgical techniques to obtain a greater amount of bone.[125] A meta-analysis reported a 6-year follow-up of short textured implants at a cumulative survival rate of 98.8%.[126] Another meta-analysis divulged no statistically significant differences in survival between short (≥8 mm or <10 mm) and conventional (≥10 mm) rough surface implants placed in partially edentulous patients.[127] The use of wider body implants is indicated with short implants because they have been shown to increase the functional surface area by 30% to 200%.[128] While no difference has been discerned between single and two-stage implant placement for short implants, a self-tapping surgical protocol has been recommended.[128] The evidence drawn on to evaluate short implants is Level 2A.

In summary, based on a Cochrane systematic review, short implants appear to be a better alternative to vertical bone grafting of resorbed mandibles, as complications for vertical augmentation are common.[129] It is still unclear whether short implants are more predictable in the posterior maxilla, in comparison to longer implants with sinus augmentation, as there are only a few comparative randomized controlled trials with short follow-up.[130,131] The placement of additional implants and splinting are recommended to offset unfavorable crown-to-implant ratios (>1:1), if present, to improve prosthetic stability when opting to use short implants.[126]

Indications for immediate placement versus delayed placement with or without immediate restoration

In evaluating the effectiveness of placing implants immediately into fresh extraction sites compared to placing implants in completely healed bone, 3 to 4 months after extractions (delayed placement), there is a suggestion that immediately placed implants may be at higher risk of implant failures and complications than delayed implants.[132] Notwithstanding this risk, the esthetic outcome may be better when placing implants just after tooth extraction.[133] Regarding the optimal technique of grafting immediate implants placed in fresh extraction sites, there is insufficient reliable evidence supporting or refuting the need for augmentation procedures or whether any of the augmentation technique is superior to the others.[134]

When comparing immediately restored implants in healed sites with a delayed loading protocol in the esthetic zone, there was no difference, resulting in a 5-year survival rate of 96.7%, although success criteria such as stable bone levels, soft tissue recession, pink esthetic index, and probing depth could not be clearly evaluated on the basis of this study.[135] With immediately placed implants, immediately restored and occlusally loaded, survival dropped by 10%.[135] Here a distinction needs to be made between a provisional implant restoration occlusally loaded and one with nonfunctional loading. Noelken et al[136] demonstrated equally high implant 5-year survival rates of 96.8% when nonfunctionally loaded immediate interim prostheses restore immediately placed implants. It is of note, however, that immediately restored and functionally loaded implants in healed bone have shown differences in success depending on the site. For the posterior maxilla, this rate appears to be technique sensitive. Randomized clinical trials are needed for immediately restored protocols in this region to be evidence-based.[137] A split-mouth design study demonstrated no difference, after a 2-year follow-up, in immediate restoration and delayed loading in the posterior mandible.[138] A 5-year prospective clinical multicenter study reported 95% implant survival with the use of wide-body single molar implants immediately restored in the mandible.[139] Evidence used to assess implant loading protocols is Level 2B. Future controlled studies to allow for a multivariate analysis of the influence of host, site, diet, and implant length on immediate loading protocols are recommended using the pink esthetic index.

In summary, indications for immediate restoration of implants are dependent on patient, site, and operator selection. Gapski et al[140] underscored the importance of implementing immediate (nonfunctional) load procedures only on patients who do not have systemic conditions, such as diabetes, hyperparathyroidism, and immunocompromise, which may cause wound healing delays. Smokers, patients with periodontitis, and bruxers are also not appropriate risks for this loading protocol.[141,142] Prevention of micromotion appears to be critical with a nonfunctional occlusal contact (for 8 weeks) and a primary insertion torque of at least 35 Ncm, which is perhaps why the posterior maxilla appears to be not as predictable as the anterior sextants and posterior mandible.[143] With the aim of preserving the soft tissue architecture in the esthetic zone and truncating the surgical timeline, immediate placement and nonfunctional loading (or the use of a customized anatomic healing abutment) offer relatively predictable techniques to preserve the facial gingival line, even with challenging thin biotypes. The effect of gingival biotype on periimplant tissue response seems to be limited only to facial gingival recession and does not influence interproximal papilla dependent on proximal marginal bone.[143] Finally, it is propitious for an experienced surgeon (>50 implants) to be engaged in immediate placement procedures.[144]

Summary

To develop greater predictability in differential implant treatment planning of the partially edentulous patient, an in-depth analysis of the systemic, local, and patient-mediated considerations must be weighed in light of the best available evidence to date. This will reveal a customized risk assessment profile. A comprehensive informed consent will be predicated on this approach. Future studies with improved controls, larger sample sizes, and longer follow-up will continue to enhance clinical decision making. Based on the present evidence, methodologies with improved scientific rigor are most needed in the areas of systemic and local factors influencing implant survival/success and factors in selecting endodontic versus implant therapy. In addition, a more detailed and predictable risk factor analysis is required for splinting implants and immediate placement and/or provisionalization by customizing the inclusion and exclusion criteria of future controlled studies. Finally, new investigations should reflect current advances in materials and techniques and be more relevant to present-day implant treatment scenarios.

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