To Extract *or* Not to Extract? Factors That Affect Individual Tooth Prognosis

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ABSTRACT

A dentist evaluates a natural tooth for its quality of health. Once this is accomplished, the clinician obtains an estimate of longevity and decides whether to extract or to treat and maintain the tooth. There often are questions and doubts involved in the decision-making process in regard to the prognosis of an individual tooth. Unfortunately in dentistry, as in all biologic sciences, there are no straightforward answers to questions.

This article will look at the literature in this area to help the practitioner in the decision-making process with regard to the compromised tooth. The article will concentrate on the single tooth or implant restoration. Other factors, such as the strategic value of a tooth and financial limitations in relation to long-term prognosis, will also be discussed.

Periodontally involved teeth receive multiple therapeutic procedures to arrest the disease and hopefully gain some attachment. Nonsurgical and surgical endodontic therapy is performed on teeth with necrotic pulps to seal the tooth or reseal the "already sealed" root canal. On occasion, a given tooth may require both periodontal and endodontic procedures followed by restoration to form and function. Today, implant dentistry has modified the treatment planning process; questionable teeth may be extracted more frequently in favor of implant placement. Heroic attempts should be discouraged when the prognosis is poor, or failure of treatment

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may result in inadequate bone for implant placement. Considerable thought has to be given to prognosis from both a periodontal and an endodontic perspective. Therapeutic decisions need to be made based on this prognosis so that success in the long term can be achieved.

Prognosis of Periodontally Involved Teeth

Attaining an accurate prognosis of periodontally involved teeth is problematic. Hirschfeld and Wasserman re-examined more than 15,000 teeth in 600 patients with advanced periodontitis, at least 15 years after receiving treatment. The patients were generally well motivated in their personal and professional dental care. They also had similar periodontal involvement at the onset and received the same treatment. However, the patients differed markedly in post-treatment course, with tooth loss ranging from 0 to 23 teeth per patient.[1] In other words, it is almost impossible to predict the chance of survival of a periodontally compromised tooth.

In an attempt to establish clinical parameters that would lead to consistently correct prognoses, McGuire, McGuire and Nunn published a series of papers. All articles were based on 100 patients with 2,509 teeth under maintenance care for up to 15 years. It became obvious that "projections relying on the commonly taught clinical parameters were ineffective in predicting any outcome other than good."[2] Although the regression model formulated predicted accurately 81 percent of the time, its accuracy dropped to approximately 40 percent when applied to teeth with an initial prognosis of less than good.[3] The same applies to the Interleukin-1 (IL-1) status of the patient, where only little correlation existed between clinical presentation of the tooth (initial prognosis) and genotype status.[4] McGuire and Nunn observed that substantially greater percentages of teeth lost had a poor or worse prognosis than surviving teeth. But the disturbing observation was that there was great variability in survival time for teeth lost. For example, teeth lost with an initial prognosis of good had a survival range of four months to 12 years. Clearly, initial prognosis did not adequately predict tooth survival and especially for posterior teeth "projections were no more predictable than a coin toss."[2,5]

Patients who smoked or were positive for IL-1 had a three-fold increased risk of losing their teeth.

On the other hand, there is evidence to support the efficacy of some clinical criteria in deciding whether to extract or maintain a tooth. Increasing probing depth, furcation involvement, mobility, percent of bone loss, having a parafunctional habit and not wearing an occlusal splint, and smoking resulted in an increased risk of tooth loss.[5] Lang et al. found a highly significant relationship between increasing probing depth and increasing bleeding on probing incidence, and a highly significant relationship between increasing bleeding on probing and loss of probing attachment. Specifically, the absence of bleeding on probing showed an almost a zero percent risk for periodontal breakdown, while pockets that constantly bled during follow-up appointments had a 30 percent risk for losing probing attachment. Although this number is still low, bleeding on probing still represents the most reliable clinical predictor for disease "activity" during periodontal maintenance.[6] Wasserman et al. confirmed the limited importance of bleeding on probing. Patients with periodontal breakdown had gingival inflammation more often than patients without breakdown. However, the teeth with the most inflammation did not necessarily correspond with the teeth with the most severe breakdown.[7]

The smoking habit and the IL-1 genotype of the patients seemed useful in predicting future risk for disease progress. Patients who smoked or were positive for IL-1 had a three-fold increased risk of losing their teeth. Patients who were IL-1 positive and heavy smokers were nearly eight times more likely to lose teeth.[4]

Success Rates of Periodontal Therapy

The results of most studies on the effectiveness of periodontal therapy are encouraging. Hirschfeld and Wasserman found that 7.1 percent of the teeth were lost for periodontal reasons. Fifty percent of the patients did not lose any teeth over a period of 22 years.[1] McFall, in a duplicate study, had very similar results.[8] Becker et al. showed comparable failure rates. When the teeth with an initial hopeless prognosis were excluded, the failure rate dropped to half (2.94 percent).[9]

Even the tooth type has been shown to be a factor in the survival of the tooth.[1,8,9] The tooth loss pattern was almost identical in Hirschfeld, Wasserman and McFall's studies. Maxillary molars are the teeth most likely to be lost, followed closely by mandibular molars. The maxillary

and mandibular canines were the teeth most resistant to periodontal breakdown.[1,8,9]

McGuire concluded it is easier to predict the prognosis for single-rooted teeth.[2] Most studies seem to agree that anterior teeth respond better to periodontal treatment and are less likely to be lost due to periodontal reasons. None of the canines were lost in a well-maintained population after 22 years of follow up.[1] Maxillary molars on the other hand, had the worst prognosis.[1,8] Ramfjord et al. found that the response of anterior teeth to periodontal treatment was marginally better than posterior teeth. The poorest results occurred for the maxillary bicuspids and molars, which may in part be related to furcation involvement and the time of the disease onset.[10] In patients with mild periodontitis, the molar teeth were four times more likely to be affected than all other teeth combined.[7] In patients with more advanced disease, 85 percent of the molar teeth presented with severe destruction.[7] It follows that molars are "problem teeth" and the efficacy of different types of treatment must be explored.

Success Rates of Surgical and Nonsurgical Therapy on Molars

In the treatment of molar teeth, there are various aspects that have to be investigated in order to evaluate the effectiveness of therapy. Teeth with and without furcation involvement have to be studied separately. Additionally, there are different therapeutic approaches for furcated molars. The treatment modalities include either preservation of the furca and strict maintenance or elimination of it by root amputation and hemisection.

Absence of furcation involvement. The treatment outcome even in the absence of furcation involvement is problematic. However, the results are far more favorable compared to teeth with destruction in the furca. Sixty-four percent of nonfurcated teeth with a questionable prognosis were lost over a course of 19 years.[8] When 323 molar teeth without furca invasion were followed for 6.5 years, 78 percent remained unchanged while the remaining 22 percent developed a furcation problem.[9]

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Presence of furcation involvement without root resection or amputation. Wang et al. concluded that in the presence of furcation involvement, teeth were twice as likely to be lost.[11] Kalkwarf et al. observed that furcation sites tended to lose probing attachment levels regardless of the type of therapy provided. This may be a result of the inability to adequately instrument these areas during therapy.[12]

Without any root resection or hemisection procedure performed, Hirschfeld and Wasserman reported loss of nearly one-third of the teeth originally diagnosed as having furcation invasion.[1] McFall found that more than half of furca-involved teeth were lost when followed from 15 to 29 years.[8]

On the contrary, Ross and Thompson reported acceptable results with nonsurgical intervention of maxillary molars with furcation involvement. After five to 24 years, 88 percent of the teeth were still functioning comfortably. However, the significance of these results is limited when one considers that an additional 11 percent showed increased bone loss and that the diagnosis of all furcations was done solely on radiographs.[13] Becker et al. published very similar results with the status of 86 percent of furcated molars remaining stable. Their conclusion was that teeth with moderate furcation involvement can be treated successfully and maintained effectively for prolonged periods.[9]

Furcation-involved teeth receiving root resection or amputation. Unfortunately, most studies of surgical intervention with root resection or hemisection do not present very promising results either. Langer et al. evaluated 100 patients receiving root resection therapy at least 10 years prior to the study. Thirty-eight percent of these teeth failed, the majority occurring between the fifth and seventh year. Mandibular molars failed at a 2-to-1 ratio compared to maxillary molars. The latter failed primarily because of progressive periodontal disease, while mandibular molars succumbed most frequently to root fractures.[14] Blomlöf et al. reported a very similar success rate of 68 percent at 10 years. Smokers seemed to have a three-fold risk compared to nonsmokers.[15]

A study that illustrated more promising results, was conducted by Carnevale et al. They examined 488 hemisected or root resected teeth. The possible failure mode could have been periodontal, endodontic or restorative. The failure rate was 5.7 percent and only 3.7 percent of all the teeth had to be extracted. The highest cause of failure was dental caries and root fractures, but not peri-

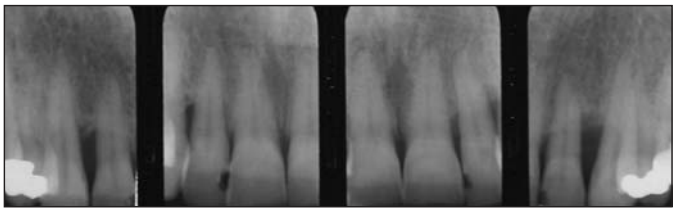

Figure 1. Status before periodontal treatment reveals mild to moderate involvement of the incisors.

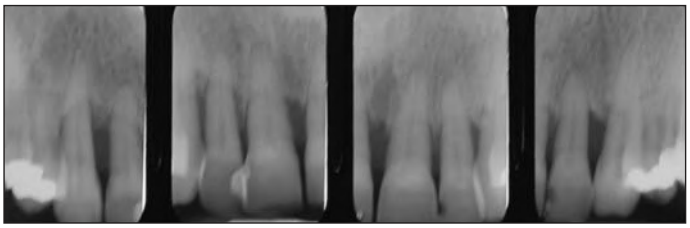

Figure 2. Three-year postop evidence of advanced periodontal destruction.

odontal disease. However, since this was a retrospective study, the number of furcated teeth that were initially extracted was not reported, and thus conclusions about the efficacy of surgical treatment of the furcated teeth should be made with extreme caution. The authors explained the higher success rates compared to other studies by the fact that resection therapy is very technique sensitive and proper case selection and restorative expertise are essential.[16]

Figure 3. Horizontal and vertical root fractures of mandibular lateral incisor that was endodontically treated and restored with a cast dowel.

Figure 4. Maxillary first bicuspids are also prone to vertical fractures, especially if restored with wide diameter-dowels.

Importance of Regular Maintenance

One aspect that all authors emphasize is the necessity for frequent recall appointments. The high success rates of Carnevale et al. are coupled with a three-month recall for 95 percent of his patients.[16] A frequency of three to four appointments per year is advocated for the periodontally involved patients.[1,2,8,9]

Achieving a proper maintenance program is not an easy task. Although recall appointments were sent every three to four months, patients attended every 5.2 months. Additionally, by the seventh year after treatment, there was a 22.1 percent dropout rate.[9]

Becker et al. reported that in a well-maintained population after 6.5 years, the annual tooth loss was 0.11 teeth per patient.[9] The authors also examined another group of patients who did not return for recall for five years. Receiving treatment without maintenance had a negligible effect on reducing probing depths, and 25 percent of shallow pockets became deeper. There was a worsening of the furcation areas and statistically significant bone loss. Finally, the mean annual tooth loss doubled, reaching 0.22 teeth per patient.[17]

Conclusion on Periodontally Involved Teeth

It is evident that with the tools available today, accurate prognosis of periodontally involved teeth is unreliable. There are some guidelines that have prognosticating value, but they should be used with caution. Survival rates of anterior teeth exceed that of posterior teeth. It follows that anterior teeth can be maintained with lower risk. However, in rare circumstances, even teeth with excellent periodontal status show rapid degradation (**Figures 1, 2**). It is the multifactorial nature of the disease that makes prognosis and sometimes preservation of the teeth unpredictable.

Success Rates of Nonsurgical Endodontic Therapy

When a tooth is fractured, grossly carious or traumatized, the choice for a patient may be either endodontic therapy or loss of the tooth. It is important for the patient and the dental practitioner to be able to decide on a course of treatment through knowledge of potential success of various treatment modalities.

In a classical study on rats, Kakehashi et al. showed that in the absence of bacteria, complete healing of exposed dental pulps occurred.[18] Sjogren et al. showed that when there was a periapical lesion present, endodontic success rates dropped by at least 10 percent.[19] They also showed that an initial negative culture resulted in a 94 percent endodontic success rate, while an initial positive culture resulted in significantly reduced success rates (68 percent).[20] Fouad et al. demonstrated that "in cases with pre-

Figure 5. Implant-supported crown No. 7 that presents with esthetic problems. It is too long and metal display is evident in the cervical area.

Figure 6. Harmonious esthetics can be achieved with implant restorations in region of tooth No. 10.

operative periradicular lesions, a history of diabetes was associated with a significantly reduced outcome."[21] The data suggests that patients, who are diabetic and have an infected root canal, may have a significantly reduced chance of healing from an endodontic infection.

Eriksen et al. showed that endodontic specialists achieve higher success rates when compared to general practitioners. They also showed that endodontic success rates varied between 54 percent and 94 percent.[22] In an investigation of nearly 2,500 teeth, Jonkinen et al. showed that success rates for endodontic therapy may be as low as 53 percent.[23] However in this study, the protocol for endodontic therapy differed from what is currently accepted as the norm. This may have had a negative influenced on the success rates.

The real cause for confusion in survival studies seems to be the way in which the term "success" is defined. If a study has strict criteria for success, the results are negatively affected. On the other hand, if the criteria are less strict, the success rates may be positively affected.

The reporting of success rates in endodontic literature can be confused by the definition of "success/failure," the time period that the outcome was measured over, the type of endodontic procedure and the unit of measurement.

Much of the literature cited success rates are dependent on resolution of the periodontal ligament space with radiographic findings alone and clinical symptoms are not considered.[24-26] Furthermore, study periods are often not adequate to allow classification of teeth displaying a reduction in periapical radiolucency but incomplete radiographic resolution, success rates from the longest period of follow up are extrapolated to that of the mean period, measurement of success are based on roots rather than teeth or have not included teeth extracted.[24,27]

Friedman and Mor in 2004 defined success as root canal treatment that "has healed" or "is healing." They also proposed a new classification: "functional retention." Functional retention is the sum of the healed and the healing sites. They also suggest that functional retention includes a tooth with a normal clinical presentation, where radiolucency is present or absent, newly emerged or persisting.[28] In the opinion of the authors, although functional retention may result in higher apparent success rates, it may not lead to a predictable endodontic outcome. Functional retention is a loose criterion for assessment of endodontic success and may mislead the reader into believing that success rates are actually higher than they really are.

Success Rates of Surgical Endodontic Therapy

Friedman and Mor pooled data from selected studies and showed that the chance of success ranged from 37 percent to 85 percent, with an average of 70 percent. The chance of functionality for surgical endodontic procedures was 86 percent to 92 percent.[28] Again, functionality increases the numerical value for success rate of surgical endodontics. But one needs to decide whether a functional tooth will result in a predictable outcome.

Restorability of Endodontically Treated Teeth

Another important issue is the restorability of endodontically treated teeth. Even if a tooth has been successfully treated with endodontics, one still needs to consider the restoration of the tooth. Goodacre et al., after reviewing 12 studies with 2,784 teeth and a six-year follow-up, 12 percent of teeth with dowels had complications.[29] Many of these complications may lead to tooth loss (**Figures 3, 4**). So, the practitioner needs to objectively assess the restorability of each endodontically treated tooth prior to commencement of treatment. The predictability of the treatment provided will be of benefit both to the patient and dentist.

Success Rates of Dental Implants

In an attempt to objectively quantify success with regard to dental implants and their restorations, many criteria have been defined. The implants should have a minimum of one year of loading, as most implant failures are detected in

Figure 7. Single crown on an implant replacing No. 5, seven years postop.

Figure 8. Poor oral hygiene habits can be detrimental, regardless of the level of treatment provided. This can be an overriding factor when treatment planning.

Figure 9. Cross-arch splinting reconstruction due to periodontal disease.

the first year of service.[30,31] Implant failures should also be defined. It is suggested that if an implant cannot be used as support for prosthetic reconstruction, it should be labeled a "sleeping implant." These are labeled surviving implants at best, as they are not usable.[32] Lindh et al. suggested these should really be classed as failures. If sleeping implants are osseointegrated, they should be regarded as "functional failures" because they are unrestorable.[32]

Smith and Zarb have also suggested that the esthetic aspect of the implant position should also be incorporated as factors for a successful result.[33] Goodacre et al. showed that 47 out of 493 crowns/prosthesis produced aesthetic problems. They found that esthetic failures had a mean of 10 percent[30] (**Figures 5**, **6**).

Gibbard and Zarb stated that "Long-term success for multiple splinted implants cannot be extrapolated to single implants."[34] In a meta-analysis of 66 studies over 10 years, Lindh et al. included 2,686 dental implants, and evaluated 570 single crowns and 2,116 implant fixed partial dentures in partially edentulous jaws. "Although the cumulative survival rate will decrease if 'sleeping implants' are considered as failed, the maximum difference is only 3.7 percent." Implant survival under load after six to seven years was 93.6 percent for fixed partial dentures and 97.5 percent for single crowns[28] (**Figure 7**). The data from the Lindh et al. study suggests that implants and their restorations work extremely predictably for single teeth or fixed partial dentures. It also shows that even with strict inclusion criterion these restorations have excellent success rates.[32]

Discussion

Unfortunately, there are no rules or formulas in dentistry that provide straightforward answers. The practitioner needs to use the knowledge from the literature along with common sense to derive a treatment plan. The picture is further complicated by a multitude of local, systemic and even psychological factors. The patient's medical conditions, the general condition of the oral environment and certainly the patient's motivation toward the treatment will influence the overall success (**Figure 8**). Thus, the actual longevity of a specific treatment modality cannot be applied to all patients indiscriminately.

Considering all these parameters, the clinician is often faced with a dilemma when deciding whether or not to extract a tooth with a poor prognosis. Traditional wisdom was based upon the concept of trying to save the tooth by all means necessary. However, with the inception of dental implants, a completely new avenue has been opened in the treatment planning process. This has created a new topic for debate within the profession. There appears to be two schools of thought. One advocates the traditional approach while the other has adopted a more aggressive approach with treatment planning, and prefers to extract and replace a compromised tooth with a dental implant and restoration.

It is imperative to understand that each therapeutic modality has an inherent biological cost. Therefore, a risk analysis should be initiated prior to any definitive decisions. In the authors' opinion, a very stringent approach is required during this analysis. A treatment with a poor risk-to-benefit ratio has a greater probability of biological consequences. In treatment planning DeVan's statement should always be a cornerstone in the dentist's mind, "our goal should be the perpetual preservation of what remains rather than the meticulous restoration of what is missing."[35]

Nyman and Lindhe have shown excellent results with the prosthetic rehabilitation of patients with advanced periodontal disease with very few prosthetic complications.[36] **Figure 9** illus-

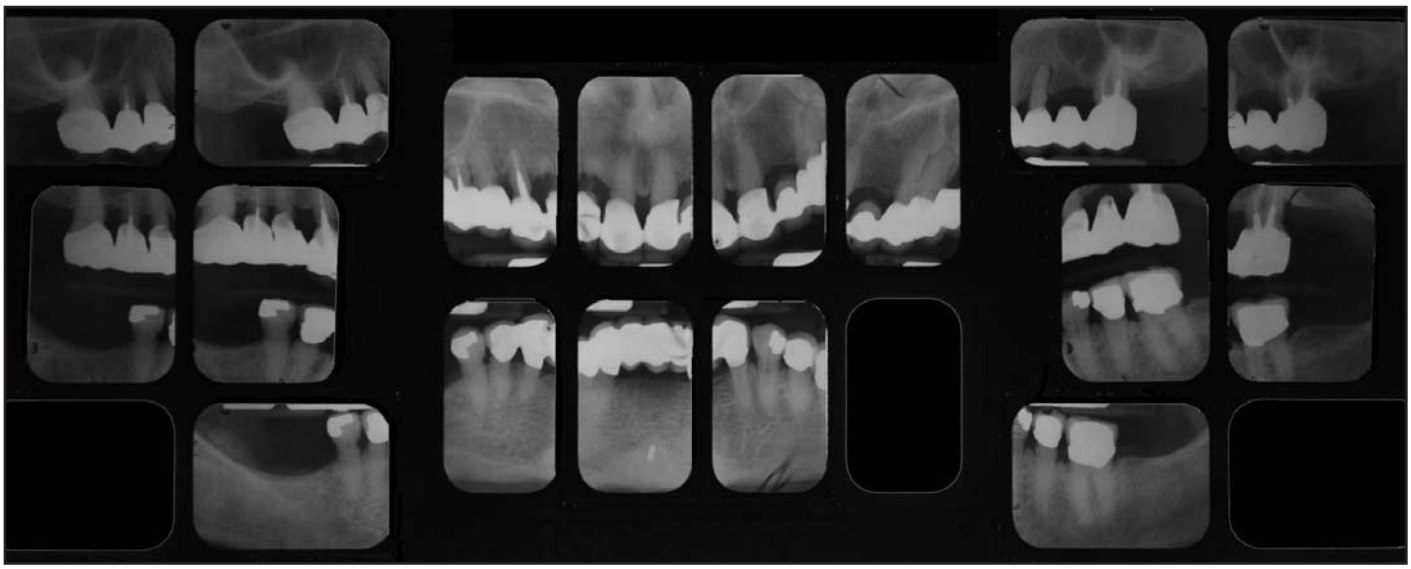

Figure 10. Full-mouth radiographs reveal caries on teeth Nos. 7 and 12, and very small roots.

Figure 11. Implants were placed. The central incisors and first molars support a metal-reinforced fixed provisional restoration.

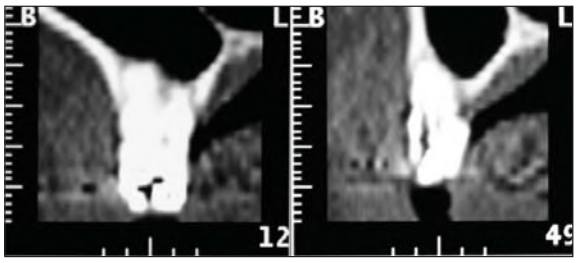

Figure 12. CT scan cuts of right and left first molar areas showing insufficient bone volume to house implants.

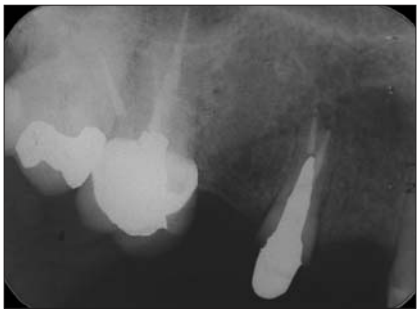

Figure 13. Tooth No. 5 has a large diameter post, periapical radiolucency, and needs a new crown.

Figure 14. Implant-supported fixed partial denture on implants Nos. 4 and 6.

trates a patient who received full-mouth reconstruction in the maxilla due to moderate periodontal disease. After 25 years, the osseous support did not show significant changes with regular periodontal maintenance (**Figure 10**). Nevertheless, the patient's medical status changed and the salivary flow decreased significantly. The result was caries development on two abutment teeth. Considering the medical history, along with the success rates of different treatment modalities, it was decided to extract most of the maxillary teeth and place implants (**Figure 11**). Under no circumstances can the previous peri-

Figure 15. Failing endodontic therapy.

Figure 16. The endodontist decided to perform apical surgery and retrograde root filling.

Figure 17. Second apical surgery and retrograde root filling.

Figure 18. Third apical surgery and retrograde root filling. Despite the endodontist's effort, the tooth was still symptomatic.

Figure 19. After the third surgery failed, the tooth was extracted. Remnants of the retrograde root filling can be observed on the radiograph.

Figure 20. A fifth surgical procedure was necessary to remove the remnants.

odontal-prosthetic rehabilitation be considered a failure after 25 years of survival. An implant-supported restoration was chosen over a tooth-borne cross-arch splint. This decision was based on the obvious risk associated with splinting numerous teeth in a medically compromised patient.

The strategic value of the tooth must also be assessed. In the patient shown in **Figure 11**, the most distal molars were maintained. Extractions would have resulted in sinus lifting procedures, which the patient wished to avoid (**Figure 12**). Although the teeth had a guarded prognosis, their value as two additional occluding units contradicted their removal. **Figure 13** shows tooth No. 5 has a large cast dowel and needs endodontic retreatment and a new crown. Implants are planned for the mesial and distal edentulous sites, while the existing teeth on the mesial and distal do not need restorations or replacement of restorations. Due to the risk involved and the low strategic value of the tooth, a three-unit implant-supported fixed partial denture was fabricated (**Figure 14**). It can be deducted that, teeth with higher strategic value will be amenable to more extensive procedures than teeth in less important positions in the arch.

Clinical Recommendations and Conclusions

Implant placement and restoration is not a technically demanding procedure.[37,38] From the results available today, which are based on follow-up studies, it seems tooth replacement with dental implants is more predictable than surgical periodontal and endodontic techniques (**Figures 15-20**). This, however, should not automatically preclude these therapeutic modalities and lead to extraction of the affected teeth. It does justify though, a relatively more aggressive approach especially in younger patients where a significantly long-term prognosis is required.

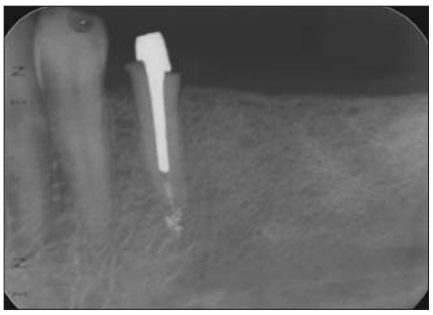

Figure 21. The root length was favorable and a narrow diameter for the dowel was intentionally maintained.

Figure 22. This tooth received root canal therapy, crown lengthening, cast dowel and core and a new crown.

Figure 23. This tooth requires endodontic retreatment, crown lengthening, dowel and core and a crown. It was decided to extract the tooth as the patient was a bruxer and the root had unfavorable anatomy.

Figure 24. Advanced periodontal disease. The treatment of choice was extraction and implant placement.

One needs to decide on the most predictable strategy for restoring a severely broken down tooth. This may involve the combination of endodontic, periodontal and restorative procedures in order to save a tooth (**Figures 21, 22**). On the other hand, what has been considered successful prior to the inception of dental implants might not be acceptable today. If the tooth has minimal coronal tooth tissue remaining with unfavorable root structure, or if multiple procedures need to be performed, one is justified in extracting the tooth in favor of a dental implant (**Figure 23**). Multiple procedures, even if independently low risk, significantly increase the risk of failure. On the other hand, removal of all teeth that do not receive a good prognosis is extremely aggressive and contraindicated.

Heroic attempts to maintain teeth with poor prognosis should be eradicated. Such attempts increase the risk for failure, as well as the cost for the patient in the long run. They may also jeopardize future treatment outcomes. For example, as periodontal destruction progresses, the risk of insufficient bone volume for implant placement increases. Historically, the teeth shown in **Figure 24** would be maintained until they exfoliated from the patient's mouth. A more aggressive approach nowadays will save the patient from the high morbidity and lower predictability of bone grafting procedures. The authors believe that the interpretation of the "…preservation of what remains" should be extended to the precious osseous structure of the ridges.[33]

Today, the clinician is blessed with an additional treatment modality. Incorporating dental implants into our treatment plans will only serve to improve the predictability and quality of care provided to our patients. CDA

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