Risks and Benefits of Connecting an Implant and Natural Tooth

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Purpose: *The purpose of this article was to review the current literature on the topic of tooth-implant supported fixed partial dentures (FPD) to determine risks and benefits for treatment planning considerations and weighing potential complications.*

Materials and Methods: *A PubMed search (April–August 2013) was performed using the keywords "tooth-implant fixed partial denture" and "tooth-implant bridge" in addition to manual searches of bibliographies of full text articles and related reviews from the electronic search.*

Results: *A total of 21 relevant articles were selected for inclusion in the topic of tooth-implant supported FPD. Although risks such as intrusion of the natural tooth existed when using tooth-implant FPD, however, current evidence supports its clinical usage. Nonetheless, to prevent potential complications, careful planning and prosthetic design are essential.*

Conclusion: *Tooth-implant supported FPDs can have the similar success like conventional FPDs or implant-implant supported FPDs. However, careful planning and prosthetic reconstruction are required to ensure long-term success. Additional research is needed to gain a greater understanding of the biological and biomechanical factors affecting tooth-implant FPDs. (Implant Dent 2014;23:253–257)*

Key Words: fixed partial denture, dental implant, bridge, marginal bone loss, survival rate

The topic of tooth-implant supported fixed partial dentures (FPDs) has been presented in literature since the early 1980s.[1] Since this time, authors have been calling for more studies either *in vitro* or *in vivo* to explore the biological and mechanical considerations of rigid and nonrigid incorporation of natural teeth and implants.[2–4] Most recently, a study examining traditional tooth supported FPDs and implant-implant FPDs only included 1 mixed tooth-implant supported denture.[5] The following is a summary of considerations and complications described in various studies. Esposito et al[6] proposed that a successful osseointegrated implant should include: function (ability to chew), tissue physiology (presence and maintenance of osseointegration, absence of pain, and other pathological processes), and user satisfaction (esthetics and absence of discomfort).[6] Similarly, the implant success criteria suggested by Albrektsson et al[7] limited to machined-surface implants: (1) The individual, unattached implant is immobile when tested clinically, (2) no radiographic evidence of periimplant radiolucency, (3) vertical bone loss less than 0.2 mm annually after the first year of loading, (4) absence of persistent and/or irreversible signs and symptoms such as pain, infections, neuropathies, paresthesia, or violation of the mandibular canal, (5) considering the previously stated criteria, minimum success rates of 85% after 5-year follow-up and 80% after 10-year follow-up. One advantage of tooth-implant supported FPDs versus implant-implant FPDs is increased tactile perception of natural teeth abutments, shown to be 8.8 times greater than implant abutments,[8] and in turn provides patients with increased chewing comfort. Other indications for tooth-implant supported FPDs are individual patient preference and limiting invasion of anatomical structures by implant-supported prostheses. Several anatomical and biological factors contribute to the inherent risk associated with tooth-implant supported FPDs such as the mobility of natural teeth due to the periodontal ligament (PDL); a 0.1 N force has been shown to cause movements of 50 to 200 μm.[9] Conversely, osseointegrated implants move less than 10 μm when connected to an FPD thus the prostheses likely will act as a cantilever.[10]

Advantages of Tooth-Implant Supported FPDs

Lang et al[11] discussed the ability for tooth-implant FPDs to provide patients with the unique ability to improve partially edentulous or nonfunctional

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occlusal schemes with fixed prostheses. Table 1 lists the benefit of using natural teeth in combination with implant-supported prostheses, which include but not limited to: reduced cost, avoidance of vital structures (depending on proposed implant placement proximity to structures such as mandibular nerve or mental foramen), reduced need for advanced graft (if implant is proposed in area of ridge deficiency), and improved patient acceptance.[8,11,12]

RISKS ASSOCIATED WITH TOOTH-IMPLANT FPDS

One of the major concerns surrounding tooth-implant supported FPDs is intrusion of the natural tooth. This phenomenon may be explained by the following theories: disuse atrophy (due to splinting to an implant a hypofunctional state is induced), differential energy dissipation (natural teeth are exposed to higher-than-normal forces due to rigid nature of implants, which stimulates osteoclastic activity of the PDL), mandibular flexure (due to the muscles of mastication and facial expression on opening, closing, and other facial movements), FPD flexure (framework flexure during function), impaired rebound memory (constant pressure on PDL causes loss of elastic memory), debris impaction or microjamming, and ratchet effect (similar to impaired rebound effects, due to unknown binding effects associated with the socket or attachment apparatus).[13,14] Intrusion of prostheses occurs in 20% of cases for providers with less than 4 years' experience, which decreases to less than 4% for providers with more than 10 years' experience[15]; however, these numbers were obtained through a survey of 45 respondents

Table 1. Advantages of Tooth-Implant Supported FPDs

Benefits of Tooth-Implant Supported FPDs
Increased tactile perception—greater chewing comfort and efficiency
Avoidance of vital structures
Reduced cost
Reduced need for advanced graft
Improved patient acceptance

from a pool of 110 distributed surveys. Other respondents from the survey suggested that coping design resulting in a lack of retentiveness might affect tooth migration and that teeth with mesial inclination were prone to migrate.[15] Rieder and Parel[15] go on to state that apical migration of teeth typically cannot be explained with a single causative factor, rather the occurrence is random and the cause could be mechanical or biological.

Fugazzotto et al[16] in a retrospective study of 2 private practice settings over the course of 10 (ranged from 3 to 14 years) years found that 843 patients received 1206 tooth-implant supported FPDs. All FPDs were screw retained, the authors stated that all FPDs were removed at least once per year and more frequently if problems warranted FPD removal. Of the 1206 FPDs, only 9 intrusion complications arose; all intrusion events were attributed to loss or fracture of retention screws.[16] In a survey of the American Academy of Osseointegration in June 1995, 2384 members were asked, with 775 respondents (32.5% response rate) a series of questions regarding implant-assisted FPD.[17] The authors found that the incidence of intrusion associated with tooth-implant FPDs was 3.5%.[17]

Naert et al[18] conducted a case study with follow-up (1.5–15 years; average 6.5 years) including a test group of 123 patients (339 implants fixed to 313 abutment teeth) and a control group (random) of 123 patients (329 implants fixed to implants—123 stand-alone FPD) were followed (1.3–14.5 years; average 6.2 years). Over time, complications with the implant-tooth group included: periapical lesions (3.5%), tooth fracture (0.6%), extraction (decay or periodontal disease) (1%), intrusion (3.4%), and cement failure (8%). The majority of implant failures was in the implant-tooth group (10) compared with only 1 in the implant-implant group, suggesting that the stand-alone option should be considered.[18] Furthermore, authors suggested that to prevent intrusion, abutment connections should be rigid.[18]

Gunne et al[19] conducted a 23-patient, 10-year longitudinal, posterior mandible, split-mouth design study with short implants (7–13 mm). Twenty patients completed the 10-year follow-up, with no implants lost after 2 years of observation, and no difference in implant failure rates between tooth-implant or implant-implant supported FPD. Results obtained from this study showed short implants are a viable option for treatment in the posterior mandible as the implants used in this study were 7 mm [37 implants {54%}] and 10 mm [29 implants {42%}], with similar frequencies of failures (3 and 4, respectively).[19] Although considering the anatomical limitations, studies suggest that there are no differences between an implant-supported FPD and tooth-implant–supported FPD over 5 or 10 years.[19,20] Table 2 lists all the potential risks associated with tooth-implant FPDs.[1,5,11–13,15–18,21,22]

SURVIVAL OF IMPLANTS

In a meta-analysis of 8 tooth-implant prosthesis studies that followed implants over 5 years found an estimated survival rate of 90.1% (82.4%–94.5%) from a total of 932 implants with 90 failures.[11] In 10-year follow-up studies (5 in total), an estimated 82.1% (55.8%–93.6%) survival rate was noted in a total of 143 implants.[11] In the previously reviewed studies, information is limited regarding the type of FPD and retention method applied. Lang et al[11] stated that FPD designs included a slight preference for metal-ceramic over gold-acrylic, and the majority was cement retained over screw retained (91%–9%, respectively,

Table 2. Risks of Tooth-Implant Supported FPDs

Intrusion of natural tooth
Biomechanical complications
Fixture-abutment failure
Loss of retention
Screw loosening/fracture (implant)
Cement failure (implant/tooth)
Fracture (tooth)
Caries (tooth)
Crown fracture
Loss of natural tooth
Endodontic involvement
Fracture
Caries
Periodontal disease
Peri-implantitis

in the studies that stated the design of FPD). Block et al[21] performed a trial where cross-arch-design-incorporated 3-unit tooth-implant FPDs were placed with a rigid or nonrigid design. They found that over the course of 5-year follow-up there was no significant crestal bone loss around implants serving as abutments.[21]

FPD Survival

Survival of FPDs is defined as the FPD remaining *in situ* without modification for the observation period.[11] A summary of the 5 and 10-year FPD survival rates can be found in Table 3 and Table 4, respectively. In meta-analysis review of 5 studies that included 115 combined tooth-implant supported FPDs, it was found that 7 FPDs failed over the course of 5 years for an estimated survival rate of 94.1% (90.2%–96.5%).[11] In review of 4 studies that followed 72 combined FPDs for 10 years, 14 failures were observed for an estimated survival rate of 77.8% (66.4%–85.7%).[11] This contrasts a review conducted by Pjetursson et al[23] which found that over 5 years, there was no difference between the failure rates of different FPD types [5.9% {tooth-implant} versus 5% {implant-implant}]; however, the 10-year outcomes saw a much higher difference between tooth-implant (22.2% failure) and compared with implant-implant supported prosthesis (13.3%). The authors concluded due to the high complication rate of implant-implant supported FPDs (38.7% over 5 years), patients and providers must fully understand this potential risk before proceeding with treatment.[23] Nonetheless, Block et al[21] suggested that since the cohort size of many tooth-implant studies are small, the need for additional research in the field is necessary and recommends that a more rigid connection be used through the 2 abutments and only when patient preferences or anatomically the indication warrants a tooth-implant borne FPD.[11]

Table 3. Five-Year FPD Survival Rates

Study	Tooth-Implant (%)	Implant-Implant (%)
Koth et al[1]	95.50	N/A
Wolleb et al[5]	100	100
Lang et al[11]	94.10	N/A
Naert et al[18]	95	98.50
Gunne et al[19]	91.30	82.60
Pjetursson et al[23]	94.10	95
Brägger et al[22]	88.90	90
Brägger et al[24]	68.2	93.9

Table 4. Ten-Year FPDs Survival Rates

Study	Tooth-Implant (%)	Implant-Implant (%)
Lang et al[11]	77.80	N/A
Gunne et al[19]	85	80
Pjetursson et al[23]	77.80	86.7

In a series of nonlinear finite element analyses articles, Lin et al[25] found that the maximum stress applied to a tooth-implant prosthetic was observed at the butt-joint interface of the abutment and the internal hexagon joint of the implant. As stated previously, biomechanical complications such as fixture-abutment failure, screw loosening, and fracture may occur over time.[11,16,22] Lin et al[25] found within the implant, alveolar bone, and tooth-implant FPD, loading condition was the main component of stress distribution while considering connector type and number of splinted teeth. They suggested that a nonrigid connector may be beneficial in a situation where 2 elements have different mobility.[25] In the second study focused on 2 load-type models (considering axial and oblique occlusal contacts), Lin et al[26] found the most stress incurred by alveolar bone was toward the lingual. This finding was attributed to the action of the occlusal forces on the splinted prosthesis and the bending movement observed. The authors stated rather than using teeth with compromised periodontal support (crown to root ratio of 1:1) or splinting the second abutment tooth, a single implant may be a better option.[26] Decreasing span length and increasing implant diameter are 2 clinical considerations to minimize implant-borne stress.[27]

Tooth Abutment Survival

Lang et al[11] reported in the meta-analysis that the reasons for loss of abutment teeth were: tooth fracture, caries, endodontic complications, and periodontitis; loss of retention was due to caries and fractured teeth. In review of 6 studies, Lang et al[11] found in 5-year follow-up studies that a total of 300 FPDs included 529 natural abutment teeth and 583 implant abutments which resulted in loss of 15 natural abutment teeth [3.2% {1.5–7.2}] and 20 implants [3.4% {2.2–5.3}]. Only two 10-year follow-up studies were included in this meta-analysis, which observed 45 FPDs consisting of 47 natural abutment teeth and 45 implants and resulted in loss of 5 natural abutment teeth [10.6% {3.5–23.1}] and 7 implants [15.6% {6.5–29.5}].[11] Regarding crestal bone loss, Block et al[21] found no significant difference between the initial and 5-year follow-up of crestal bone levels surrounding natural abutment teeth and found greater than 5 mm intrusion in 25% of the nonrigid FPD group and 12.5% of the rigid group. Overall, authors observed intrusion in 66% of the nonrigid FPDs compared with 44% for the rigid group.[21] This implies that it is better to use rigid connector when it comes to tooth-implant connection.

Complications

Biological complications for tooth abutments in tooth-implant supported FPD include: caries, loss of vitality, periapical pathologies, or periodontal disease progression and peri-implantitis for implant abutments.[5]

Lang et al[11] stated that the 13 studies in the meta-analysis discussed soft-tissue complications and "peri-implantitis." The first study focusing on tooth-implant FPDs examined the application of single crystal aluminum oxide, cylindrical configured implants (Bioceram, Kyocera American Inc., San Diego, CA) in distal and pier abutments in loaded fixed partial prostheses.[1] At 5 years, the radiographic follow-up was qualitatively assessed in a rating of positive (serviceable implant) and negative (failed implant), yet the radiographic measurements consisted of negative ratings for the following components: collar bone (5), radicular bone (3), and evidence of infrabony pocket formation (3). Despite these findings, Koth et al[1] dismissed these factors and stated "no implants showed bone change significant enough to be rated as negative in this index."

Brägger et al[22] used International Team for Implantology implants to observe long-term survival of FPDs with relatively short spans [median 3 units {2–14}] and had groups of FPDs that were tooth-tooth, implant-implant, and implant-tooth supported. In the implant-tooth group, 15 patients received 18 FPDs that contained 19 implants and 18 teeth, which resulted in loss of 1 FPD, loss of 1 implant abutment, and 1 bone defect with secondary fracture of implant. Clinically, authors found that of the 103 total implants, 10 implants [in 5 patients, over 19 sites {9.6%}] experienced peri-implantitis, defined as probing pocket depth of ≥5 mm and presence of bleeding on probing at a site.[22] Other biological complications that were noted in this study were periodontitis (seen in 6 tooth abutments), secondary caries (4 tooth abutments), and endodontic complications (7 tooth abutments). In the Brägger et al[22] study, over the course of the 4- to 5-year observation period, technical complications were seen on a rate of 20.4% in implants (21 in total) and 6.3% (10 in total) in natural teeth. Of the technical complications listed in implants, the most common observed was minor porcelain fracture (10.7%; 11 incidents), followed by occlusal screw loosening (6.8%; 7 incidents), then loss of retention (2.9%; 3 incidents). The technical complications listed with natural teeth, the most common observed was porcelain fracture (5.6%; 8 incidents), followed by loss of retention (0.7%; 1 incident). The authors did not observe a statistical difference in the number of incidents between the types of retention [cemented {16.5%} and screw retained {11.5%}]. However, the authors did find that the design of the FPD had a statistically significant higher complication rates in extensions than FPD without extensions (37.1% vs 11.1%).[22] The bruxism patients also had a statistically significant complication than patients who did not exhibit bruxism traits (60% vs 17.3%).[22] In a 10-year follow-up study, Brägger et al found tooth-implant FPDs had more failures than single crown or implant-implant FPDs.

Lang et al[11] included in their meta-analysis other technical complications such as abutment fracture or abutment screw fracture of 0.7% over 5 years and intrusion of abutment teeth of 5.2% over 5 years. Kindberg et al[28] observed 36 patients with 115 implants and 85 abutment teeth over the course of a range of 14 months to 8 years. During the follow-up period, 9 implants were lost (3 during healing and 6 after loading), 5 abutment teeth were lost, and 2 (5%) of the 41 prostheses were lost during follow-up, both maxillary prostheses. The authors stated that 1-year postplacement, marginal bone loss was observed in 40% of the implants and all implant abutment to framework connections were screw retained.[28] Within the study, the cumulative implant survival rate was 89.9%, and the authors stated that combined natural teeth, implant supported rigid superstructures had excellent long-term results.[28] With respect to marginal bone loss, Hosny et al[29] found that 1.08 mm was lost in the first 6 months and 0.015 mm yearly over 14 years.

FPD DESIGN

Schlumberger et al[30] described various treatment planning options and considerations when restoring tooth-implant FPDs and suggested the first option should be completely implant supported FPDs, but tooth-implant supported options can be considered and optimized through different prosthetic designs such as nonrigid and rigid connectors.

Due to the intimate nature of the keyway mechanism of nonrigid connectors, frictional resistance can prevent complete stress relief of the natural tooth, which over time could cause orthodontic-like forces resulting in intrusion.[30] Cohen and Orenstein propose the nonrigid connector system to limit the cantilever effect on the natural tooth and direct the loading forces of the FPD in the long axis of the implant. This can be achieved by incorporating the design advantages of greater flexibility by using an extracoronal implant crown attachment and improved esthetic outcome by hiding the attachment with the reverse-attachment design.[10]

Applying the rigid connector design requires passive fit of a multiple-unit prosthesis, which can lead to the aforementioned fracture or loosening of implant components. Often obtaining passive fit of the prostheses results in reduction of the copings either to "dampen" the stress on the implant or accommodate for flexure of the prosthesis.[30,31]

In summary, a conservative approach would be reserving tooth-implant supported FPDs to situations in which the patient desires a fixed prosthesis but would otherwise not be a candidate for conventional FPDs or implant-implant supported FPDs. Such circumstances include proposed abutment locations where implant placement would not otherwise be possible (eg, proximity to vital structures or ridge deficiency) and where cost would prohibit complete implant-supported FPDs or advanced grafting. Considering biological and physical complications associated with natural teeth versus implants, natural teeth pose more risk to a prosthetic system than an implant-implant device. Long-term studies and controlled trials of tooth-implant FPDs are still needed as tooth-implant FPDs that are not common in the literature, likely due to the inexperience of providers or lack of clinical situations that arise.

CONCLUSION

Although the long-term success of natural tooth-implant FPDs remains to be determined, the present literature supports tooth-implant FPD clinical usage. To prevent potential complications, careful planning and prosthetic design are essential. Future areas of research could include distribution of occlusal forces and consideration of occlusal schemes. Through thorough maintenance and planning, tooth-implant FPDs can be successful; however, constant attention needs to be given by provider and patient. To increase predictability, cases for combination FPDs should include ideal proposed implant location, healthy natural abutment teeth, and excellent patient factors such as occlusion, oral hygiene, and motivation.

Disclosure

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