Developing Treatment Algorithms for Restoration or Replacement of the Compromised Tooth

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Introduction

The introduction of newer therapeutic modalities, surgical and restorative techniques, and restorative materials has dramatically expanded available treatment options regarding the compromised tooth. While a potential boon for clinicians and patients alike, such expansion places greater demands on the diagnostic and treatment-planning capabilities of the clinician. The challenge is not in mastering available surgical and restorative treatment techniques, but rather in determining when to apply each treatment modality and how to utilize the chosen therapeutic approach to its maximum benefit for the patient.

Treatment decisions should always be made in consideration of the health of the patient, the appropriateness of the therapy, the informed desires of the patient, and the costs of the therapy. Therapeutic costs to be assessed are not only financial, but also biologic, esthetic, therapeutic, temporal, and psychological. In addition, the prognosis of each therapeutic option over time must be considered.

When faced with a single compromised tooth, treatment options include restoration of the tooth, in conjunction with endodontic, orthodontic, and/or periodontal therapies where necessary; tooth removal and replacement with an implant-supported single crown; or tooth removal and replacement with a three-unit fixed partial denture. It is imperative that selection of a specific treatment approach is not grounded in the clinician's less-than-thorough understanding of the advantages, disadvantages, and potentials of each treatment option. A clinician's lack of understanding or experience with a given treatment approach, or failure to master delivery of such therapy, is a poor excuse for selecting one therapeutic option over another. Rather, treatment outcome expectations, the various risks of each therapeutic option, and the prognosis of each treatment approach should be carefully considered and weighed in the decision-making process.

The challenge is how best to quantify the tooth survival rates of recommended procedures and therapies. While excellent documentation is present regarding success and failure rates of specific therapies, the literature is woefully inadequate in assessing treatment outcomes for other modalities. Many articles poorly define patient selection, overall patient dental health, criteria for success, and other confounding factors. In addition, a number of published reports utilize materials that are no longer employed on a day-to-day basis. Finally, there is a paucity of literature comparing various treatment approaches in the same patients or clinical practices. As a result, while the goal is to render the decision-making process as scientific as possible, a number of "soft" factors influence this process, including clinician bias and perspective. It is for this reason that clinical dentistry is still a unique combination of art and science.

Diagnostic Requirements

A thorough examination and diagnosis must always be carried out, and a comprehensive interdisciplinary treatment plan must be formulated prior to initiation of any active therapy. Such an examination always begins with an open discussion with the individual patient, so as to assess the patient's needs and desires. Failure to ensure such open avenues of discussion increases the risk of patient dissatisfaction, along with poor treatment outcomes. Thorough data collection is a must. Examination of hard and soft tissues, use of models with face-bow mountings, and analysis of the patient's occlusion in conjunction with a high-quality full series of radiographs provide baseline data needed for decision making and treatment recommendations. Three-dimensional imaging is often required. Such imaging provides especially important information when assessing the bone support on the palatal root of a maxillary molar, the precise extent of an endodontic lesion that is present, the assessment of available bone if tooth extraction and implant placement are contemplated, and assurance of the absence of other pathologies that may either influence the course of therapy or pose significant health risks to the patient.

All potential etiologies must be identified and assessed prior to formulating a comprehensive treatment plan, including systemic factors, periodontal status, the presence or absence of parafunction, carious lesions, endodontic lesions, and trauma, among others.

As the available treatment options and "ideal" treatment plan are being formulated for presentation to the patient, it is important that both the predictability and expected treatment outcome of each therapeutic approach be honestly and openly assessed and discussed. Such an assessment allows the patient to choose the treatment option for which he or she is best suited physically, financially, and psychologically.

Teeth that can be predictably restored to health through reasonable means should always be maintained, if such retention is advantageous to the final treatment plan and addresses the patient's desires and wishes. Once again, lack of understanding about the predictably attainable results following periodontal and/or endodontic therapy, as well as the expected long-term prognoses of various approaches, often results in formulation of treatment plans that do a disservice to the patient.

It is inappropriate to remove all teeth that show any degree of compromise and replace them with implant-supported prosthetics. However, it is equally inexcusable to fail to understand and incorporate regenerative and implant therapies into available treatment armamentaria when addressing a patient's unique situation.

The success rates of procedures that have statistical track records can be presented to the patient to help him or her weigh the pros and cons of each option. Such data can also be used to support the treatment decisions of the dentist. Unfortunately, the success rate of a particular procedure performed by the practitioner in question, which is of greatest value, is often unavailable statistically. Usually, the dentist can only state that his or her success with this particular procedure is based on the number of times it has been performed successfully. This history of success and/or failure often shapes the treatment plan.

Assessing the Individual Tooth

Prior to making a determination as to the advantages or disadvantages of retaining a given tooth, there are a number of parameters that must be appropriately assessed.

Periodontal Considerations

The periodontal status of the tooth in question is an absolute indication or contraindication to an attempt at long-term maintenance through periodontal and restorative therapies. There is no question that pocket depths in excess of 4 mm are not maintainable by either the patient or the dental professional. Therefore, except in instances where teeth are being maintained in older or medically compromised patients, pocket elimination must be a feasible treatment outcome in order to consider restoration and retention of a given tooth. Such pocket elimination may proceed through periodontal resective therapy, periodontal regenerative therapy, or a combination of the two.

Pocket elimination also includes resolution of any furcation involvements that are present. Performing extensive restorative therapy on a furcated tooth because it demonstrates "only" a Class I furcation involvement is ill advised. It is well established that such areas will continue to break down, due to the "cul de sac" that will continue to trap plaque despite the best professional and patient plaque-control measures. There is no argument in the literature over whether or not furcation involvements progress. The only points to be considered are how quickly a given furcation involvement will progress, such progression upon the impact of the planned therapy, and the influence of overriding patient concerns (e.g., age, health, etc.).

A stable band of attached keratinized tissue, and hence an intact fiber barrier system, must be present to help provide adequate defense against the added plaque accumulation and potential periodontal compromise inherent in placement of restorative margins at the gingival crest or intrasulcularly. If such a band of attached keratinized tissue cannot be established due to various anatomic or psychological considerations on the part of the patient, then the tooth is ill suited for restoration and retention.

If a stable periodontal milieu may be established for reception of restorative dentistry, without unduly compromising the support of the tooth in question, the argument for retaining the tooth is greatly enhanced. However, should the tooth in question demonstrate extensive periodontal attachment loss, or should performance of necessary preprosthetic crown-lengthening osseous surgery significantly alter the crown-to-root ratio of the tooth, the tooth may be a poor candidate for retention.

A minimum of 3–4 mm of healthy tooth structure must be available crestal to the alveolar bone crest to allow both redevelopment of an appropriate attachment apparatus and establishment of the necessary ferrule in the preparation design. If the restorative-margin tooth interface is deep subgingivally, patient home care is compromised, and the resultant increased plaque accumulation may reinitiate not only the periodontal inflammatory process, but also recurrent caries at the aforementioned interface.

Endodontic Considerations

In addition to determining whether or not endodontic therapy can be carried out on a given tooth, care must be taken to assess the expected residual tooth structure following such endodontic intervention, and the ability of this residual tooth structure to withstand load application over time.

Natural tooth contours may result in a thin isthmus of tooth structure following endodontic therapy. Areas of specific concern are two-rooted maxillary first bicuspids and the furcal aspect of the mesial root of a lower molar. Teeth with the highest endodontic failure rates are mandibular first premolars, followed by maxillary laterals, maxillary first and second premolars, the mandibular second premolar, and maxillary and first molars.[1]

While root canal systems are generally predictable in morphology, complicating or unique attributes set many teeth apart. Zillich and Dawson describe mandibular first premolars as either easy or exceedingly difficult to treat.[2] This par-

ticular tooth will present with a second or third canal 23 percent of the time. In addition, these canals may divide at any point within the root. Maxillary premolars exhibit variations similar to mandibular premolars, often making them difficult to successfully treat.

Sjögren reports 8- to 10-year success rates of 96 percent in teeth with vital pulps, and 86 percent if the pulp is necrotic, following endodontic therapy.[3] The manner in which the tooth is obturated affects success; however, endodontic success does not always equate to restorative success. The factors confounding endodontic therapy make restorative options more challenging. Placement of a post in a maxillary or mandibular first premolar that falls in the 23 percent complex root canal configuration category may be impossible or result in a compromised prognosis, due to the mechanics of preparing the internal aspect of an irregular cavity with walls of varying thickness using a rotary instrument.

The absolute and relative contraindications to retention of a given tooth are listed in Table 1. If tooth extraction and implant placement are to be contemplated, it is important to realize that such a treatment choice does not preclude the need for appropriate diagnosis and assessment before carrying out therapy.

Table 1. Local Factors Influencing When to Perform Crown-Lengthening Osseous Surgery (CLS)

Factor	Perform CLS and Keep Tooth	Remove Tooth
Can make tooth periodontally stable?*	Yes	No^
Can treat the tooth endodontically?	Yes	No^
Will compromise adjacent support?	No	Yes^
Will induce secondary occlusal trauma?	No	Yes~
Requires periodontal, endodontic, and restorative therapies?	No	Yes~
Presence of parafunction?	No	Yes~
Esthetic compromise following therapy?	No	Yes~
Large number of visits required?	No	Yes~
Complex therapy required?	No	Yes~
Excellent long-term prognosis?	Yes	No^
Patient wants to keep tooth?	Yes	No~

* Denotes probing depths ≤ 3 mm; no furcation involvements; adequate attached keratinized tissue
^ Absolute indication for tooth removal
~ Relative indication for therapy

Implant Receptor Site Considerations

A number of site-specific factors must be considered if tooth removal and implant placement are to be entertained. The position, quantity, and quality of the available bone are of paramount importance. A malpositioned tooth may result in an extraction socket whose position precludes ideal implant positioning without either regenerative therapy at the time of tooth extraction, followed by subsequent implant placement or concomitant regenerative therapy at the time of tooth removal and implant insertion.

The assessment of bone quantity must be carried out in a three-dimensional manner. An assessment limited to evaluating the length of the implant that may be placed and whether or not the implant will be inserted wholly within an intact extraction socket, is inadequate. A patient with a thin, highly scalloped biotype, or one who has undergone buccal orthodontic tooth movement or has caused hard- and soft-tissue recession through aggressive brushing, will demonstrate a thin, highly labile buccal alveolar bony plate following tooth removal. Placement of an implant in such a situation without concomitant regenerative therapy to protect and increase the bulk of the buccal bone will leave the patient with a situation of high bone resorption upon application of functional load. Any implant placed must be housed in adequate bone to withstand functional forces buccally and lingually/palatally, over time.

Assessing Cost-Benefit Ratios

A risk/reward benefits analysis must be undertaken to help determine the most reasonable approach to a given situation. The development of an appropriate treatment algorithm mandates recognition and evaluation of all applicable cost-benefit ratios. These cost-benefit ratios are biologic, esthetic, financial, temporal, psychological, and therapeutic in nature. Appropriate assessment must also take into consideration not only the present but also the future status of the treatment delivered.

Biologic Considerations

Biologic costs impact both the tooth under direct consideration and adjacent teeth. The tooth being assessed may pay a biologic price in terms of loss of tooth structure following preparation with or without endodontic intervention; loss of supporting bone following preprosthetic periodontal therapy, when necessary; or development of furcation involvements following preprosthetic crown-lengthening osseous surgery.

Case Study I

A patient presents with a subgingival fracture on the buccal aspect of a mandibular first molar. (See Figure 1.) This tooth has already undergone orthodontic therapy. Radiographic examination demonstrates the short residual root trunk present between the root fracture and the entrance to the buccal furcation. (See Figure 2.) Due to the short distance between the subgingival margin of the buccal fracture and the entrance to the furcation (approximately 1.3 mm), performance of the necessary crown-lengthening osseous surgery would result in development of a significant buccal furcation involvement, as well as a compromised prognosis for the tooth following completion of therapy.

Removal of such a tooth and its replacement by an implant with concomitant regenerative therapy may appear at first to be an overly aggressive treatment approach. The argument might be made that the patient would be better served by placing a crown on the tooth and "trying to hold on to it for as long as possible," especially as endodontic therapy had been performed some years before.

Such a treatment option is not in the best interest of the patient unless patient health precludes more comprehensive care, or patient age leads the clinician to think that the tooth will not have to function for much longer. Post-and-core buildup and a full-coverage restoration without periodontal surgical therapy entails significant expense, and will result in a milieu that institutes a periodontal inflammatory lesion almost immediately upon completion of tooth restoration. At best, the disease process will proceed slowly. At worst, the tooth will become significantly compromised and periodontally untreatable in the near future.

Performance of crown-lengthening osseous surgery prior to post-and-core buildup and full-coverage restoration of the tooth will also entail additional expense and will not provide a periodontal milieu conducive to placement of restorative dentistry without the initiation of an inflammatory periodontal lesion.

Conservative therapy is removal of the tooth and placement of an implant and subsequent restoration, so as to provide a healthy, functional situation for the patient.

The biologic costs to the adjacent teeth must also be considered. If crown-lengthening osseous surgery performed around a given tooth will unduly compromise the periodontal support of the adjacent teeth, such therapy is not indicated. Performing treatment that compromises healthy teeth is inadvisable when predictable therapeutic modalities such as tooth extraction and implant placement exist. Figure 3 demonstrates a mandibular first molar with recurrent subgingival caries on its distal aspect. The position of the caries is such that crown-lengthening osseous surgery can be safely performed without unduly compromising the supporting bone of either the first molar or the mesial aspect of the second molar. In contrast, Figure 4 is a radiograph of a mandibular first molar that demonstrates recurrent subgingival caries on its distal aspect, which represents a much greater compromise than that encountered in Figure 3. Due to the extension of the caries along the distal root, appropriate crown-lengthening osseous surgery would involve removal of significant osseous support and attachment apparatus from the mesial aspect of the second molar, as well as a possible inability to attain the necessary 4 mm of biologic width between the recurrent caries and the entrance to the buccal furcation of the first molar.

Case Study II

A patient presents with recurrent caries around a crown on a maxillary second bicuspid. (See Figure 5.) The caries appears on the interproximal surface of the second bicuspid. If the caries had been

Figure 1. A patient presents with a buccal subgingival fracture of a mandibular first molar.

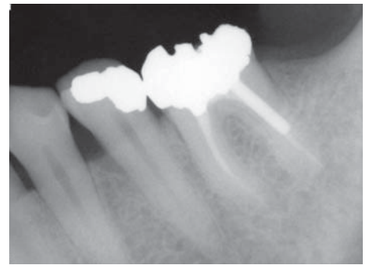


Figure 2. Radiographic examination demonstrates a short residual root trunk between the fracture and the entrance to the buccal furcation. Performance of crown-lengthening osseous surgery would result in a significant buccal furcation involvement on the first molar.

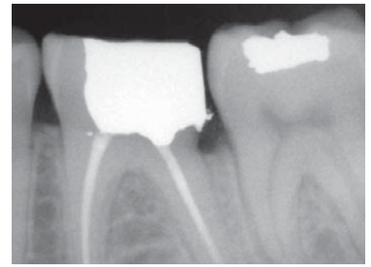


Figure 3. A patient presents with recurrent subgingival caries on the distal aspect of the mandibular first molar. The position of the caries renders this tooth an excellent candidate for crown-lengthening osseous surgery.

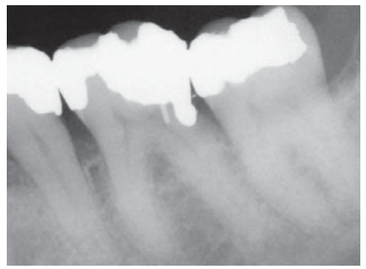


Figure 4. A patient presents with recurrent subgingival caries on the distal aspect of the mandibular first molar. Crown-lengthening osseous surgery would necessitate removal of significant bone support from the mesial aspect of the mandibular second molar and may compromise the entrance to the buccal furcation of the mandibular first molar. The first molar should be removed and replaced.

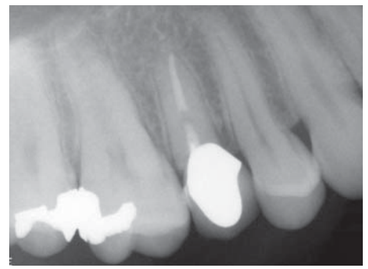


Figure 5. A patient presents with recurrent caries on the distal aspect of the maxillary second bicuspid. Crown-lengthening osseous surgery would result in significant compromise of the bone support on the mesial aspect of the first molar and invasion of the mesial furcation of the first molar.

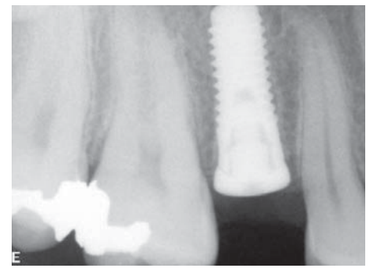


Figure 6. The tooth is removed and replaced with an implant.

located on the buccal or palatal aspects of the tooth, crown-lengthening osseous surgery could safely be performed without affecting the support of the adjacent teeth. Unfortunately, performance of the necessary crown-lengthening osseous surgery would significantly compromise the mesial support and result in development of a mesial furcation involvement, of the adjacent first molar. As a result, it is more prudent to remove the tooth and place an implant at the time of tooth removal. (See Figure 6.)

Esthetic Considerations

The effects of crown-lengthening osseous surgery on the patient's esthetics must be assessed. While palatal caries on a maxillary anterior tooth may be safely exposed for restoration, the same procedure performed interproximally or buccally often results in an unacceptable esthetic treatment outcome. In such situations, other treatment options should be explored. While supereruption of the tooth prior to crown-lengthening osseous surgery could be considered, such an approach is not ideal, as the supererupted, crown-lengthened, and restored incisor would present with a poor crown-to-root ratio and thus a limited prognosis after the patient had been subjected to extensive and expensive therapies.

Financial Considerations

The financial ramifications of each treatment approach play a significant role in selection of a given therapeutic modality. In order to better assess this consideration, a questionnaire was sent to 100 periodontists in urban and suburban areas throughout the United States in 2008. The periodontists were asked, in consultation with their restorative partners, to provide information regarding the costs of various therapies. Only 87 periodontists sent back the requested information, so 13 additional periodontists were individually contacted and asked to provide the same information. (See Table 2.)

The average cost of restoration of a natural tooth was 1.3X. If crown-lengthening osseous surgery was required, an additional cost of 1.1X was added, for a total cost of 2.4X. If endodontic therapy was necessary, an additional fee of 0.9X to 1.3X was added, for a total fee of 3.3X to 3.7X. Finally, if a core buildup was carried out after endodontic therapy, an additional 0.6X of cost was added, for a total fee of 3.9X to 4.3X.

Table 2. Relative Fees for Various Therapies

Therapy	Fee
Endodontic—Single Root	0.9X
Endodontic—Multiple Roots	1.3X
Core Buildup—Natural Tooth	0.6X
Crown—Natural Tooth	1.3X
Pontic	1.4X
Crown-Lengthening Periodontal Surgery	1.1X
Regenerative Periodontal Surgery	1.9X
Orthodontic Supereruption	2.8X
Extraction	0.3X
Three-Unit Fixed Bridge	4.3X
Implant	2.1X
Implant Abutment (stock) and Crown	2.2X
Implant Abutment (custom) and Crown	2.7X
Regenerative Therapy at Tooth Extraction	0.7–1.4X
Sinus Augmentation	2.5X
Osteotome Sinus Lift	0.9X
Osteotome Sinus Lift at Time of Implant Placement	N/C

The average cost of tooth extraction, implant placement, and restoration with a stock abutment and single crown was 4.6X. If regenerative therapy was necessary in conjunction with implant placement, an additional fee of 0.7X to 1.4X was added, for a total fee of 5.3X to 6.0X.

Considering only the financial ramifications of therapy, it becomes obvious that if a tooth may be restored in a healthy manner necessitating either crown-lengthening osseous surgery or endodontic therapy and post-and-core buildup, it is prudent to do so. However, if crown-lengthening periodontal surgery, endodontic therapy, post-and-core buildup, and full-coverage restoration are required on a given tooth, and the tooth could instead be replaced with an implant, abutment, and crown without performing extensive regenerative therapy, it is more logical financially to follow the implant course of treatment. Naturally, financial considerations do not stand alone in determining the appropriate therapeutic approach.

Temporal Considerations

Temporal requirements must also be considered. If tooth retention mandates an excessive number of visits to perform the necessary periodontal therapy, endodontic therapy, and subsequent restoration, the patient may be better served through tooth extraction and implant placement at the time of tooth removal. Following healing, two restorative visits will usually be required. However, implant reconstructive therapy will only be viewed in such a manner if all treating clinicians understand the potentials of various therapeutic approaches.

The ability to extract a tooth, debride the socket, and successfully place an implant at the time of tooth removal, with or without immediate temporization, has been well established throughout the literature. Numerous articles have elucidated various treatment algorithms for implant placement at the time of tooth removal.[4] The literature conclusively demonstrates that the predictability of osseointegration if implants are placed at the time of tooth extraction or are placed into intact bone following healing are interchangeable when considering implant placement at the time of extraction of single-rooted teeth.

Implant placement at the time of multirooted tooth extraction has traditionally been viewed as a compromised treatment approach due to the technical difficulties in ideally positioning the implant, and the unpredictability in effecting appropriate regeneration of bone in the residual extraction socket surrounding the implant. However, two recent publications documenting more than 650 cases demonstrate the long-term predictability of implant placement at the time of extraction of maxillary or mandibular molars with performance of concomitant regenerative therapy.[5,6]

Immediate implant placement at the time of tooth extraction should not be viewed as a compromise, but rather, as another therapeutic alternative to be considered when developing appropriate viable treatment algorithms.

Immediate implant placement at the time of tooth extraction may also shorten the time required to perform therapy. Utilization of such a treatment approach will often result in a significantly shorter course of therapy than crown-lengthening osseous therapy, endodontic therapy after appropriate healing has been carried out, and post-and-core buildup and restoration of the tooth in question.

Psychological Considerations

Patient demands and desires may lead to selection of one treatment approach over the other. If a patient is psychologically unable to deal with the thought of losing his or her tooth, or is afraid of having an implant placed, extraordinary efforts may be made in an attempt to save the tooth in question. Patient desires may also mandate tooth extraction and replacement with an implant. A patient who is ill suited for complex multidisciplinary care, or one who states that he or she does not wish to maintain a given tooth and subject it to extensive therapy "unless the result is guaranteed," is a poor candidate for performance of crown-lengthening osseous surgery, endodontic therapy, and tooth restoration.

Complexity of Care

Complexity of care is an important consideration. A tooth for which performance of appropriate endodontic therapy would be difficult if not impossible is ill suited for retention. In addition, if the complexity of surgical and/or restorative therapy required increases the chances of immediate or long-term failure, then tooth retention is not advised.

Figure 7. Implants are in place in the positions of the first and second premolars. A mesiobuccal root amputation has been performed on the first molar. Crown-lengthening osseous surgery has been performed on the second molar.

Figure 8. The castings are in place on the model. Note the straight emergence profile of the casting out of the gingiva in the area of the mesiobuccal root amputation on the maxillary first molar.

Implant utilization does not eliminate all concerns regarding complexity of care and the required clinical skills to perform appropriate therapy. Surgical access, site compromises, or difficulty in restoration following osseointegration of the implant is each a serious contraindication to tooth removal and implant placement.

Predictability of Care

The long-term predictability of therapy is paramount when selecting a treatment approach. There is a paucity of literature comparing long-term success rates of teeth restored with single crowns—with or without prior endodontic intervention—and single implant-supported crowns. A comparison of studies purporting to evaluate one or the other of the treatment modalities is difficult. Significant advances in endodontic techniques and restorative materials render many of the older studies of no use in carrying out such a comparison. In addition, the advent of rough-surfaced implants and various implant designs and restorative options invalidates the inclusion of older studies when comparing long-term success rates of different treatment approaches. Available literature assessing success rates of teeth restored with single crowns—with or without prior endodontic therapy and utilizing newer restorative materials—reports success rates in the range of 94 percent.[7] Implant success and survival rates for rough-surface implants restored with single crowns have been consistently reported in excess of 95 percent over five to 10 years.[8]

The Cost of Retreatment

The commitment necessary upon retreatment must also be carefully weighed. Failure of a natural tooth restored with a single crown may be due to crown fracture, recurrent caries, root fracture, development of an endodontic lesion, or progressive periodontal disease. The dangers of root fractures following endodontic therapy that results in inadequate tooth structure to withstand functional forces over time have already been reviewed. Most of the complications listed above would result in significant retreatment or tooth removal and replacement.

In contrast, complications around osseointegrated rough-surface implants restored with cemented single crowns usually take the form of porcelain fracture or soft-tissue inflammation. The inflammation is easily treated through debridement and/or mucogingival therapy. Depending on the method that had been employed to attach the crown to the implant, treatment may require either removal of the crown and application of new porcelain or replacement of the crown. Either need is less involved and less traumatic to the patient than tooth removal and replacement. Naturally, a third treatment option is tooth removal and placement of a three-unit fixed-partial denture. An in-depth discussion of this option, as compared to implant placement and restoration for replacement of a single missing tooth, has been explored in detail and will not be discussed here.[9]

Case Study III

A patient presents with extensive periodontal destruction in the maxillary left posterior sextant. The maxillary first and second premolars were hopeless. A Class III buccal-to-mesial furcation in-

Figure 9. Eleven years postoperatively, the second molar has already been replaced by an abutment and crown. Recurrent caries is now noted around the retained roots of the first molar.

Figure 10. A patient presents with deep, recurrent caries on the maxillary first and second premolars and maxillary second molar.

Figure 11. Following extraction of the first and second premolars and second molar, implants were placed and restored in both premolars and the first molar position.

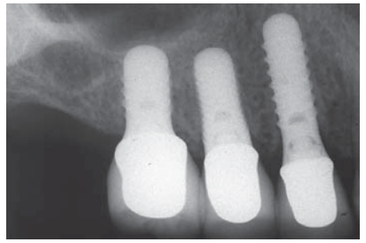


Figure 12. A radiograph taken eight years posttherapy demonstrates stability of the peri-implant crestal bone.

volvement was noted on the maxillary first molar. The maxillary premolars were extracted and implants were placed with concomitant regenerative therapy. Crown-lengthening osseous surgery was performed on the first and second molars, in conjunction with a mesiobuccal root resection on the maxillary first molar. Examination of the master cast demonstrates implant positions, as well as the contour attained on the maxillary first molar following root resection and appropriate odontoplasty. (See Figure 7.) Castings were fabricated on the implants and natural teeth, ensuring that a straight emergence profile of the casting from the gingival was present in the area of root resection. (See Figure 8.) Five years later, the second molar decayed and had to be removed. At the time of tooth extraction, it was replaced by an implant, which was subsequently restored with a single crown.

Six years later—11 years after the initial surgical therapy was carried out—the patient presents with significant recurrent decay on the retained roots of the maxillary first molar. (See Figure 9.) This tooth will now have to be extracted and replaced with an implant. While five and 11 years, respectively, fall within accepted timeframes for assessing treatment success, the patient was not well served by this therapeutic approach. As significant reconstructive and implant therapy was already being carried out, and as the patient demonstrated a relatively high caries rate, it would have been more logical to extract the premolars and molars, place four implants with concomitant regeneration, and restore them with individual abutments and crowns.

The financial costs of multiple procedures performed on a tooth may appear excessive if the prognosis or expected outcome of treatment deteriorates. In addition, each therapy represents an inconvenience to the patient, possible discomfort, and a healing period. Should multiple procedures be chosen to accomplish a goal if an approach requiring fewer visits would afford the same treatment outcome expectations and prognosis of the therapy? Training has traditionally advocated preservation of a given tooth as the optimal therapy to offer to a patient. However, hidden unknowns such as an undetected crack in the tooth, damage to the root wall during post preparation, an exposed furcation due to a necessary crown-lengthening procedure, a root system that has unrealized complexities, or an endodontic fill that is "only clinically acceptable" all conspire to yield a result whose unpredictable prognosis cannot be calculated.

Case Study IV

A patient presents with significant caries on the maxillary first and second premolars and the maxillary second molar. (See Figure 10.) The maxillary first molar is missing. Due to a combination of the extension of caries subgingivally, and caries having destroyed much of the bulk of the tooth mesially and distally, it was decided that it was more prudent to extract the three teeth and place implants in the positions of the first and second premolars and the first molar. No opposing mandibular tooth was present in the second molar position. Subsequent to attainment of osseointegration, the implants were restored with abutments and crowns. (See Figure 11.) Radiographic examination eight years after therapy had been performed demonstrates stability of the peri-implant crestal bone. (See Figure 12.)

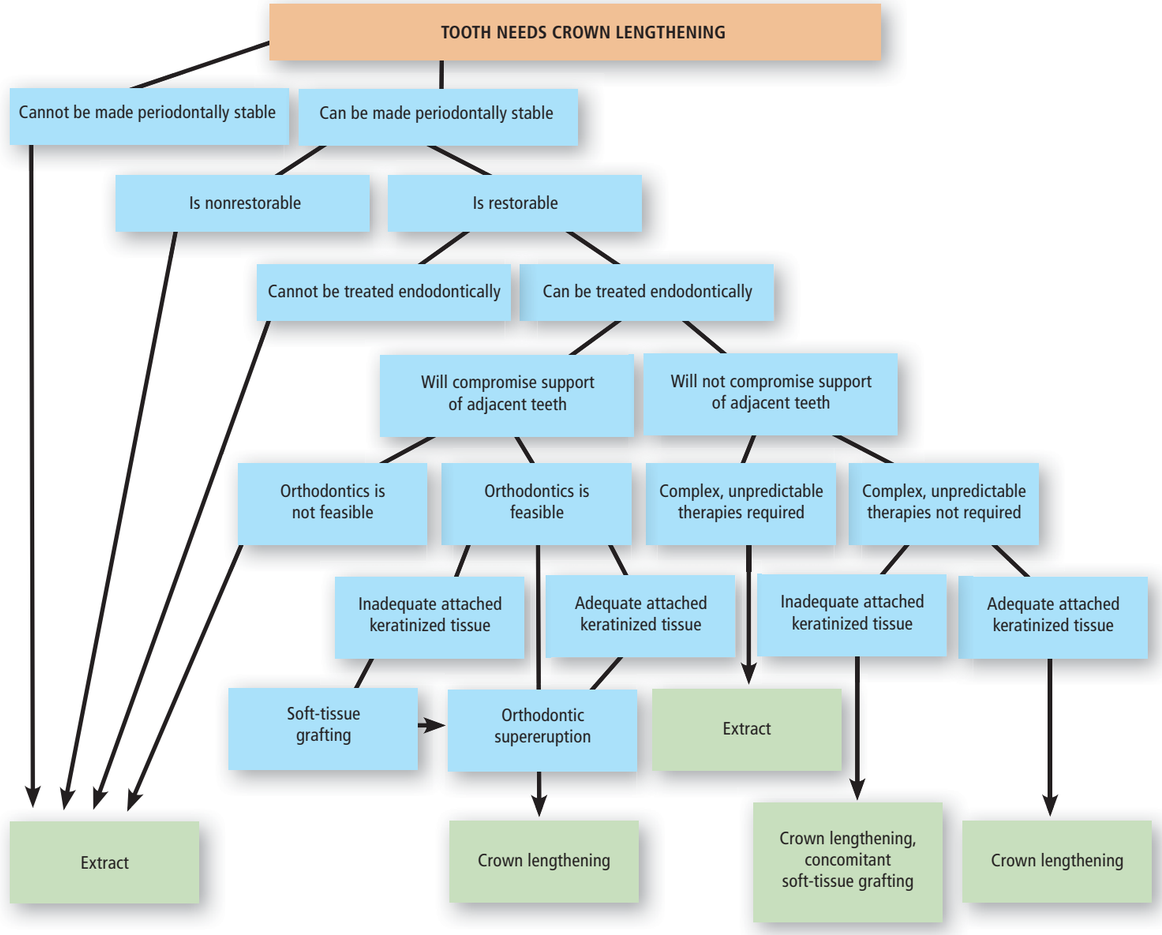
Single-tooth replacement with osseointegrated implants and crown restorations has proven to be a highly predictable treatment modality. Numerous longitudinal and retrospective studies demonstrate survival rates at least equal to other methods of tooth replacement, over time.[8,10-12] Jivraj and Chee state that "decisions to salvage questionable teeth should be weighed against the predictability of implant therapy and the efficacy of long-term outcomes."[13]

Does this mean that all decayed teeth, or teeth requiring endodontic therapy, should be extracted and replaced by implants? It does not. Such a treatment approach is unjustifiable. There is no doubt that crown-lengthening therapy, followed by appropriate restorative intervention, is highly predictable. However, such treatment should not be blindly performed without appropriately assessing other available therapeutic modalities. (See Table 1.)

Conclusion

A number of treatment options afford themselves to the clinician when faced with a compromised tooth. However, prior to determining which treatment approach to pursue, whether it be tooth retention with periodontal and/or endodontic therapy, or tooth removal with implant placement and restoration, the indications, contraindications, potentials, and risks of each treatment approach must be assessed. (See Table 3.) The final decision should be based on what is in the best interest of the patient, and not be determined by the clinician's diagnostic or clinical limitations. ■

Table 3. A Tooth Requiring Crown Lengthening



References

1. Miller HM. Incidence of extraction at the U of Oregon Dental School. Oral Surg. 1958;11:1226-1228.
2. Zillich R, Dawson J. Root canal morphology of the mandibular first and second premolars. Oral Surg. 1973;36:738-744.
3. Sjögren U. Success and failure in endodontics. Austral Endodont Newsletter. 1996;22(2):26.
4. Fugazzotto PA. Treatment options following single rooted tooth removal: a literature review and proposed hierarchy of treatment selection. J Periodontol. 2005;76:821-831.
5. Fugazzotto PA. Implant placement at the time of maxillary molar extraction: treatment options and reported results. J Periodontol. 2008;79:216-223.
6. Fugazzotto PA. Implant placement at the time of mandibular molar extraction: description of technique and preliminary results of 341 cases. J Periodontol. 2008;79:737-747.
7. Salinas TJ, Eckert SE. In patients requiring single tooth replacement, what are the outcomes of implants as compared to tooth supported restorations? Int J Oral Maxillofac Implants. 2007;22:71-92.
8. Fugazzotto PA, Vlassis J, Butler B. Success and failure rates of 5,526 ITI implants in function for up to 73+ months. Int J Oral Maxillofac Implants. 2004;19:408-412.
9. Fugazzotto PA. Decision making when replacing a missing tooth. Dent Clin North Amer. 2009;53:97-129.
10. Schmitt A, Zarb GA. The longitudinal clinical effectiveness of osseointegrated dental implants for single tooth replacement. Int J Prosthodont. 1993;6:187-202.
11. Ekfeldt A, Carlsson GE, Borgesson G. Clinical evaluation of single tooth restorations supported by osseointegrated implants: a retrospective study. Int J Oral Maxillofac Implants. 1994;9:179-183.
12. Becker W, Becker BE. Replacement of maxillary and mandibular molars with single endosseous implant restorations: a retrospective study. J Prosthet Dent. 1995;74:51-55.
13. Jivraj S, Chee W. Treatment planning of implants in posterior quadrants. Br Dent J. 2006 (July 8);201(1):13.