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Revisiting Tooth Preservation in Prosthodontic Therapy

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Abstract

Dental implants have been established as long-term supports for tooth replacements, and they have profoundly altered treatment concepts of traditional prosthodontics. The use of teeth as prosthetic abutments is revisited relative to implants as predictable support mechanisms for fixed and removable prostheses. The purpose of this review is to appraise tooth preservation in a different manner while considering implants as additional and even preferred support mechanisms for dental prostheses. Data reviewed in this article include a comparison of implants and traditional prostheses and their effects on abutment teeth, the use of periodontally and endodontically compromised teeth as abutments, and prosthetic complications potentially created by healthy remaining teeth. The evidence presented suggests that the longstanding objective of tooth preservation during prosthetic treatment be appended to include the use of dental implants for fixed/removable prostheses, and to avoid or remove teeth presenting as liabilities that diminish the overall prognosis. Patients are not well served if they are faced with biologic, economic, and psychological burdens associated with ongoing revisions of dental rehabilitations using natural teeth. Dentists must use all means available to carefully evaluate remaining teeth to determine if they benefit or impair proposed prosthetic outcomes.

In 1952, Milton DeVan elucidated his opinion that the role of prosthodontic therapy should be ". . .the constant preservation of what remains rather than the meticulous restoration of what is missing."[1] The profession came to realize that the quest to restore a compromised dentition to functional and esthetic acceptability might actually jeopardize the health of the supporting teeth.[2–4] At the time of DeVan's statement, only natural teeth and residual ridges were used to support fixed and removable prostheses. During the past quarter century, a paradigm shift occurred, and implant treatment options have given clinicians cause to reevaluate this tenet.[5] Guckes et al noted that as dentists reconsider DeVan's goal of tooth preservation, dental implants may offer the best biological solution for long-term, successful prosthetic replacement.[6] Reliance on traditional objectives of tooth preservation is partially responsible for the reluctance to use dental implants, but saving teeth at all costs is not always desirable.[7] There are situations where patients would be better served by extracting compromised teeth, which previously would have been saved, and replacing them with implant restorations. In other cases, avoidance of compromised teeth by using implants as abutments might improve the prognosis of those teeth. There may be instances where even healthy, viable teeth become liabilities to the overall prognosis. The purpose of this article is to explore the impact of implant dentistry on the concepts of tooth preservation and extraction in the context of prosthodontic tooth replacement.

Patient examples illustrated herein are classified according to the Prosthodontic Diagnostic Index (PDI) of the American College of Prosthodontists. This index categorizes completely dentate,[8] partially edentulous,[9] and completely edentulous patients[10] according to objective, evidence-based criteria. Among the factors evaluated for classification are the condition of the teeth, occlusion, location and extent of edentulous areas, and residual ridge morphology. The PDI provides a systematic diagnosis by degree of prosthodontic complexity from Class I, ideal or minimally compromised, to Class IV, severely compromised. It is primarily designed to facilitate an appropriate and predictable treatment plan.

Implants as a means to preserve remaining teeth

Dental implants effectively achieve the objective of preserving tooth structure by their use as support for prostheses replacing missing teeth; prevention of tooth reduction in preparation for fixed partial dentures (FPDs); clasping of abutment teeth for removable partial dentures (RPDs); and elimination of additional occlusal loads on abutment teeth for either of these prosthetic replacements. Lekholm et al[11] noted, "Most studies only focus on the outcome of placed implants, whereas few deal with what simultaneously happens to the teeth present at the time of implant placement." Some authors have provided credibility to implants

supporting prostheses for tooth preservation by examining teeth adjacent to implant sites and then comparing outcomes to teeth used as abutments. A 10-year retrospective analysis of 196 teeth adjacent to 110 single-tooth implants by this author demonstrated that these teeth suffered far fewer complications than would have been expected if they were used as abutments for FPDs.[12] From these data, the author concluded, "Implants can be effective in preserving intact teeth in patients undergoing initial prosthodontic therapy and preventing the use of additional teeth as abutments in patients whose existing prosthesis must be replaced." Krennmair et al[13] later performed a similar analysis of 148 teeth adjacent to single implants over a 3-year period and also reported exceedingly low complications: no extractions, no endodontic therapy, and only four teeth warranted restorations. They concluded that implants clearly maintained the integrity of adjacent tooth structure and should be given increasing preference to traditional fixed prosthetic solutions. Misch et al[14] more recently evaluated teeth adjacent to implants on a larger scale, citing 1377 single implants and 2589 adjacent teeth. They reported, similar to the previous two authors, minimal complications. No adjacent teeth were lost during the 10-year period: 5% demonstrated dental caries and 0.4% required endodontic treatment. In review, these three studies consistently reported minimal complications on teeth adjacent to implants and provided strong evidence of the tooth-sparing effect of implants used in lieu of teeth as prosthetic-support mechanisms. The author believes that implants should be the preferred method of treatment for tooth replacement where adjacent teeth are intact, particularly with the large population of young patients with congenitally missing teeth, but otherwise healthy dentitions. These young patients are typically categorized as PDI Class I, with only one or two single missing teeth, intact adjacent teeth, and edentulous ridges suitable for implant placement (Figs 1 to 3).

Consequences of conventional fixed and removable prostheses

Studies have compared the value of FPDs or RPDs relative to long-term tooth retention. Pretzl et al[15] and Carnevale et al[16] demonstrated higher rates of tooth loss on teeth used as abutments for fixed/removable prostheses. Longitudinal reports indicated that prosthesis failure was common and occurred with higher frequency in RPDs than with FPDs.[17-19] In contrast to the tooth-sparing effect of implants, Ziataric et al[20] examined the status of abutment and nonabutment teeth and noted that RPDs may increase the incidence of caries, damage the periodontium, and increase the amount of stress on remaining teeth. In a record review, in an admittedly small sample, Cabanilla et al[21] reported that abutment tooth loss for RPDs was more than three times the frequency recorded for FPDs. Re-restoration and expansion of existing prostheses may carry increased biologic risks and higher costs of dental care. In a long-term study of prosthesis longevities, Karlsson[22] noted that 17% of failed FPDs led to the loss of distal abutments. Tan et al[23] performed a Medline search from 1966 through 2004 and found 1764 patients receiving 3548 FPDs. Although the probability of 10-year survival was reported as 89.1%, few studies provided relevant information that determined the extent of biologic complications, such as caries, pulpal inflammation, and recurrent periodontitis. They did determine, however, that dependence on nonvital, endodontically treated teeth as strategic abutments carried significant risk. Examining restored and nonrestored teeth over a 15-year period, Miyamoto et al[24] noted that tooth preparation significantly decreased the long-term prognosis for the prepared teeth. The discourse on the merits and limitations of FPDs and RPDs may be irrelevant. Certainly, neither appears to enhance the prognosis of the supporting teeth; both likely compromise the health of teeth used as abutments (Figs 4 to 8).

Compared with the low rate of endodontic complications when implants are used to avoid using teeth as abutments, the practice of using teeth as abutments for fixed prostheses leads to higher rates of endodontic intervention. Goodacre and Spolnik[25] reviewed literature related to the incidence of endodontics for teeth used as abutments for FPDs. They recorded incidences of endodontic treatment after tooth preparation from 3% to 23% over a 2- to 10-year period. Christensen[26] surmised that the increased need for endodontic treatment reported by general dentists was caused, in part, by tooth preparation, and the accompanying procedures necessary for fabrication of FPDs. Avivi-Arber and Zarb[27] also noted that "fixed prostheses are associated with the sacrifice of sound tooth tissue and inherent risks of pulp injury."

Incorporating implants into prosthetic treatment can have a tooth-sparing effect even when conventional FPDs are part of a treatment plan for replacing missing teeth. Retrospectively examining patients in an undergraduate dental clinic, De Backer et al[28] reported 20-year survival rates for short- and long-span FPDs of 71% and 54%, respectively. They concluded that FPDs seem to be "an acceptable, reliable, and financially worthwhile treatment." They further noted, however, that additional tooth abutments or using endodontically treated teeth as abutments created greater risk of complications, and treatment plans that included larger prostheses could be improved by using dental implants to avoid using additional teeth for prosthesis support.

Reviews gleaned from clinical data indicated that tooth replacement with implants resulted in higher success rates than comparable replacements with FPDs. In a meta-analysis, Scurria et al[29] reported 95% and 84% success for single-tooth implants and three-unit fixed prostheses, respectively, at 60 months. Lekholm et al[11] reported a larger disparity between the two types of prostheses: 66% success rate of FPDs at 15 years (smaller prostheses were more successful than larger spans), 91% success rate for single-tooth implants at 20 years. Torabinejad et al[30] demonstrated that a single implant or an endodontically treated tooth with a well-fitting crown exhibited greater long-term success than an FPD replacing a single tooth. In his review, Weigl[31] concluded that it was better to replace a single tooth with an implant than with an FPD.

In review, implants used as load-bearing abutments for dental prostheses appear to preserve teeth by avoiding using them as abutments, and conserve tooth structure by eliminating the biologic complications associated with traumatic tooth preparation, interim prostheses, and cementation of interim/definitive prostheses. The overall benefits of using implants to support dental prostheses include reducing mechanical and biological

Figure 1 Sixteen-year-old male patient with congenitally missing maxillary lateral incisors; PDI Class I.

Figure 3 Patient from Figure 1: Implant restorations replaced the maxillary lateral incisors; the central incisors and canines adjacent to the implants remained intact.

complications and enhancing prosthesis longevity when compared with conventional fixed and removable prostheses.

Periodontally involved teeth and implant therapy

Complex dental protocols once required when using periodontally compromised teeth for prosthesis support appear to be declining. Due to enhancements in implant technology and long-term predictability, Spear noted that "the use of FPDs may become an anachronism, much like the specialized preparations of hemisectioned molars required in perioprosthodontics."[32] In a comprehensive review of the literature, Holm-Pederson et al,[33] and later Tomasi et al,[34] concluded that survival of implants after 10 years of service does not surpass the longevity of periodontally and endodontically compromised, but successfully treated, teeth. Walton,[35] however, noted that the focus should be less on the comparative life spans of teeth and implants and more on treatment planning decisions to use implants if they will result in a more predictable prognosis than the use of questionable teeth as abutments. Walton reported a dramatic decrease in the use of periodontally compromised teeth as FPD abutments from 1984 to 2007; he concluded that "heroic" efforts to save periodontally compromised teeth are no longer considered appropriate. Anson[36] also noted that retention of periodontally compromised teeth may further erode bone potentially needed for future implant placement. Kao concluded that the high success rates of implants have shifted treatment plans to earlier strategic extraction of periodontally compromised teeth.[37] The current trend, therefore, is towards diminished use of periodontally compromised teeth as abutments and increasing use of implants to support fixed prostheses.

Patients with tooth loss due to a history of recurrent and chronic periodontal disease present a dilemma in treatment planning for tooth replacement. Implants in these patients may demonstrate a higher rate of bone loss and lower implant survival.[11,38,39] In a review of periodontal status related to tooth retention, Greenstein et al[40] concluded that clinical parameters may not accurately predict disease progression and future tooth loss in teeth with a periodontal prognosis other than "good." They stated that "the determination to extract a tooth should be based on its clinical and periodontal status, a reasonable interpretation of the data in the literature, clinical experience, and the patient's stated objectives." Determination of an accurate prognosis of teeth with periodontal attachment loss remains a challenge.[41] Cabanilla et al[21] found that teeth used as abutments for fixed and removable prostheses with a prognosis of "good" carried a 9.3-fold lower rate of tooth loss than those with any other more compromised periodontal prognosis. In another review of the literature, Heitz-Mayfield and Huynh-Ba concluded, "Implant placement in patients with a history of treated periodontitis is not contraindicated; studies have reported implant survival rates over 90% over a period of 3 to 16 years; there is an increased risk of peri-implantitis."[42] Despite these potential complications, implants still provide patients who have lost their teeth due to aggressive periodontal disease an alternative to inevitable tissue-borne removable prostheses (Figs 9 to 11).

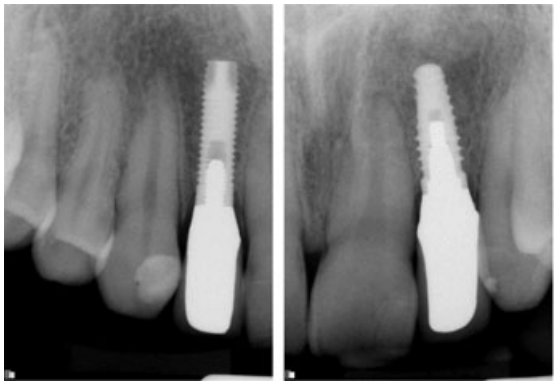

Figure 2 Periapical radiographs of the patient in Figure 1 with metal ceramic crowns in place, seated on custom abutments.

Implants and the assessment of endodontically treated teeth

Some dental professionals have raised the question that overzealous use of implants could cause a serious decline in the need for endodontic treatment. Recent reviews have compared the relative prognoses of endodontically treated teeth with those

Figure 4 Fifty-eight-year-old female patient with a loose implant- and tooth-supported complete fixed prostheses that was 5 years old at the time of this photograph.

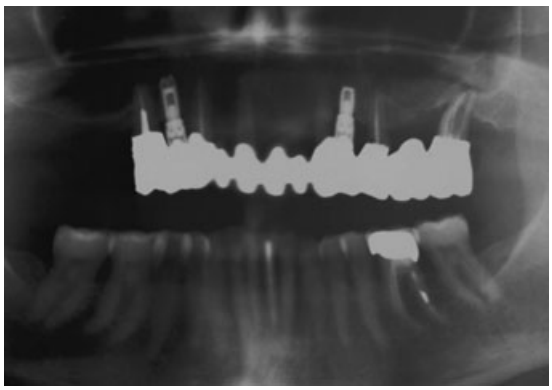

Figure 5 Preoperative panoramic radiograph of the patient in Figure 4. The metal ceramic prosthesis was supported by endodontically treated teeth and two implants.

Figure 6 Intraoperative photograph after the prosthesis was removed revealed extensive caries of the distal abutments. This patient was diagnosed as PDI Class IV, due to the combination of severely compromised abutment teeth and high esthetic demands.

of implants and reported conflicting results.[23,30,43-50] A review by Heffernan et al[43] indicated higher implant success rates and lower success rates for endodontically treated teeth. The authors reported, "We are really beginning to question, in light of growing support in the literature for the longevity of implants, whether endodontically treated teeth are appropriate evidence-

Figure 7 Postoperative image with the new prosthesis in place. The treatment plan included removal of the remaining teeth and placement of eight additional implants.

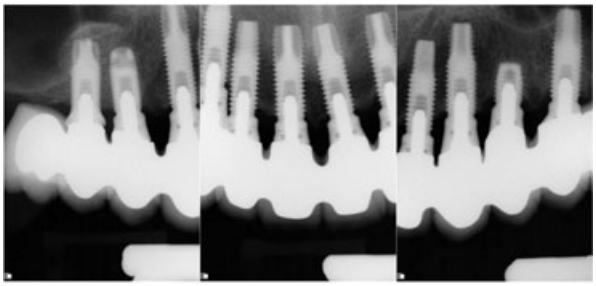

Figure 8 Five-year post-insertion radiographs revealed minimal crestal bone loss and excellent marginal integrity of the prosthesis.

based choices for the support of coronal restorations." In their systematic review, Heydecke and Peters[44] observed that an endodontically treated tooth requiring a dowel and core caries a less optimistic prognosis than a dental implant. Morgano and Brackett[45] recommended extraction of teeth with poor prognoses, including endodontically treated teeth with insufficient tooth structure for adequate ferrules, and placement of implants as an option that provides a better long-term outcome.

In contrast to the above data, a comparative review by two endodontists reported implant survival rates as low as 62% for partially edentulous patients, which seemed unfavorable compared with endodontic success rates; however, this review included esoteric implant types, such as sapphire implants, rarely used clinically compared with the ubiquitous titanium implants generally placed by most clinicians. The authors advised that the natural dentition is the "best implant," and the first goal should be the preservation and restoration of a healthy dentition.[46] Other reviews in the endodontic literature revealed a bias towards endodontically treated teeth over implants when comparing endodontic and implant outcomes.[47-49] Felton addressed this apparent partiality in a recent editorial, noting that many published success rates place endodontically treated teeth in a less favorable light than depicted in the reviews above.[50] The need for endodontic therapy alone should not be a pivotal factor for tooth extraction in favor of implant placement. The objective of implant treatment is not to remove healthy endodontically treated teeth, but to provide a reasonable replacement when these teeth are deemed unrestorable (Figs 12 to 14).

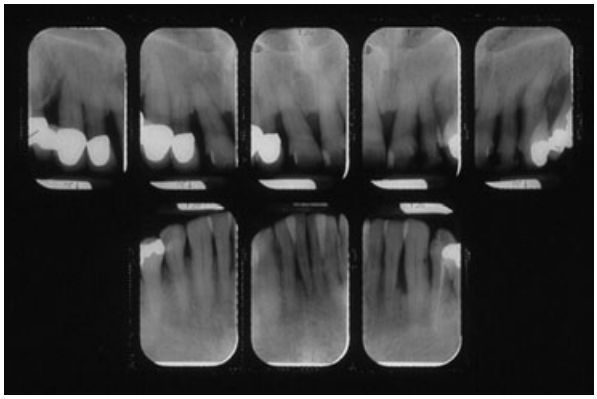

Figure 9 Anterior preoperative periapical radiographs of a patient who presented with mobile teeth and inflamed periodontal tissues. This patient was classified as PDI Class IV having moderate/severe periodontitis. The maxillary teeth presented with a hopeless prognosis.

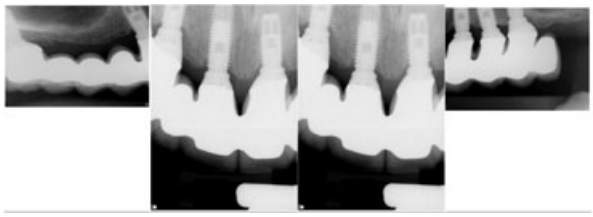

Figure 10 Anterior postoperative periapical radiographs of the patient in Figure 9, 1 year after completion of implant prosthodontic therapy. All teeth were extracted, and implants were placed to support a maxillary fixed implant prosthesis.

Figure 11 The patient's (Fig 10) maxillary fixed prosthesis 13 years postoperative. The patient reported no prosthetic complications since the implants, abutments, and prosthesis were inserted.

Figure 12 Maxillary central incisor post-endodontic treatment. It was discolored and imparted a bluish hue to the gingiva. The tooth was restored with a composite resin veneer in an attempt to mask the discoloration.

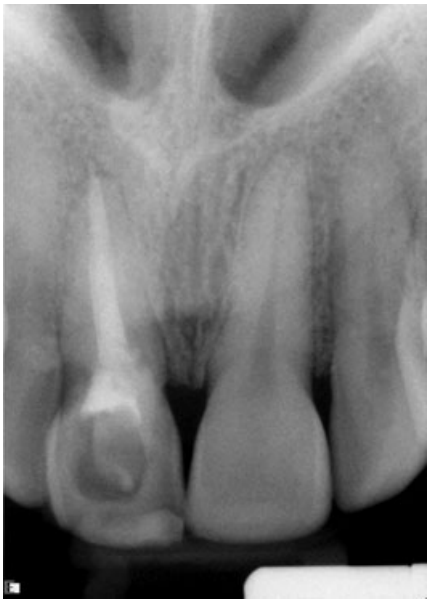

Figure 13 Periapical radiograph of the tooth in Figure 12. External resorption was evident. Although the patient was completely dentate at the time of examination, the prognosis of the affected incisor was hopeless, and the partially edentulous criteria of the PDI were used to classify the arch as Class I.

Figure 14 Normal gingiva and tooth shade were restored with the implant restoration. The adjacent teeth were not involved in this treatment.

Several reviews examined the prognosis of endodontically treated teeth when used as abutments for FPDs. In a Medline search from 1966 to 2004, Tan et al[23] found 1764 patients and 3548 FPDs 1 to 25 years postinsertion and discovered that the presence of cast posts and dowels and nonvital abutment teeth were associated with increased retention loss and fracture of teeth and cores. They cautioned against overdependence on nonvital teeth as strategic abutments. Torabinejad et al,[30] in another systematic review, found that endodontically treated teeth and implant single crowns demonstrated similar and high success rates, but that FPDs had significantly lower survival rates. The authors noted that tooth preparation and subsequent provision of FPD restorations were widely considered to increase the risk of pulpal, periradicular, and periodontal disease. They recommended that endodontic treatment should be given priority in otherwise sound teeth with apical pathology; in instances where single teeth were to be extracted or were missing, single implant restorations were preferred over FPDs.

The above studies provide some objective guidance to clinicians on the use of endodontically treated teeth or implants in dental prostheses. A healthy, endodontically treated tooth with an adequate ferrule generally demonstrated a good prognosis when supporting a single crown; the prognosis diminished when these teeth were used as supporting abutments, particularly in longer spans. Clinicians must still rely primarily upon clinical judgment and patient expectations to determine the value of maintaining or removing compromised endodontically treated teeth and replacing them with implants.

Healthy teeth as liabilities to comprehensive treatment planning

Much has been written about the comparisons between implants and compromised teeth, but there is a glaring void concerning the subject of healthy teeth that may pose a liability to the overall prosthetic treatment plan. This subject is bound to create more controversy in implant prosthodontic discussions than any of the issues heretofore mentioned. An optimum long-term prognosis may sometimes preclude teeth that are otherwise restorable. Treatment scenarios involving healthy tooth extraction in favor of implant placement merit discussion and future research. Two common patient conditions are demonstrated below to elucidate the potential dilemma sometimes presented by restorable remaining teeth when implants were part of the treatment plan.

Consider a 75-year-old female patient with six restorable remaining mandibular anterior teeth who has not accommodated well to a Kennedy Class II RPD. This particular patient considered a fixed prosthesis if it would provide greater comfort and potentially reduce the complications she experienced in the past. Three treatment plans were presented: (1) Preserve the remaining anterior teeth and fabricate a new RPD; (2) Preserve the remaining teeth and provide fixed implant solutions for the posterior quadrants; and (3) Remove the anterior teeth and place five implants between the mental foraminae and seat a resin-metal fixed implant prosthesis (hybrid prosthesis).

Which treatment plan was most predictable? The patient did not have a positive history with a removable prosthesis and not even a new, clinically excellent RPD would guarantee patient satisfaction. The prognosis of the remaining teeth, particularly when endodontically treated, may be greatly reduced when used to support an RPD. Although the second option of placing posterior implants retains the anterior, compromised teeth, at least three implants per quadrant would be needed for the edentulous spans from first premolar to second molar to occlude with the remaining maxillary teeth. Custom abutments would support eight splinted metal ceramic retainers and pontics. The expense for this treatment would be significantly higher than the other two options. If either of the above two treatment plans of retaining the remaining mandibular teeth were selected, the partially edentulous criteria of the PDI would categorize this patient as Class IV: severely compromised. The third option including extraction of the remaining anterior teeth might initially seem aggressive, but may actually provide the best outcome. The PDI, now based on criteria of complete edentulism, elevates this patient to Class I; ideal or minimally compromised. She presented with excellent ridge form and optimal osseous quality and quantity for implant placement. As noted by Kopp, implant placement in the anterior mandible entails low surgical risk and high restorative predictability.[51] The cost of the third alternative involving extraction of the anterior teeth would be lower than the other options, major prosthetic revisions would be minimal, and comfort/satisfaction will likely be higher than the other two options. The patient selected the third option (Figs 15 to 17).

Another common patient presentation involves two or three healthy remaining maxillary teeth. In this example, a 40-year-old female patient presented with advanced periodontal disease of the maxillary teeth (Figs 18 to 20). Most of the teeth were assessed as having hopeless prognoses; the maxillary left central incisor, lateral incisor, and canine all demonstrated minimal bone loss. The long-term prognosis associated with three remaining teeth to support an RPD is questionable. If they are retained and an implant prosthesis is planned, either implants must be placed mesial and distal to the teeth with separate prostheses, or the teeth have to be included into the implant prosthesis. If at least six implants are placed, does retention of the teeth really improve or augment the prognosis? Individual crown restorations of the teeth and implants would likely require more implants than a single splinted prosthesis. Preparation of the teeth and inclusion into the prosthesis would increase the complexity of the prosthetic treatment. It is the author's opinion that it would be less costly and less problematic to remove the teeth and fabricate an implant-supported overdenture or fixed prosthesis. Based on this patient's age, her history of disease, the position of the teeth, and the ability to place sufficient implants for a fixed implant-retained prosthesis, these otherwise healthy teeth were not going to contribute to the long-term prognosis and, in fact, would probably complicate an otherwise predictable implant-retained prosthesis. Similar to the previous example, retaining the three relatively healthy teeth would place this patient's maxillary arch into partially edentulous PDI Class IV: severely compromised. Removal of the teeth would improve the rating to a completely edentulous PDI Class II: moderately compromised due to moderate loss of alveolar bone. All remaining maxillary teeth were extracted, seven implants were placed, and a fixed implant-retained prosthesis was fabricated.

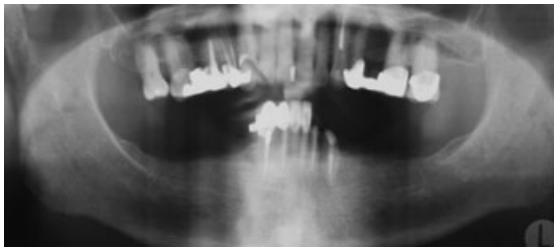

Figure 15 Preoperative panoramic radiograph demonstrated adequate periodontal support for the mandibular anterior teeth; most of the anterior teeth were endodontically treated. If the teeth were to be extracted, completely edentulous criteria of the PDI placed the mandibular arch in Class I.

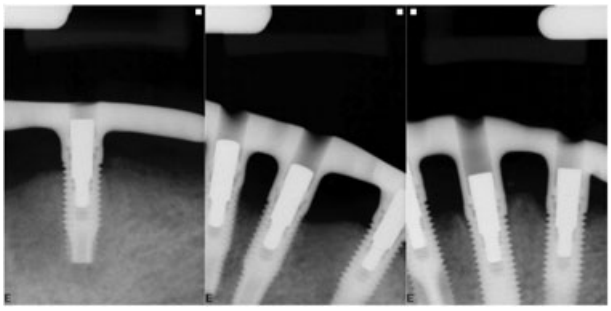

Figure 16 Postoperative radiograph demonstrated excellent bone/implant contact and the framework of a fixed implant-retained mandibular prosthesis.

Figure 17 Postoperative clinical image with the implant prosthesis in place. The patient's objective of improved esthetics was achieved.

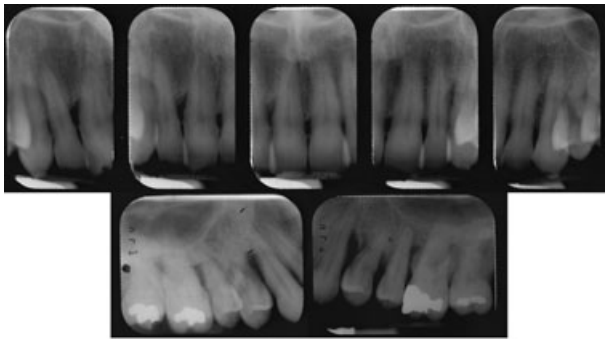

Figure 18 Preoperative periapical radiographs revealed minimal bone loss of the maxillary left central incisor, lateral incisor and canine, and severe bone loss of the remaining maxillary teeth. PDI Class II was established using the criteria of complete edentulism.

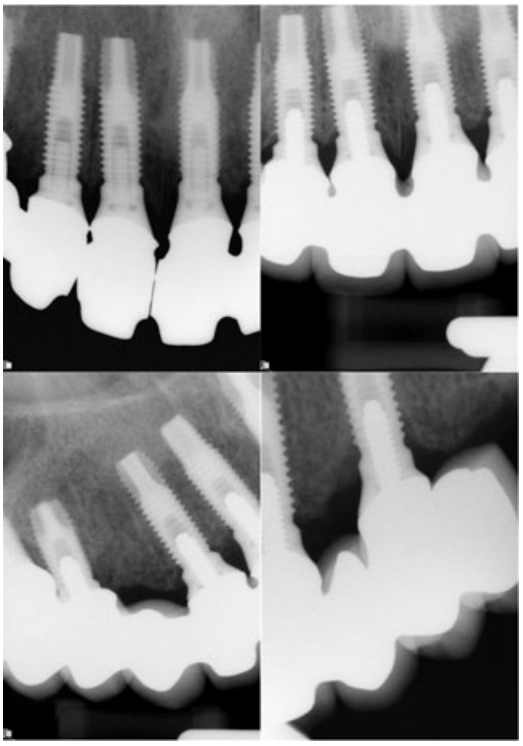

Figure 19 Postoperative radiographs 1 year after the prosthesis was placed. Note the level of the interproximal bone.

Figure 20 One year post-placement clinical image of the maxillary fixed prosthesis. All of the implants remained integrated, and soft tissue health was maintained.

These are two compelling examples of partially edentulous patients where teeth presented more problems and fewer benefits to the prosthetic treatment. Considerations in making the optimal decision to extract or retain teeth include: will the teeth bring benefits or liabilities to the planned prosthesis; do they decrease or increase the long-term cost; do they increase or decrease the complexity of the restoration; do they reduce dental visits and revisions or commit the patient to more dentistry?

Summary and conclusions

Preservation of remaining teeth has been a noble objective of dentistry for over 50 years. The purpose of this review has not been to suggest that this tenet should be ignored or is no longer applicable, but to temper it in light of substantial evidence that implants can serve as predictable, additional support mechanisms for prostheses. Bone and tooth preservation of dental implants has altered perceptions of traditional prosthodontic therapy. Evidence reviewed in this article, comparing conventional prosthetic tooth replacement to implants, provides an alternative perspective of tooth preservation versus extraction:

(1) when used as abutments, implants provide a tooth-sparing effect by accepting their own load and preventing known biologic consequences associated with tooth preparation,
(2) traditional FPDs and RPDs generate trauma biological to supporting teeth and diminish their overall prognosis,
(3) endodontic complications are higher on abutment as compared to nonabutment teeth,
(4) implant prosthetic success rates are generally higher than tooth-supported prostheses success rates of comparable spans,
(5) although accurate diagnostic periodontal criteria are lacking, implants used as abutments provide more predictable success rates than periodontally compromised teeth,
(6) healthy endodontically treated teeth with single crowns have success rates comparable to implants, but compromised endodontically treated teeth do not fare as well as implants when used as abutments for fixed prostheses,
(7) otherwise healthy teeth sometimes present as liabilities to the overall prognosis.

The evidence presented herein gives the profession cause to reevaluate the concept of tooth preservation. The author recommends that a new or appended treatment objective should be to use those support mechanisms that provide patients with the best long-term prognosis and circumvent or eliminate teeth that are detrimental to a sound long-term, satisfactory prognosis. Dental implants are a preferred method of tooth replacement, and teeth should be avoided or removed if they diminish the overall prognosis. The principle of saving healthy and/or compromised teeth at all costs is no longer the best option and could result in less-than-optimal outcomes. The use of implants has evolved from an esoteric alternative for disabled edentulous patients, to a superior standard of care that augments the prognosis of compromised dentitions for both young and mature patients.

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