Adult Orthodontics in the 21st Century: Guidelines for Achieving Successful Results

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For the past two decades, increasing numbers of adults have been referred to orthodontists for correction of their malocclusions. Adults usually are cooperative, clean their teeth, show up for appointments, and are appreciative of the clinician's efforts. However, adults may have problems other than malposed teeth and jaws that make their orthodontic treatment more challenging. Adults may have old and failing restorations, edentulous spaces, abraded teeth, periodontal bone defects, gingival level discrepancies, hopeless teeth, and a variety of other restorative and periodontal problems that could compromise the orthodontic result. In the past, orthodontists made all of the decisions about the treatment plan for a child or adolescent. However, in the compromised adult malocclusion, the team of orthodontist, oral and maxillofacial surgeon, periodontist, and restorative dentist must interact together to make prudent treatment decisions for the patient. This article will describe a series of five guidelines to help manage the interrelationship of orthodontics with periodontics and restorative dentistry.

Generate Realistic Treatment Objectives

The first step in any type of dental therapy is to establish treatment objectives. It is impossible to achieve the correct end result if the appropriate goals or objectives have not been identified before treatment. In adolescent patients with nonrestored complete dentitions, orthodontic treatment objectives tend to be idealistic. After all, if patients have intact dentitions without restorations, it is appropriate to expect that ideal esthetic and occlusal treatment should be attainable, if the patient cooperates. Because of this tendency, many orthodontists are trapped into applying these same idealistic treatment objectives to adult patients, who often have missing or abraded teeth, old restorations, or other restorative and periodontal complications. Idealistic treatment objectives may not be appropriate for the orthodontic-periodontic-restorative patient. For these patients, it is important to establish realistic, not idealistic, treatment objectives. Realistic treatment objectives generally fall into four categories.[1] These objectives should be economically realistic, occlusally realistic, periodontally realistic, and restoratively realistic. This article focuses on occlusally realistic objectives.

In young patients, it is important to establish ideal occlusal objectives, such as an Angle Class I canine relationship with normal overbite and overjet relationships. When treatment planning the occlusion for young patients, the orthodontist is missing two critically important pieces of information: *(1)* because of their young age, children and adolescents have no occlusal history; and *(2)* the orthodontist unfortunately cannot predict the future habits or problems that young patients will encounter during their lifetime. Therefore, in these situations it is appropriate for the orthodontist to create an ideal occlusion. However, in the adult patient, orthodontists often overlook the most valuable piece of information, ie, the patient's dental history. Has the adult patient demonstrated parafunctional occlusal habits, evidence of temporomandibular joint disorders, cracked teeth or restorations, wear facets, abraded incisors, or other signs and symptoms that would suggest that the treatment plan should alter the existing occlusion? Not all adult occlusions need to be corrected to an adolescent ideal. In all adult patients, the dental history, as well as the future restorative requirements, play a greater role in determining the final occlusion (Fig 1). For example, it may not be necessary to cor-

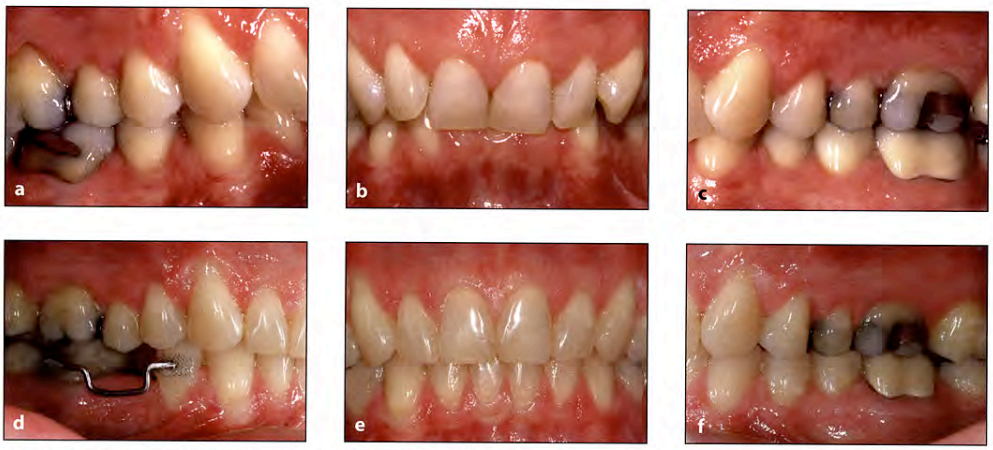

Fig 1 This 52-year-old male patient had a bilateral Class II, division 2 malocclusion with a deep anterior overbite, retroclined maxillary incisors, a missing mandibular second premolar, and a mandibular dental midline that deviated to the right *(a to c)*. The patient had no symptoms of temporomandibular joint disorder, and the periodontium was healthy. The treatment objectives included reduction of the deep overbite, opening space for the missing premolar, correction of the dental midline, and establishing normal overjet *(d, e)*. Because of the inclination of the anterior teeth and the anterior tooth-size relationships, a Class I canine relationship was established on the right *(d)*, and a Class II relationship was maintained on the left *(f)*. The objectives were achieved without correcting the Class II canine relationship on the left side.

rect posterior crossbites in adults who have no occlusal interferences, no shift of the mandible, and whose dentition can be restored adequately despite a posterior crossbite relationship.

If patients are missing many teeth, it may not be prudent to establish idealistic occlusal objectives. An ideal Angle Class I posterior occlusion is achievable in a patient with a complete nonrestored, nonabraded dentition. However, if the patient is missing several teeth and will require extensive restorative treatment after orthodontics, it may be more prudent to establish treatment objectives that are occlusally realistic for the specific patient. For example, the restorative dentist may suggest altering an Angle Class I occlusion to facilitate restoration of the teeth. It is critical for the orthodontist to be aware of these alterations before bracket placement in order to achieve an occlusally realistic relationship for the restorative patient.[1]

Create the Vision

After an orthodontist has treated several hundred adolescent patients with complete dentitions, it is easy to visualize or foresee the final orthodontic result before beginning treatment. However, some adult orthodontic patients may be missing several teeth. If teeth have been absent for several years, the remaining teeth may have drifted. In other situations, it may be necessary to position teeth in unusual relationships. These patients may require a combination of orthodontics and restorative dentistry to rehabilitate their occlusion. In these patients it may be difficult for the orthodontist to visualize the final result. Orthodontists may not be aware of the restorative requirements or the eventual restorative treatment plan. It may also be difficult for the restorative dentist to visualize the final result, because the restorative dentist may not know the orthodontic possibilities.

It is possible to predetermine the final occlusal and restorative outcomes by completing a diagnostic waxup for these patients. A diagnostic waxup is mandatory for any patients who are missing multiple permanent teeth[2] and will require a combination of orthodontics and restorative treatment (Fig 2). In addition, those patients in whom implants will be used first for orthodontic anchorage and later for restorative abutments will require a diagnostic waxup[3] to position the implants properly prior to the beginning of orthodontics. The orthodontist should never make the restorative decisions, but should consult the restorative dentist while planning treatment for these patients. In that way, the orthodontist may reposition the teeth to simulate realistic orthodontic objectives that will be in harmony with the patient's restorative requirements. By using a diagnostic waxup, both practitioners, as well as the patient, can visualize the result. The diagnostic waxup is the blueprint for treatment in these patients.

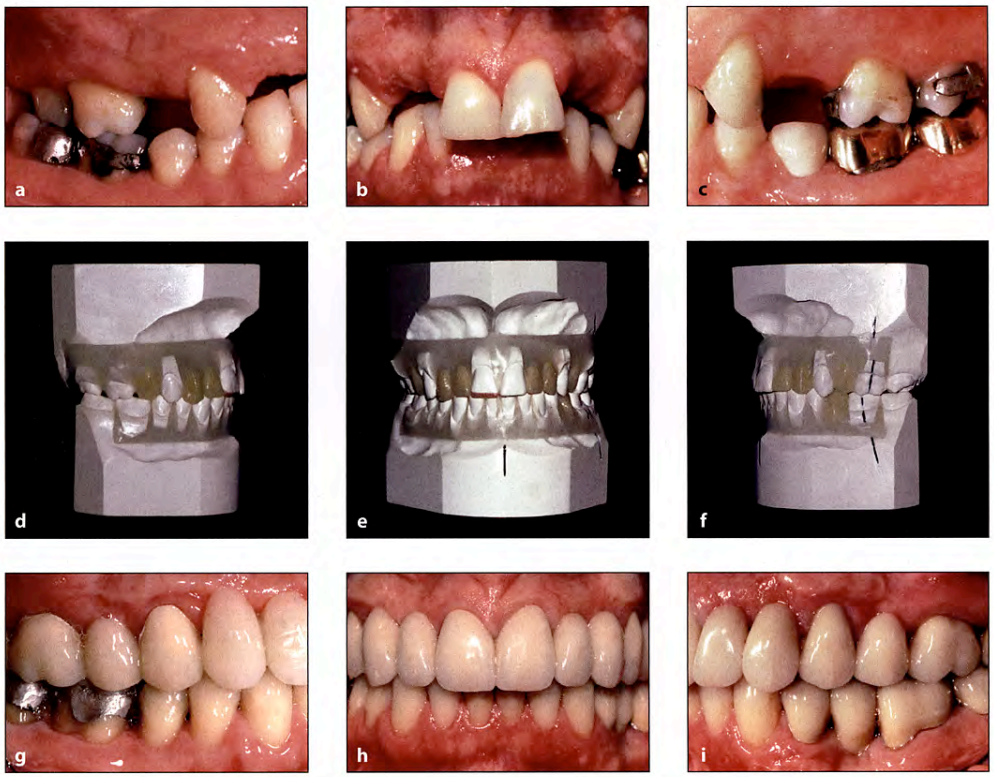

Fig 2 This 32-year-old female patient had a Class II, division 1 malocclusion with a deep anterior overbite *(a to c)*. Both maxillary lateral incisors and all four maxillary premolars were congenitally missing. The restorative dentist wanted the maxillary canines positioned in the first premolar positions to restore the maxillary arch with three segments of fixed restorations connected at the canines with a semirigid connector. A diagnostic waxup *(d to f)* provided the guide so the orthodontist could position the canines in their appropriate locations. The widths of the pontics and abutments in the final restored maxillary arch are functionally and esthetically correct *(g to i)*, because the vision was created with the diagnostic waxup.

Identify Who Will Correct Periodontal Defects

Many adult orthodontic patients have underlying periodontal defects that will need to be resolved before, during, or after orthodontic therapy. It is mandatory that the orthodontist and periodontist discuss the management of these patients to determine who will be responsible for correcting the periodontal problems.[4]

Adult orthodontic patients may also have osseous defects that could compromise the patient's ability to clean their teeth adequately and that require correction before or during orthodontic therapy.[5] These osseous defects include interproximal craters, one-, two-, or three-wall defects, furcation defects, and horizontal defects.

Interproximal craters can be the most volatile intrabony defects in the orthodontic patient. These are two-wall defects in which the remaining walls are the buccal and lingual walls. Attachment loss occurs on the mesial and distal surfaces of the adjacent roots. Orthodontic movement cannot improve interproximal craters.[5] If the crater is mild to moderate but the patient cannot maintain the area adequately, it may require resective bone removal and recontouring prior to placement of orthodontic brackets.

One-wall defects are treated most efficiently by the orthodontist.[6] In these situations, periodontal pathogenic bacteria have destroyed the attachment on three of the four interproximal walls, leaving one wall remaining. These defects are difficult for a periodontist to manage, because resective surgery could be too destructive, and regenerative therapy is

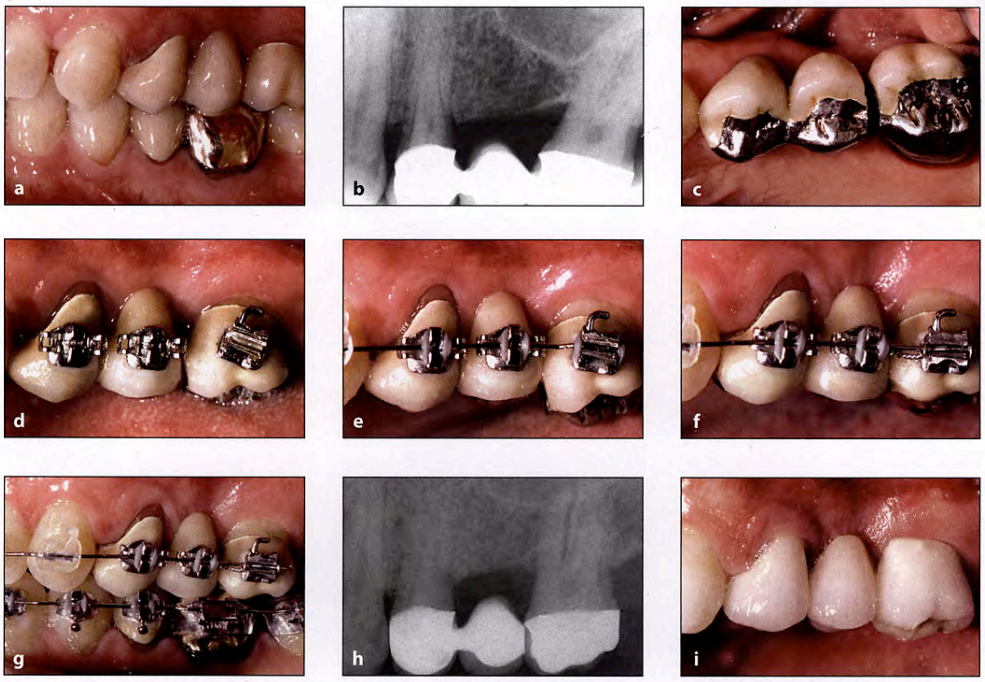

Fig 3 This 43-year-old patient had a 6-mm bleeding pocket on the mesial of the maxillary left first molar *(a)*. This tooth was an abutment for an existing three-unit fixed partial denture. The periapical radiograph shows the one-wall defect that was present mesial to the tipped first molar *(b)*. The treatment plan involved sectioning of the partial denture *(c)*, placing the molar bracket perpendicular to the long axis of the root *(d)*, and inserting an archwire to upright and erupt the tooth *(e)*. Because the crown had been overcontoured, the occlusal surface was equilibrated *(f)* to establish satisfactory occlusal contact *(g)*. The posttreatment radiograph shows the amount of molar extrusion that was accomplished to eliminate the one-wall defect *(h)* so the final partial denture could be placed on a periodontally healthy tooth *(i)*.

inappropriate. However, orthodontic eruption of the tooth will eliminate the defect (Fig 3). In these situations, the orthodontist must place the bracket more apically on the facial surface of the crown and perpendicular to the long-axis of the root of the tooth. As the tooth erupts, the orthodontist must equilibrate the crown to avoid premature contact with teeth in the opposing arch and to prevent increased mobility of the erupting tooth. The orthodontist should evaluate a progress periapical radiograph to determine when the tooth has been erupted sufficiently. When the interproximal bone is flat between adjacent teeth and the one-wall defect has been eliminated, then the extrusion of the tooth is complete. Most of these erupted and equilibrated teeth will require a crown to cover the dentin that may have become exposed during the eruption process.

Two-wall defects are best treated with orthodontics and periodontal surgery.[6] When two walls are remaining in an interproximal region and the patient cannot maintain the area, it is difficult for a periodontist to completely resolve the defect with resective or regenerative treatment. These defects often require orthodontic eruption of the affected tooth, followed by crown lengthening to improve the restorability of the tooth.

Three-wall defects are not resolvable with orthodontics. If the patient cannot adequately maintain a three-wall defect during orthodontic therapy, it must be resolved prior to bracket placement. These defects are generally treated with regenerative therapy, using either autogenous or alloplastic bone grafts in the affected area.[5] Generally orthodontic tooth movement can begin a short time after placement of the bone graft in order to enhance the fibroblastic and osteoblastic turnover that is necessary to heal the defect and move the adjacent teeth.

Furcation defects are typically divided into three classifications. Class 1 furcation defects are typically very shallow; they do not enter the molar furcation deeply and usually are observed or monitored during orthodontic therapy. Class 2 furcation defects extend into the furcation but do not com-

Fig 5 This 29-year-old female patient has crown-length discrepancies between the maxillary central and lateral incisors and canines *(a, b)*. The labial sulcular depths of all anterior teeth were 1 mm, and the cementoenamel junctions were at the bottom of the sulcus. The anterior teeth on the right had been abraded, and the teeth had continued to erupt *(c)*. Therefore, the correct treatment plan involved intrusion of the right central and lateral incisors and canine *(d)*, provisional restoration of these teeth with resin composite *(e, f)*, and replacement of the orthodontic brackets *(g)* for 6 months to stabilize the intruded teeth. At the end of orthodontics *(h)*, the lengths of all six anterior teeth were equivalent. Two years later, after final restoration with porcelain veneers *(i)*, the intruded position of the anterior teeth is stable.

edentulous space that is created prior to orthodontics, especially if that space must be maintained during and after orthodontic therapy. In addition, the mechanics could be more complicated if several teeth must be removed prior to orthodontic treatment. The fewer teeth the patient has, the more difficult it is to anchor the remaining tooth movement. If possible, it is advantageous for the orthodontist to maintain hopeless teeth in the dental arch during orthodontic treatment (see Fig 4). They provide anchorage and space maintenance for the orthodontist and occlusal function and intraoral comfort for the patient. Therefore, it is desirable to extract hopeless teeth after orthodontic treatment as long as the periodontal health of adjacent teeth can be maintained.

Position Teeth to Facilitate Ideal Restorative Dentistry

In the nonrestored adolescent patient, orthodontic positioning of teeth is determined by the size and shape of the teeth. Ideally, if the sizes of all teeth are compatible, then a Class I occlusion with complete interdigitation is possible. However, in the orthodontic-restorative patient, it may not be prudent to position teeth ideally. If restorations are planned for the patient, it may be advantageous to position teeth to facilitate restorative treatment. Specific restorations require different types of tooth positioning.

A common problem in the adult orthodontic patient is wear or abrasion of the maxillary incisors, with uneven gingival levels and unequal crown length of adjacent central incisors (Fig 5). The treatment for this problem could consist of periodontal crown lengthening to level the gingival margins, orthodontic extrusion of the longer central incisor, or intrusion and restoration of the shorter tooth. To diagnose this problem adequately, the clinician must first evaluate the labial sulcular depth of the maxillary incisors.[9] If the sulcular depths are uniformly 1 mm, then the discrepancy in gingival margins may be due to uneven wear or trauma of the incisal edges. The clinician must decide if the amount of gingival discrepancy will be noticeable (see Fig 5). If so, bracketing

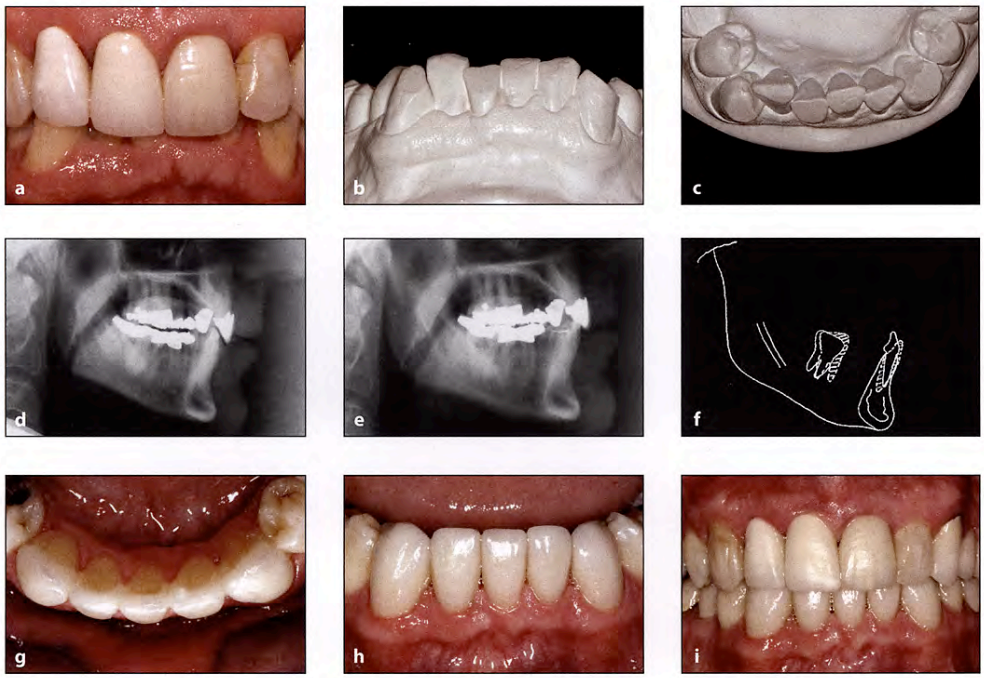

Fig 6 This 52-year-old male patient had a deep anterior overbite *(a)* and a protrusive bruxing habit that produced significant wear of the mandibular incisors *(b, c)*. There was no space for the restorative dentist to restore these teeth *(d)*. Orthodontic treatment was initiated to intrude the mandibular incisors *(e, f)* so they could be restored with porcelain veneers *(g, h)*. Not only was the deep overbite corrected *(i)*, but also the orthodontic intrusion permitted the restoration of esthetics and function to this debilitated dentition.

and alignment of these teeth must be accomplished in a way that improves the esthetics and restorability of the abraded teeth. In these situations, the gingival margins, not the incisal edges, are used as a guide in tooth positioning.[10] As the gingival margins are aligned, the discrepancy in the incisal edges becomes more apparent (see Fig 5). These incisal discrepancies are restored temporarily with composite restorations and then permanently with porcelain veneer restorations, after the teeth have stabilized. If the gingival margin discrepancies are corrected by leveling the gingival margins orthodontically, the tooth positions should be maintained for at least 6 months to avoid relapse. As teeth are intruded, the orientation of the periodontal fibers changes and becomes more oblique.[11] It typically takes at least 6 months for these fibers to reorient themselves in the horizontal position and stabilize the tooth position.

Mandibular incisal edge abrasion is also a common problem in the adult orthodontic-restorative patient (Fig 6). When this occurs, the mandibular incisors typically erupt to maintain contact. This presents a restorative dilemma for the restorative dentist because it leaves no space to place the incisal restoration. Without orthodontics to intrude the mandibular incisors and create restorative space, the patient would require periodontal crown lengthening with bone removal and apical positioning of the gingival margin. If severe wear has occurred, root canal therapy and a post and core on the short, abraded mandibular incisors could also be required. However, orthodontics is a tremendous benefit for restorative patients with significant wear of the mandibular incisors. By intruding the mandibular incisors (see Fig 6), the orthodontist can create space for the restoration, avoid gingival surgery, eliminate the need for endodontic treatment, and thereby simplify the restoration of the abraded teeth.

Consider Implants to Facilitate Difficult Tooth Movement

In recent years, dental implants have become an accepted method of replacing missing teeth.[12] Today, millions of implants are placed annually to rehabilitate and reestablish patients' occlusions. In many of these individuals, the teeth

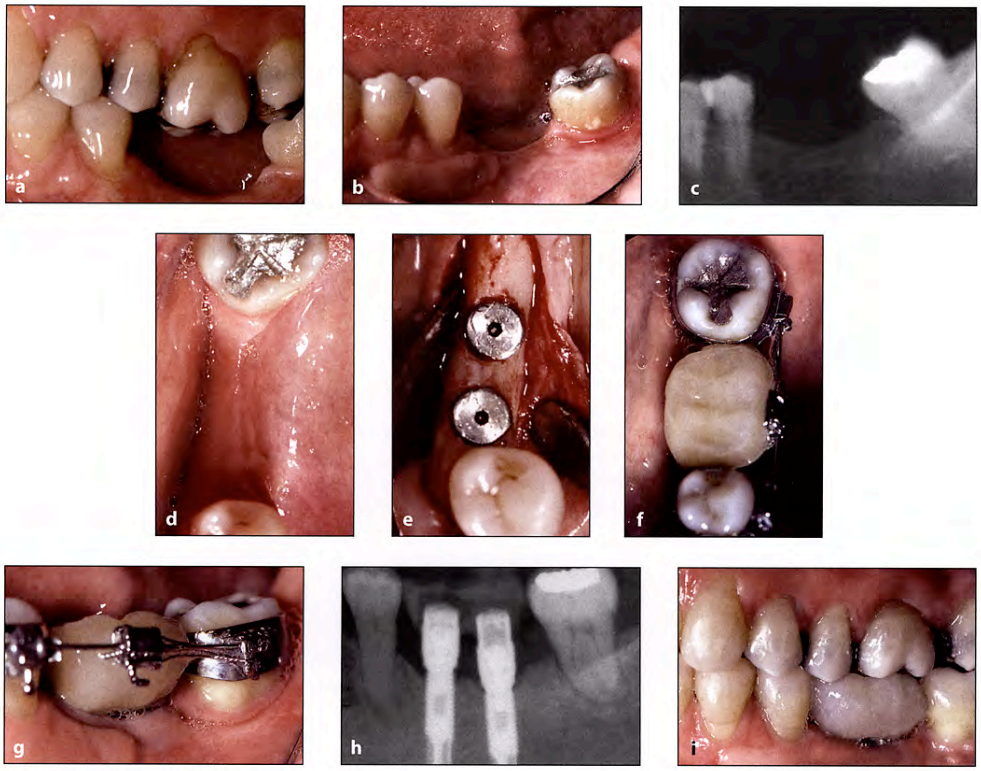

Fig 7 This adult female had lost her mandibular left first and second molars as a result of dental caries, and the maxillary left first molar had supererupted *(a)*. In addition, the mandibular third molar had tipped mesially *(b to d)*. The restorative plan was to place two premolar implants to replace the missing teeth *(e)*. The implants would be used as anchorage to upright the third molar and move the tooth *(f, g)* and roots *(h)* mesially. By using the implants as anchorage, the posterior occlusion was maintained, and the implants were restored to provide occlusion for the maxillary left first molar *(i)*.

may be in a less-than-ideal position to accept the integration of a single implant or a group of implants with the remaining teeth. These patients could benefit from orthodontics to reposition malposed teeth to enhance the overall occlusal scheme.[13] However, if significant numbers of teeth are missing, the orthodontist is at a disadvantage because of a lack of anchorage to effect the desired tooth movement.

There are several types of implant systems available to provide anchors for tooth movement. These include subperiosteal onplants,[14–16] interproximal transitional implants,[17] palatal implants,[18–20] mini-implants,[21–23] and titanium plates.[24–26] These auxiliaries are typically placed between the roots of teeth, apical to the roots of teeth, or in the retromolar regions of the maxilla and mandible. Although they are efficient anchors for tooth movement and are very versatile, they are also expendable. Usually they are removed after orthodontic treatment and discarded. Although this may be an extra expense, in a completely dentulous patient, this technology may be appropriate. However, in a partially edentulous patient, where implants will be used as anchors to restore the occlusion, these restorative implants could be used initially for orthodontic anchorage and later as restorative abutments after orthodontics has been completed.[13]

The indications[13] for using a restorative implant as an orthodontic anchor include intra-arch intrusion of teeth that have overerupted, intra-arch retraction of teeth that are proclined, and intra-arch protraction of teeth that are positioned distally (Fig 7). In each of these situations, the implant must be placed prior to orthodontic bracketing. However, the implant must be positioned appropriately so it will not only satisfy the orthodontic requirements, but also be in a suitable position for the final restoration. The orthodontist must construct a diagnostic waxup after consultation with the restora-

tive dentist and surgeon. The diagnostic waxup permits construction of a placement guide for the surgeon to provide accurate positioning of implants and must be constructed in a series of specific steps to insure accuracy. These steps have been documented in previous publications.[13,27,28]

After placement, the implants must integrate with the bone prior to orthodontic loading. The timing of implant loading for single implants is determined by the amount of time required by the bone adjacent to the implant to undergo secondary osteon (remodeling) formation around the implant.[29] If multiple implants are placed at the same time, they are often loaded immediately after placement, using a provisional prosthesis. Even though the bone around the implant has not completely remodeled, the rigidity supplied by cross-arch splinting allows for integration to occur around the functioning implants.[30] Recent research has shown that when implants are loaded with static or continuous load in the same direction, the bone on the implant surface develops more rapidly.[31,32] However, when a dynamic load is applied to the implant (not continuous and in different directions), much less bone develops on the implant surface.[32] When the implant is loaded continuously, the same biomechanical message is delivered to the bony surface, which is to stimulate bone formation on the compressed surface to form more supporting bone. When the force on the implant is dynamic or intermittent, the biomechanical message is not clear, and less bone is formed. Therefore, if implants will be used for orthodontic anchorage, they could be loaded immediately, since an orthodontic load is continuous and in the same direction.

Previous animal studies have shown that when implants are loaded, more bone is developed on the pressure, or compressive, side of the implant.[33] This is opposite of what happens around teeth. When the periodontal ligament of a tooth is loaded with a compressive force, bone resorbs on the pressure side and deposits on the tension side. However, implants do not have a periodontal ligament, and therefore the bone that forms on the pressure side of the implant is referred to as *buttressing bone,* which develops in response to implant loading.

After the implant has been uncovered, a provisional restoration must be placed so the orthodontic force can be attached to the implant. The type of provisional restoration varies, depending on the type of orthodontic mechanics.[13] In some situations, a tooth-shaped plastic restoration is required. However, in other situations, a metal abutment is sufficient to provide the anchorage. In general, if orthodontic brackets are not to be used, a simple metal cap can be placed on top of the implant. In most situations, if the teeth adjacent to the implant are to be moved toward the implant, a provisional plastic restoration is necessary to permit accurate positioning of these teeth during the orthodontic process. The size of the provisional crown can be ascertained from the diagnostic waxup used to create the placement guide.

Summary

This paper has discussed and illustrated a series of five guidelines for managing the orthodontic patient with periodontal or restorative complications. One of the most important steps is to generate realistic treatment objectives that will fit the patient's needs, desires, financial capabilities, and the goals of the team members. Then, a visual representation of the final result must be created in the form of a diagnostic waxup. This provides the blueprint or end point of treatment for the entire team. Next, the periodontal problems must be identified, and the person responsible for the treatment of osseous defects must be determined. If certain teeth are hopeless, the timing of extraction must be sequenced to facilitate the needs of all practitioners on the team. Finally, the future position of a tooth should be determined by the specific restorative or periodontal needs of the patient. If the team of periodontist, surgeon, orthodontist, and restorative dentist follow these five guidelines, the management of their orthodontic-periodontic-restorative patients will be simplified, predictable, and pleasurable.

References

1. Kokich V, Spear F. Guidelines for managing the orthodontic-restorative patient. Semin Orthod 1997;3:3–20.
2. Kokich V. Anterior dental esthetics: An orthodontic perspective. III. Mediolateral relationships. J Esthet Dent 1993;5:18–22.
3. Kokich V. Managing complex orthodontic problems: The use of implants for anchorage. Semin Orthod 1996;2:153–160.
4. Kokich V. Orthodontic-restorative management of the adolescent patient. In: McNamara JA Jr (ed). Orthodontics and Dentofacial Orthopedics. Ann Arbor, MI: Needham Press, 2001:425–452.
5. Kokich V. The role of orthodontics as an adjunct to periodontal therapy. In: Newman MG, Takei HH, Carranza FA (eds). Carranza's Clinical Periodontology, ed 9. Philadelphia: Saunders, 2002: 704–718.
6. Ingber J. Forced eruption: Part I. A method of treating isolated one- and two-wall infrabony osseous defects—Rationale and case report. J Periodontol 1974;45:199–206.
7. Mathews D, Kokich V. Managing treatment for the orthodontic patient with periodontal problems. Semin Orthod 1997;3:21–38.
8. Zachrisson B, Mjör I. Remodeling of teeth by grinding. Am J Orthod 1975;68:543–553.
9. Kokich V. Anterior dental esthetics: An orthodontic perspective. I. Crown length. J Esthet Dent 1993;5:19–23.
10. Kokich VG, Kokich VO, Spear F. Maximizing anterior esthetics: An interdisciplinary approach. In: McNamara JA Jr, Kelly K Jr (eds). Frontiers in Dental and Facial Esthetics. Ann Arbor, MI: Needham Press, 2001.
11. Reitan K. Clinical and histologic observations of tooth movement during and after orthodontic treatment. Am J Orthod 1967;53:721–745.
12. ADA Council on Scientific Affairs. Dental endosseous implants: An update. J Am Dent Assoc 2004;135:92–97.
13. Kokich V. Comprehensive management of implant anchorage in the multidisciplinary patient. In: Higuchi K (ed). Orthodontic Application of Osseointegrated Implants. Chicago: Quintessence, 2000:21–32.

14. Block M, Hoffman D. A new device for absolute anchorage for orthodontics. Am J Orthod Dentofacial Orthop 1995;107: 251–258.
15. Kluemper GT, Spalding PM. Realities of craniofacial growth modification. Atlas Oral Maxillofac Surg Clin North Am 2001;9:23–51.
16. Armbruster PC, Block MS. Onplant-supported orthodontic anchorage. Atlas Oral Maxillofac Surg Clin North Am 2001; 9:53–74.
17. Gray JB, Smith R. Transitional implants for orthodontic anchorage. J Clin Orthod 2000;34:659–666.
18. Keles A, Erverdi N, Sezen S. Bodily distalization of molars with absolute anchorage. Angle Orthod 2003;73:471–482.
19. Giancotti A, Greco M, Docimo R, Arcuri C. Extraction treatment using a palatal implant for anchorage. Aust Orthod J 2003; 19:87–90.
20. Celenza F. Implant-enhanced tooth movement: Indirect absolute anchorage. Int J Periodontics Restorative Dent 2003;23: 533–541.
21. Ohmae M, Saito S, Morohashi T, et al. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. Am J Orthod Dentofacial Orthop 2001;119:489–497.
22. Kyung SH, Choi JH, Park YC. Mini-screw anchorage used to protract lower second molars into first molar extraction sites. J Clin Orthod 2003;37:575–579.
23. Cheng SJ, Tseng IY, Lee JJ, Kok SH. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. Int J Oral Maxillofac Implants 2004;19:100–106.
24. Chung KR, Kim YS, Linton JL, Lee YJ. The miniplate with tube for skeletal anchorage. J Clin Orthod 2002;36:407–412.
25. Sherwood KH, Burch J, Thompson W. Intrusion of supererupted molars with titanium miniplate anchorage. Angle Orthod 2003; 73:597–601.
26. Sugawara J, Daimaruya T, Umemori M, et al. Distal movement of mandibular molars in adult patients with the skeletal anchorage system. Am J Orthod Dentofacial Orthop 2004;125:130–138.
27. Smalley W. Implants for orthodontic tooth movement: Determining implant location and orientation. J Esthet Dent 1995; 7:62–72.
28. Smalley WM, Blanco A. Implants for tooth movement: A fabrication and placement technique for provisional restorations. J Esthet Dent 1995;7:150–154.
29. Roberts WE, Smith R, Zilberman Y, et al. Osseous adaptation to continuous loading of rigid endosseous implants. Am J Orthod 1984;86:95–111.
30. Tarnow DP, Emtiaz S, Classi A. Immediate loading of threaded implants at stage 1 surgery in edentulous arches: Ten consecutive case reports with 1- to 5-year data. Int J Oral Maxillofac Implants 1997;12:319–324.
31. Piatelli A, Corigliano M, Scarano A, Costigliola G, Paolantonio M. Immediate loading of titanium plasma-sprayed implants: A histologic analysis in monkeys. J Periodontol 1998;69:321–327.
32. Duyck J, Ronold HJ, Van Oosterwyck H, Naert I, Vander Sloten J, Ellingsen JE. The influence of static and dynamic loading on marginal bone reactions around osseointegrated implants: An animal experimental study. Clin Oral Implants Res 2001;12:207–218.
33. Turley P, Shapiro P, Moffett B. The loading of bioglass-coated aluminum oxide implants to produce sutural expansion of the maxillary complex in the pigtail monkey. Arch Oral Biol 1980;25: 459–469.