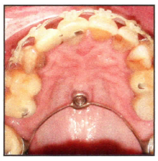
Implant-Enhanced Tooth Movement: Indirect Absolute Anchorage



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Four case reports demonstrate the effectiveness of indirect anchorage in orthodontics. These cases demonstrate the variety of situations in which absolute anchorage can be applied. A maxillary premolar extraction case illustrates the effectiveness of anterior retraction with this technique. A maxillary posterior protraction case shows the ease with which space closure can be achieved. Dual-arch capability is demonstrated through a four-premolar extraction case. Lastly, a case of severe dental mutilation devoid of any anchor units under conventional methods depicts how effectively distal driving can be accomplished. The technique involves the simple placement of a midpalatal endosseous implant that provides anchorage by indirect means to various teeth by virtue of a transpalatal arch soldered to its abutment. Once stabilized by such means, dramatic movements can be achieved in situations that would otherwise overtax anchor units and result in loss of anchorage. Teeth that would otherwise require stepwise and sequential movements can be mobilized en masse, greatly simplifying mechanotherapy and dramatically shortening treatment time. When no longer needed, the palatal implant is explanted and leaves no permanent deformation or defect after 2 or 3 weeks of healing. (Int J Periodontics Restorative Dent 2003;23:533–541.)

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In light of Newton's third law, which states that every action has an equal and opposite reaction, orthodontic tooth movement has always been a delicate balancing act. Moving all teeth simultaneously is a very rare occurrence; there is usually an anchor segment that is geared to be stronger and dominant over an active segment that contains the teeth undergoing movement. When the anchor segment is composed of teeth, which is usually the case, it is under the same constraints and limitations as the active segment; if the anchor units are teeth, it stands to reason that they would have a similar propensity to mobilize as the active units. Consequently, orthodontists must ensure that the anchor segment is in some way stronger than the active unit. Various schemes allow for this to occur, and usually come in the form of outnumbering the active units. This requires that movements in the active segment be sequenced such that moving multiple teeth en masse is not feasible. The cost of doing so comes in the form of the time required to break up a segment and achieve movements sequentially. Still, untoward movements in the anchor segments are inevitable. Orthodontists plan for movement in the anchor segments because of its inevitability and label their treatment plans as minimal, moderate, or maximum anchorage owing to the amount of slippage that they are willing to accept. Time-consuming, technique-sensitive, and compliance-dependent measures are taken to gear mechanotherapy accordingly. Shortcomings in any of these areas result in less than ideal outcomes and detract from predictability.

The inclusion of implants as anchor units dramatically alters the balance between anchorage and active segments, and can be harnessed in ways that offer significant advantages to the practitioner. Implants have proven to be reliable and effective sources of orthodontic anchorage,[1–4] so much so that a new category of anchorage has arisen. In addition to the previously mentioned minimal, moderate, and maximum anchor schemes, orthodontists who employ implants as anchor units have experienced the benefits of what has now been termed "absolute anchorage." Not only have implants proven to reliably withstand orthodontic loads, but there is also evidence that they can experience adaptations and strengthening of their investing osseous tissues in response to orthodontic load.[5–7]

Comparisons between the functional demands placed upon implants by occlusal and orthodontic loads help to clarify why implants are so effective as orthodontic anchors. However, it should be mentioned that just as endosseous implants have proven their superiority over subperiosteal designs, the same holds true in the context of orthodontic applications. If one accepts that implants have clearly proven to withstand occlusal loading, the comparison to orthodontic loading is easily acceptable. Strictly in terms of magnitude, there is little comparison between the two. Orthodontic loading is normally less than 5 g of force in the most extreme circumstance, yet occlusal loading can be on the order of kilograms. With respect to direction, orthodontic force is unidirectional once applied; occlusal force can be in every direction. Lastly, orthodontic load is continuous, whereas occlusal forces are sudden and intermittent. Consequently, in all three respects, orthodontic demands are far gentler than those of occlusion. The author has yet to experience the deintegration of an implant from orthodontic force application, nor have any been reported to date.

Implant anchorage, or absolute anchorage, can be achieved in orthodontics in a variety of situations, but all can be classified as one of two schemes. "Direct anchorage" is defined as enhanced anchorage using forces that originate from the actual implant. This would imply an implant located in a dental position and either destined to function as a tooth replacement or already doing so. This implant is then loaded orthodontically, much as an attachment on a natural tooth would be, by virtue of elastics or springs applied to effect pressure or tension upon it for the purpose of moving teeth that are similarly engaged. As previously discussed, an implant acting as a direct anchor is much more stable than the teeth activated against it; consequently, multiple teeth can be moved simultaneously when pitted against a single implant anchor, saving much time and effort. Most important, the actual movement desired is very predictable and easily controlled.

The other setup that employs implants in anchorage is known as "indirect anchorage," defined as enhanced anchorage using an implant to stabilize dental units, which in turn serve as the anchor units. This implies an implant in a location other than a dental one, such as the retromolar region or midpalatal area, joined to a tooth or teeth by virtue of a rigid connector. The indirectly anchored teeth then serve as an origin for orthodontic force. As these implants are not destined to be restored or used for tooth replacement, they are usually explanted after serving their orthodontic function. Retromolar implants and the mechanisms by which they are used for indirect anchorage have previously been reported.[2] The midpalatal implant is the central focus of this article.

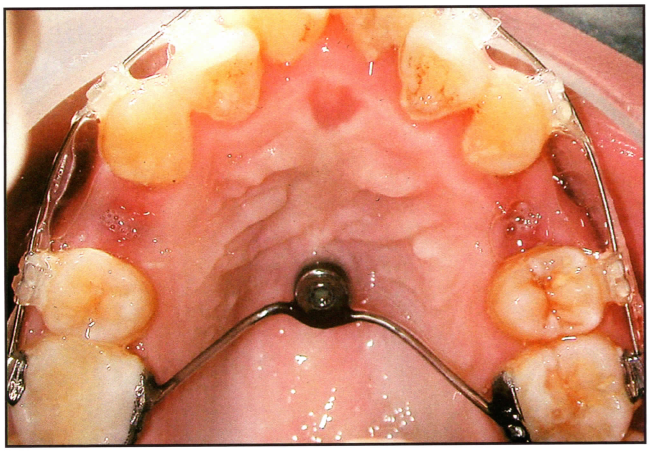


Fig 1a *Severe maxillary anterior crowding is evident. Midpalatal implant placed in maxillary midline, and first premolars extracted. TPA bonded to palatal surfaces of first molars, and chain elastic stretched over orthodontic brackets and archwire molar to molar for en masse retraction of six anterior teeth. No molar movement is anticipated.*

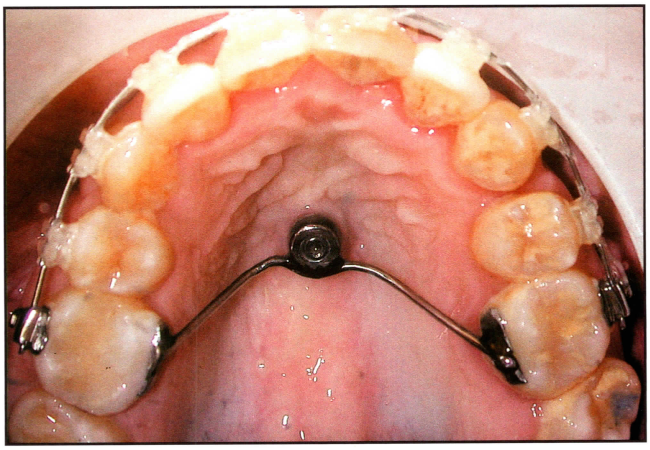


Fig 1b *Space closure is completed in 10 months; extraction space is closed entirely by anterior retraction, with no posterior protraction of molar segments detectable.*

Case reports

Case 1

A 30-year-old woman presented a Class II division 1 malocclusion characterized by severe crowding and protrusion of the maxillary anterior teeth (Fig 1). The situation was complicated by the patient's poor hand-eye coordination and motor skills. Dental hygiene was judged to be poor at introduction, remained so throughout the treatment, and required frequent hygiene visits to manage. Consequently, patient compliance or ability to comply could not be counted upon, and mechanotherapy designed to obviate the need was employed.

Initial preparation consisted of complete-mouth debridement, home care instruction, caries control, and extraction of maxillary first premolars. The midpalatal implant was placed and allowed to integrate for 8 weeks prior to impression taking and loading 10 weeks postimplantation. A fixed orthodontic straight-wire appliance was bonded in place, and initial leveling and aligning stages were accomplished during this period. Upon securing a rigid transpalatal arch (TPA) soldered to the implant abutment and directly bonded to the palatal surfaces of the maxillary molars, full activation of the appliance could be initiated. Retraction of the six anterior teeth was accomplished en masse by simple application of a chain elastic from molar to molar. In this way, retraction that would otherwise require intermaxillary Class II elastics to preserve anchorage was achieved by intraarch (Class I) elastics, and the need for the patient to change them was eliminated. The patient was seen every 2 or 3 weeks for the purpose of inserting a fresh chain elastic and to trim the distal ends of the archwire as arch circumference was decreased and the wire protruded out the end of the molar tubes. Complete space closure was achieved in 10 months. The TPA was debonded and unscrewed, and the implant was explanted uneventfully. Fixed orthodontic appliances were debonded, and a conventional Hawley-type retainer was fabricated for immediate insertion.

Case 2

A 36-year-old woman was referred for management of bilateral congenitally missing maxillary second premolars (Fig 2). The patient was given various treatment options, including three-unit fixed prostheses, single-tooth implants (which would have required sinus floor elevation on one side), and orthodontic

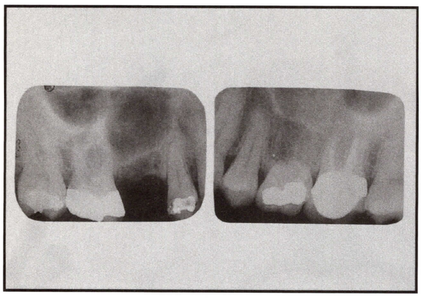


Fig 2a *Periapical radiographs show congenitally missing second premolars.*

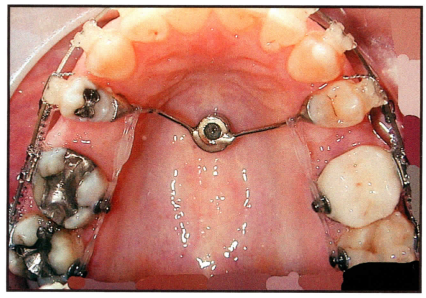


Fig 2b *Fully activated orthodontic appliance. Midpalatal implant offers indirect anchorage to maxillary first premolars by virtue of TPA bonded to their palatal surfaces. Molar protraction accomplished by buccal and palatal force application.*

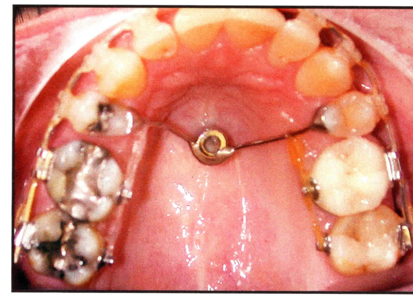


Fig 2c *Space closure nearly completed entirely by posterior protraction. Note the protrusion of the archwire out the back of the buccal tube in the maxillary right quadrant, a sign of sliding tooth movement.*

space closure. The latter option was deemed to be challenging because the spaces left by the retained deciduous teeth were larger in mesiodistal dimension than a second permanent premolar would have left. Overbite and overjet relationships were normal anteriorly and would not tolerate any anterior retraction. The patient was educated as to the implications of implant placement in the palate and the advantages that indirect absolute anchorage offered. She elected to take this route.

The implant was placed and managed as described in the following section. The TPA was soldered to its abutment and bonded to the palatal surfaces of the maxillary first premolars. Sliding mechanics were employed by stretching nickel-titanium coil springs from the second molar buccal tubes to the indirect anchor first premolar teeth. Molar protraction such as this would normally incur rotation of the molar teeth about the palatal roots; this was countered by bonding palatal buttons to the first and second molars, to which chain elastics were secured and stretched around the TPA. In this way, space closure was effected by developing force both buccally and lingually. Whereas protracting two molars bilaterally and simultaneously against first premolars (arguably the weakest tooth in the arch) would clearly overtax the anchorage, the indirect absolute anchorage offered by the palatal implant allowed easy and expedient space closure. The patient was seen every 2 to 3 weeks to maintain activation of the appliance and to clip the distal ends of the archwire. Space closure was completed in 8 months. The TPA was debonded and removed, the palatal implant was explanted, and the orthodontic appliance was debonded. A conventional Hawley retainer was inserted.

Case 3

A 30-year-old woman presented with the chief complaint of facial fullness and teeth that protruded too much (Fig 3). Her dentition was diagnosed as Class I crowded, with significant bimaxillary dental protrusion. In what might normally be treated as a four–first premolar extraction situation and labeled "maximum anchorage," the decision was made to go one further and treat by absolute anchorage. In this way, the entire extraction space availed by the removal of first premolars would be used for anterior retraction, and anchorage for retraction in both arches would be gained from the indirectly anchored maxillary molars. Retraction would be accomplished without the need for anchor-reinforcing auxiliaries such as a headgear or lip bumper.

Fixed orthodontic appliances were placed, four first premolars

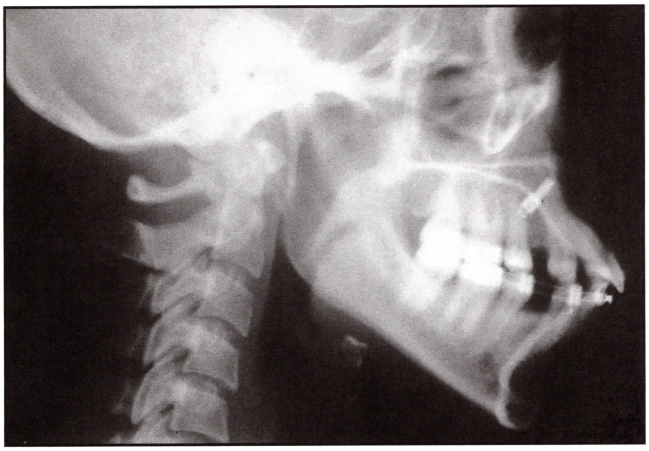
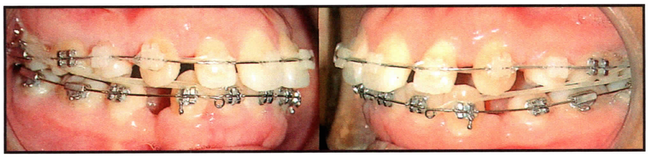


Fig 3a (left) *Lateral cephalogram before retraction of anterior teeth shows midpalatal implant in palatal bone. Orthodontic diagnosis is Class I bimaxillary dental protrusion. All first premolars extracted.*

Fig 3b (below) *Left and right buccal views: Class III elastics from maxillary second molars to anterior loop for mandibular space closure; Class I elastics from first molar to first molar for maxillary space closure. Maxillary midpalatal implant used for anchorage in both arches.*



were extracted, initial leveling and aligning steps were accomplished, and the midpalatal implant was placed. Impression taking was performed at 8 weeks, and the implant was loaded by virtue of a maxillary TPA bonded to the palatal surfaces of the first molars and soldered to the implant abutment 10 weeks postimplantation. From this point on, retraction was accomplished in both arches by sliding straight-wire mechanics. No bends, stops, or closing loops were required; retractive forces were applied by Class I (chain) elastics from first molar to first molar in the maxilla and by virtue of Class III elastics to anterior loops in the mandible. In essence, 12 anterior teeth were retracted en masse over 13 months against an anchor system consisting of the two maxillary first molars indirectly anchored to the palatal implant. Posttreatment cephalometric radiographs demonstrated no posterior movement, full anterior retraction, and a significant increase in interincisal angulations. Facial changes were concomitantly significant.

Case 4

This healthy 63-year-old woman presented with a Class II division 1 mutilated dentition characterized by a severe maxillary protrusion and deep bite (Fig 4). The patient's incisors were noted to protrude through her lips at rest. Tooth loss and periodontal problems would normally preclude the possibility of orthodontic treatment, as the remaining maxillary molars displayed at least 50% attachment loss and could not be considered reliable sources of anchorage.

After initial therapy, mechanotherapy was commenced by virtue of a complete maxillary arch of straight-wire appliances and a palatal implant

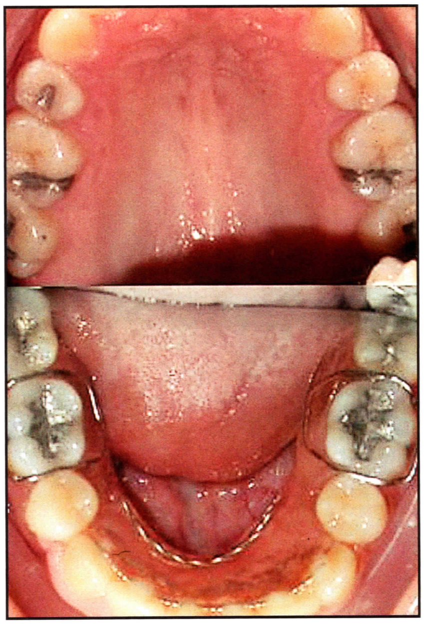


Fig 3c *Space closure completed in both arches. Retention is accomplished by a mandibular Hawley retainer as well as a bonded lingual canine-to-canine wire for antirotational security. Maxillary retainer is also a Hawley type.*

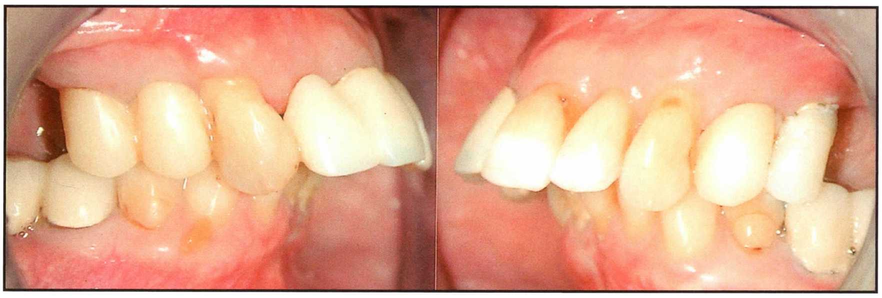


Fig 4a *Left and right buccal views of mutilated Class II division 1 malocclusion characterized by severe maxillary protrusion and deep bite.*

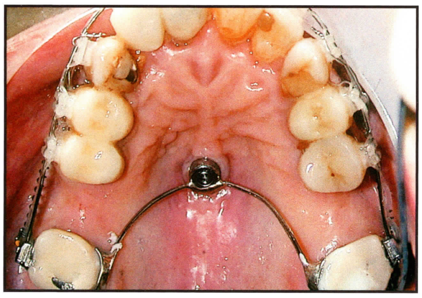


Fig 4b *Fully active orthodontic appliance stabilizes maxillary molars in absolute anchor scheme by TPA bonded to their lingual surfaces and soldered to midpalatal implant. Ten anterior teeth are retracted en masse.*

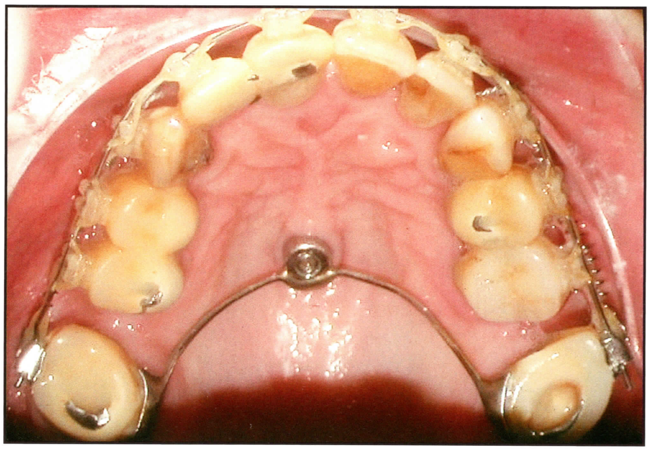


Fig 4c *Completion of phase 1 retraction. Note decrease in first molar pontic space dimension and arch circumference.*

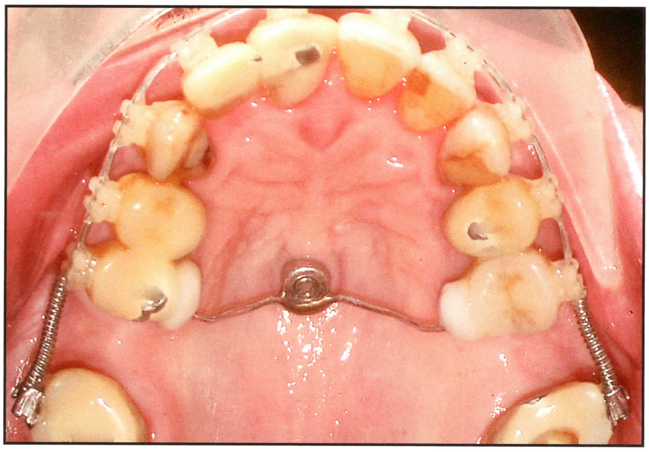


Fig 4d *TPA is debonded from molars and recurved to allow bonding to palatal surfaces of second premolars. In this way, phase 2 has occurred using open-coil springs on the archwire across the pontic spaces to drive the second molars distally. Maxillary second molars have been driven distally, as evidenced in the reappearance of first molar pontic spaces.*

that served as the indirect anchor. Complete-arch dental retraction was accomplished in two phases. Phase 1 involved the retraction of the entire anterior segment, second premolar to second premolar (one lateral incisor was a pontic in a provisional restoration), en masse against the indirectly anchored second molars. This was accomplished by stretching chain elastics from molar to molar and using nickel-titanium open-coil springs bilaterally. The patient was seen every 2 weeks for reactivation and to trim the distal ends of the archwire. Upon completion of phase 1 retraction, the TPA was debonded and retrieved to reform it. The TPA was then bent to conform to the palatal surfaces of the repositioned second premolars and reinserted by bonding to them and securing the abutment to the implant. In this way, phase 2 was initiated, with the goal

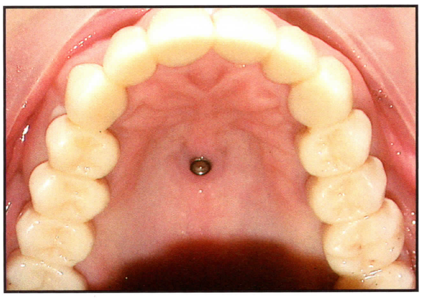
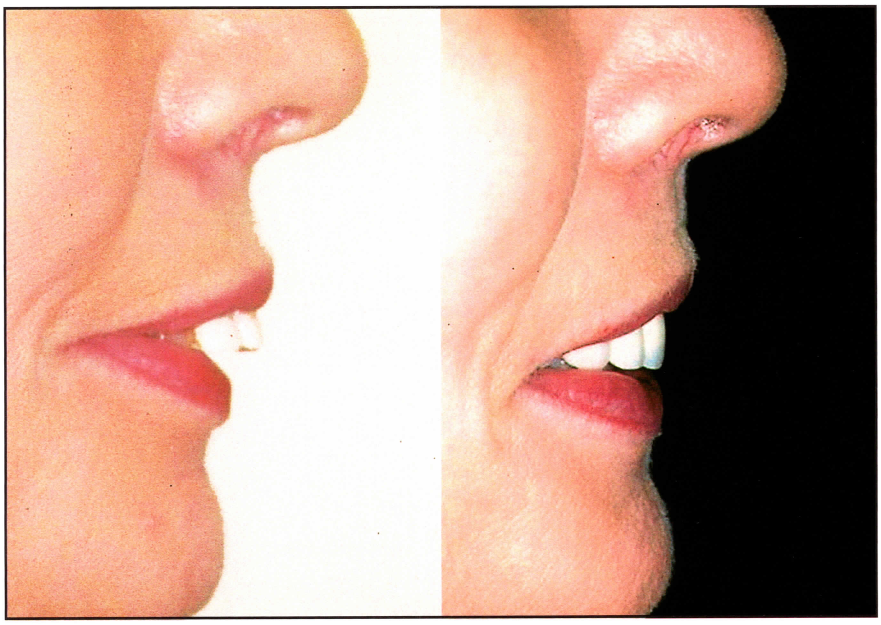


Fig 4e *Complete-arch provisionalization provides stability. (Restorative dentistry by Dr Charles Lennon, New York.)*

Fig 4f (right) *Close-up of facial profile pre- and posttreatment demonstrates dental and facial changes accomplished by retraction of maxillary dentition.*



of distally driving the maxillary second molars. This was accomplished by using open-coil spring on the archwire to expand the first molar pontic spaces by distalizing the second molars. It is worth noting that this system employs the recently retracted anterior segment as an anchor segment immediately, a scheme not considered reliable by conventional orthodontic measures. The total time required to achieve complete maxillary dental repositioning by single-arch mechanics, a feat not normally achievable by any means, was 18 months. Complete maxillary arch debonding and provisionalization followed.

Technique

The placement, management, and explantation of midpalatal implants are simple and predictable steps, with only slight variations from what has become routine in conventional implant practice. The discussion that follows centers around the use of the Straumann OrthoSystem implant, with which the author has experience in nearly 30 cases. The implant is an endosseous implant with a self-tapping design and rough surface texture for rapid and predictable integration. Although it is designed for use in either retromolar or palatal locations, this article addresses only the latter. The implant measures 3.3 mm in diameter and 4.0 or 6.0 mm in length. It has a polished transmucosal element that measures 2.5 mm. Various lengths of abutments are available to accommodate different soft tissue thicknesses. The abutment is stainless steel to allow for conventional soldering to it.

The placement of the implant is simple, owing to the fact that the technique is a "punch and place" surgery, and also because exact position of the implant is not nearly as critical as it can be in the case of dental implants. A lateral cephalogram is used to roughly determine the thickness of the palatal bone and where best to place the implant. Having achieved local anesthesia in the area, a mucosal trephine is used to core out the soft tissue at the implant site. No incision, flap, or sutures are needed. A small indentation is made with a round bur at the center of the soft tissue punch, and a single spade that corresponds to the length of the desired implant is used to drill to depth. The spade at once drills the osteotomy, prepares a shoulder around it, and stops the operator from penetrating beyond the desired depth. The implant is carried in its holder by hand and screwed in until fully seated and bottomed out. Complete seating can be verified by feel and by taking a lateral cephalogram. A cover screw or abutment is placed, and postoperative instructions given. Because the implant is not submerged, a second-stage surgery is not required; however, it is important that the patient understand that it must not be disturbed during the integration period.

A period of 8 weeks is specified for integration. At that time, a simple irreversible hydrocolloid impression can be taken using the impression cap that snaps onto the head of the implant. Impression taking and laboratory fabrication of the TPA are greatly simplified if a bonded rather than a banded system is employed. A laboratory model is made by snapping the lab analogue into the impression cap that is lifted off with the impression. At 10 weeks postimplantation, the fabricated TPA can be placed in the mouth and the appliance loaded. This is accomplished by securing the abutment to the implant by screwing it down and bonding its ends to the teeth that will serve as the (indirect) anchor units.

Having achieved an indirect absolute anchor system, the orthodontic appliance can be activated and the desired movements achieved with great expediency, ease, and predictability. Once completed, the anchor system can be disassembled and the implant removed by using the guide and explantation drill provided. Postexplantation healing is usually uneventful and does not require any special reconstructive or reparative measures. Experience with morbidity has been negligible.

Discussion

As implant dentistry continues to become mainstream, clinicians have been forced to learn and adapt to new treatment options and modalities. From visualization to treatment planning, execution, final result, and even long-term maintenance, implantology has forced us to modify our skill sets. Despite this transformation in the restorative and surgical specialties, the author does not believe that the orthodontic specialty has experienced such a dramatic impact in response to implant dentistry. Orthodontists may have modified the way in which they set cases up from a preprosthetic standpoint, perhaps to receive implants rather than fixed prostheses, but they have not really embraced the potential that implants offer as sources of anchorage. The use of an implant as part of an orthodontic appliance and an integral part of mechanotherapy, rather than just an inclusion at the end of treatment, has only begun to be explored. The potential implants offer to the orthodontist in terms of appliance control and ease of manipulation promises to change that. The ultimate extension of this potential would be the use of implants that are designed solely for orthodontic purposes, with no intention for restoring or even retaining such devices once their function has been completed.

Use of the OrthoSystem implant for absolute anchorage has proven to have many attractive features. First is the ability to offer treatment possibilities that were not previously feasible. This comes about in two forms. One is the potential to treat cases not considered candidates by conventional orthodontic means, as in case 4, which had no other source of reliable anchorage; the other is that the inclusion of indirect anchorage can change a treatment plan by offering an outcome that is not otherwise possible. Extraction cases can become nonextraction cases, for example, as distal driving is very easily and effectively achieved without undue side effects. Second, absolute anchorage obviates dependency on patient compliance. Extraoral means of anchorage such as headgear devices could be rendered obsolete by such technology. The need for patients to change and wear elastics is often eliminated, as intraarch mechanics prove to be more than sufficient with this system. Management of the appliance and case become entirely under the orthodontist's control.

Absolute anchor systems can greatly simplify mechanotherapy. Intricate wire bending becomes superfluous as the need to preserve anchorage is eliminated. Tip-backs, toe-ins, stopped arches, cinched arches, and a seemingly endless assortment of anchorage-conserving mechanisms and details are no longer required. Operator expertise is no longer as critical, and chair time is greatly reduced. Treatment times can be significantly reduced by harnessing implant anchor systems, not because teeth can be moved faster or greater forces can be applied, but rather because the resiliency of the anchorage system allows for predictable en masse movements. Segments that previously required sequential and individual movements can now be moved as one, simultaneously.

References

1. Roberts WE, Helm FR, Marshall KJ, Gongloff RK. Rigid endosseous implants for orthodontic and orthopedic anchorage. Angle Orthod 1989;59:247–256.
2. Roberts WE, Marshall KJ, Mozsary PG. Rigid endosseous implant utilized as anchorage to protract molars and close an atrophic extraction site. Angle Orthod 1990;60:135–152.
3. Higuchi KW, Slack JM. The use of titanium fixtures for intraoral anchorage to facilitate orthodontic tooth movement. Int J Oral Maxillofac Implants 1991;6:338–344.
4. Ödman J, Lekholm U, Jemt T, Thilander B. Osseointegrated implants as orthodontic anchorage in the treatment of partially edentulous adult patients. Eur J Orthod 1994;16:187–201.
5. Roberts WE, Smith RK, Smilbermann Y. Osseous adaptation to continuous loading of rigid endosseous implants. Am J Orthod 1984;56:95–111.
6. Wehrbein H, Merz BR, Hammerle CHF, Lang NP. Bone-to-implant contact of orthodontic implants in humans subjected to horizontal loading. Clin Oral Implants Res 1998;9:348–353.
7. Gotfredsen K, Berglundh T, Lindhe J. Bone reactions adjacent to titanium implants subjected to static load. A study in the dog (I). Clin Oral Implants Res 2001;12:1–8.