Maintaining Vector Control During Alveolar Distraction Osteogenesis: A Technical Note

Alan S. Herford, DDS, MD[1]/Franco Audia, DDS, MS[2]

Distraction osteogenesis is a predictable method for restoring missing tissue prior to implant placement. However, pull from the soft tissue can alter the desired direction of the distraction. This article describes and illustrates techniques that are useful for maintaining the desired vector during alveolar distraction osteogenesis. These methods can prevent the need for further intervention and allow for ideal placement of endosseous dental implants without compromising results. INT J ORAL MAXILLOFAC IMPLANTS 2004;19:758–762

Key words: *dental implants, distraction osteogenesis, vector control*

Alveolar defects can range from small, isolated areas to extensive areas of bone loss involving the entire arch. It is preferable to reconstruct these regions prior to implant placement to avoid complications (eg, poor implant angulation or esthetics) or implant failure. Various techniques are available to augment these sites prior to implant placement. Both the size and geometry of the defect must be considered when deciding on the treatment.[1] Some options available include guided bone regeneration, onlay block grafting, and more recently, alveolar distraction.

One advantage of alveolar distraction osteogenesis is that both hard and soft tissues are reconstructed. Since many alveolar defects involve loss of both bone and attached gingiva, distraction osteogenesis can be an advantageous treatment option. Alveolar distraction is a predictable method for increasing bone height prior to implant placement.[1–10]

Many authors have discussed the importance of precise treatment planning and determining the correct vector of distraction.[1–4,6] When placing the distraction device, it is important to ensure correct angulation. Even if the distractor is originally angulated appropriately, the pull of the soft tissue may change the direction of the transported segment. It is important to identify this early to avoid compromised results. This soft tissue pull is most commonly in a palatal or lingual direction. Various techniques for maintaining vector control during alveolar distraction osteogenesis are described herein.

MATERIAL AND METHODS

Precise treatment planning involves deciding the optimal vector prior to placement of the alveolar distraction appliance. As meticulous surgical technique is performed, the distractor is oriented in the

[1]Chairman, Department of Oral and Maxillofacial Surgery, Loma Linda University Medical Center, Loma Linda, California; Director of Oral and Maxillofacial Surgery, Arrowhead Regional Medical Center, Colton, California.
[2]Former Chief Resident, Department of Oral and Maxillofacial Surgery, Loma Linda University Medical Center, Loma Linda, California.

Correspondence to: Dr Alan Herford, Division of Oral and Maxillofacial Surgery, Loma Linda University Medical Center, Anderson Street, Loma Linda, CA 92350. Fax: +909 558 0285. E-mail: aherford@sd.llu.edu

COPYRIGHT © 2004 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

758-762 Herford 9/21/04 2:44 PM Page 759

Fig 1 *(a)* A distractor in a deficient mandibular alveolar ridge. Note the lingual pull causing a change in the vector of distraction. *(b)* Orthodontic brackets bonded to adjacent teeth secure an elastic power chain. Note that this technique can cause rotation of the teeth immediately adjacent to the osteotomy.

desired direction as determined preoperatively. After approximately 5 to 7 days, the distraction phase is begun. Close observation is important during this stage for early detection of any change in vector direction. If it is determined that soft tissue pull has altered the desired direction of distraction, early intervention is recommended. Some techniques available for vector control include use of:

- An elastomeric chain secured to adjacent teeth
- A wire splint secured to adjacent teeth
- Cross-arch elastics
- A surgical acrylic resin splint
- Palatal distraction appliances
- "Molding" the regenerated tissue
- Osteotomy after distraction completed

Orthodontic brackets secured to adjacent teeth can provide a great deal of vector control during distraction osteogenesis. The brackets can be placed on either the lingual or the buccal surface of the teeth, depending on the desired correction. The placement of brackets on a minimum of 2 teeth with equal or greater root surface area per tooth than the teeth that previously occupied the segment being transported is recommended (eg, an edentulous segment of the mandibular central incisors would require a minimum of 4 brackets placed on the mandibular lateral incisors and canines). This anchorage appears to minimize unwanted opposing forces on the anchorage teeth.

An elastomeric chain can be placed and used to direct the continued distraction and regain the correct vector of distraction (Fig 1). The use of an elastomeric chain is ideal for transporting distracted bone segments for several reasons. They are inexpensive and easy to use, which makes them a practical option. The elastomer forces decay rapidly and thus apply interrupted rather than continuous forces, which allows for movement of the segment into an ideal position and for retention during early consolidation.

A large orthodontic wire can be secured to the adjacent teeth with composite or orthodontic brackets (Fig 2). Utilizing diagnostic casts, slotted orthodontic brackets can be prepared for indirect application on the patient. This allows for passive application of the wire to be used for anchorage, thus minimizing the risk of unwanted tooth movement. A 0.016 × 0.022-inch stainless steel square wire, which typically has a higher stiffness index and lower shape memory than other metals, is a good choice. The wire can be bent to enclose the pin of the distractor, or it can be connected to the distractor with ligature wire or elastics (Fig 3). The loop is passed over the distraction rod and its ideal position determined. If necessary, the wire can be stepped buccally or lingually. The archwire is then secured to the adjacent teeth using the bonded brackets or composite bonding to maximize anchorage. It is important that the wire be placed close enough to the occlusal plane to avoid impeding distraction of the segment. The wire splint can be adjusted during the distraction to fine-tune final location of the regenerated tissue. Alternatively, an arch bar can be used in much the same fashion, with the lugs providing a place to secure the elastomeric chain.

Because more force is usually required to overcome the pull of the palatal (lingual) tissue, it is rare that the vector will need to be redirected toward the palate. If this circumstance arises, an additional treatment option includes the judicious use of cross-arch elastics (Fig 4). The advantages of elastomeric chains, which have already been described, may be applied to orthodontic molar band cleats for cross-arch mechanotherapy. A transpalatal wire soldered to bilateral molar bands may also be used to pull an anterior maxillary segment in a palatal direction. Because a great amount of force can be generated very quickly, it is important to monitor these

COPYRIGHT © 2004 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

758-762 Herford 9/21/04 2:45 PM Page 760

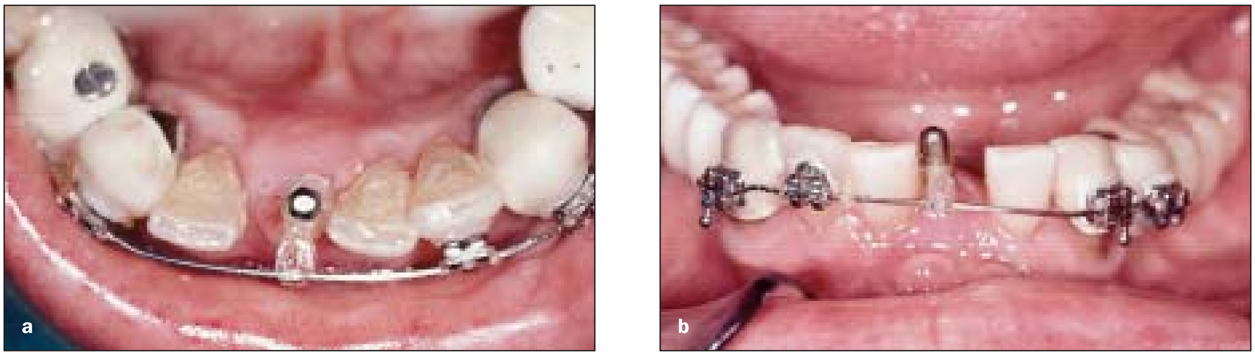

Fig 2 *(a and b)* An elastic chain connects the lingually directed distractor to the orthodontic wire. This technique does not place rotational forces on the teeth immediately adjacent to the osteotomy. *(c)* Maintenance of the correct vector in the posterior mandible.

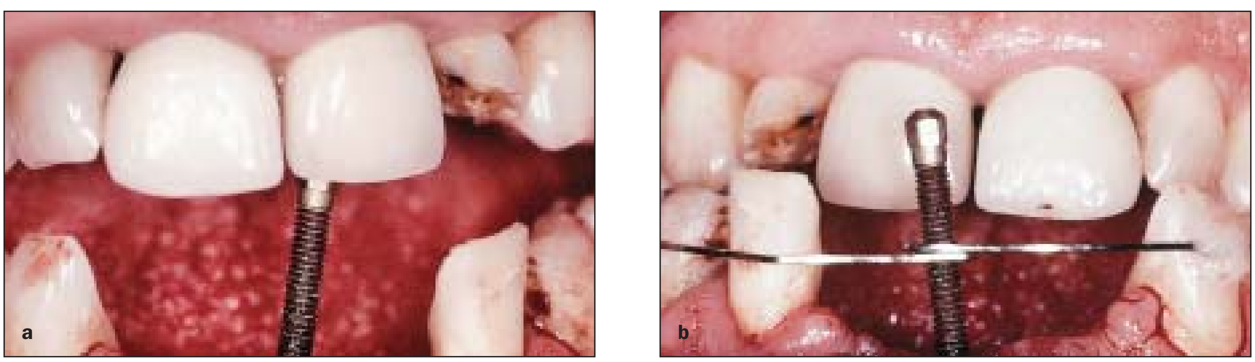

Fig 3 *(a)* Anterior mandibular alveolar distraction prior to implant placement in a patient with Class III malocclusion. Note the pull of the transport segment by the muscular attachments to the genial tubercle, causing the patient to occlude on the distractor. *(b)* A large orthodontic wire is used to gain immediate vector control. The stabilization wire, which is secured to the adjacent teeth, allows for distraction in the desired direction and the avoidance of contact with the maxillary central incisors.

Fig 4 An elastic chain is secured to the distractor to direct the transport segment in a more palatal direction.

COPYRIGHT © 2004 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Fig 5 A splint can be used to maintain the desired vector. The alveolar distractor is guided by the acrylic resin splint.

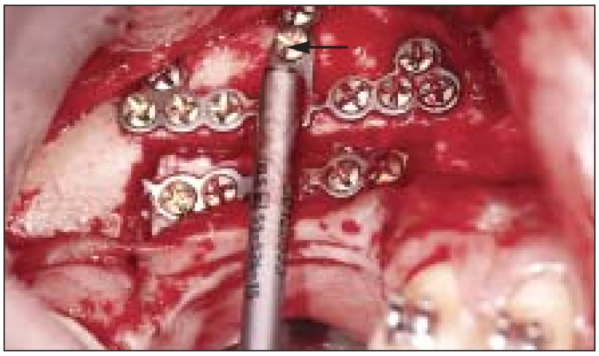

Fig 6 A distraction device with a stabilization strut *(arrow)* secured to the mandible inferiorly.

patients closely and frequently during this procedure. Alternatively, a distraction appliance can be placed lingually to overcome the thick palatal tissue.

A surgical acrylic resin splint may be used to guide the transported bone segment (Fig 5). This is useful for alveolar segments that do not have adjacent teeth for use with any of the previously described methods. A diagnostic waxup of the ideal terminal distraction point of the alveolar ridge is made on a stone dental cast. An acrylic resin splint is then fabricated in the standard fashion from that cast. In the authors' experience it is often necessary to fixate the splint to overcome strong soft tissue forces, especially on the palate.

Some distraction devices have a stabilization strut (Fig 6). This strut adds rigidity and minimizes changes in vector during activation of the distractor. Another method for minimizing changes in vector involves applying manual pressure to the distracted segment during the distraction phase and early in the consolidating phase. The manipulated segment should be secured in the desired location. Yet another option is to fixate the segment with resorbable material. An osteotomy and repositioning of the segment may be required if this manual pressure does not correct the placement.

DISCUSSION

Distraction osteogenesis provides a predictable method for reconstructing deficient alveolar ridges. Alveolar defects often represent composite defects. An advantage of distraction osteogenesis is that both the hard and soft tissues can be reconstructed.

When figuring out the desired vector for the distractor, it is helpful to take into account the quality of tissue, especially on the palate. The pressure from the oral musculature and the pull from the thick palatal tissue can alter the desired vector in a palatal or lingual direction. Occasionally during anterior mandibular alveolar distraction, the genioglossus and geniohyoid muscles may displace the transport segment lingually (Fig 3). Because of these factors it is extremely unlikely for the vector to become too facial. It is often necessary to overcompensate by directing the distraction appliance more toward the facial to overcome the anticipated soft tissue pull and subsequent change in direction of distraction.

Close observation is important during the distraction phase. This allows for early intervention and correction back to the desired direction of distraction. Many simple techniques are available to maintain vector control; however, patient compliance is important to ensure success.

When placing orthodontic brackets on adjacent teeth, it is important to guard against movement of the teeth adjacent to the gap. It is also possible to cause rotation of the adjacent teeth, especially teeth with minimal root surface area, such as mandibular incisors. Securing the wire splint or elastic chain to a minimum of 2 teeth on either side of the defect is recommended. An advantage of using an orthodontic wire rather than an elastic chain is that it is less likely to cause movement of the adjacent teeth.

The distraction phase is followed by a period of consolidation and complete mineralization of the regenerated tissue. It is possible to perform limited "molding" of the newly formed bone prior to complete ossification.[5] This manipulation is best performed within 1 to 2 weeks after completion of the distraction. The repositioned segment should then be splinted to maintain the new position.

At the end of the consolidation phase it is not possible to manually reposition the regenerated bone. It may be necessary to perform an osteotomy and reposition the segment into the correct position. This is preferable to placing the dental implant in a compromised position.

COPYRIGHT © 2004 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

CONCLUSION

Alveolar distraction osteogenesis can be a very predictable and successful method for restoring alveolar ridges prior to implant placement. Close observation during the distraction process enables one to intervene if necessary and maintain the desired direction of distraction. If vector control is maintained, the distracted bone and ultimately the osseointegrated implant will be optimally located for prosthetic restoration.

REFERENCES

1. Boyne PJ, Herford AS. An algorithm for reconstruction of alveolar defects before implant placement. Oral Maxillofac Surg Clin North Am 2001;13:533–541.
2. Grayson BH, McCormick S, Santiago PE, McCarthy JG. Vector of device placement and trajectory of mandibular distraction. J Craniofac Surg 1997;8:473–480 [erratum 1998;9:2].
3. Samchukov ML, Cope JB, Cherkashin AM. The effect of sagittal orientation of the distractor on the biomechanics of mandibular lengthening. J Oral Maxillofac Surg 1999;57: 1214–1222.
4. Ahn JG, Figueroa AA, Braun S, Polley JW. Biomechanical considerations in distraction of the osteotomized dentomaxillary complex. Am J Orthod Dentofac Orthop 1999;116: 264–270.
5. Hanson PR, Melugin MB. Orthodontic management of the patient undergoing mandibular distraction osteogenesis. Semin Orthod 1999;5:25–34.
6. Kunz C, Hammer B, Prein J. Manipulation of callus after linear distraction: A “lifeboat” or an alternative to multivectorial distraction osteogenesis of the mandible? Plast Reconstr Surg 2000;105:674–679.
7. Gaggl A, Schultes G, Santler G, Karcher H. Three-dimensional planning of alveolar ridge distraction by means of distraction implants. Comput Aided Surg 2000; 5:35–41.
8. Liou EJ, Figueroa AA, Polley JW. Rapid orthodontic tooth movement into newly distracted bone after mandibular distraction osteogenesis in a canine model. Am J Orthod Dentofacial Orthop 2000;117:391–398.
9. Chin M, Toth BA. Distraction osteogenesis in maxillofacial surgery using internal devices: Report of five cases. J Oral Maxillofac Surg 1996;54:45–53.
10. Liou EJ, Polley JW, Figueroa AA. Distraction osteogenesis: The effects of orthodontic tooth movement on distracted mandibular bone. J Craniofac Surg 1998;9:564–571.

COPYRIGHT © 2004 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.