15 Treatment Planning and Orthodontic Management of Patients Undergoing Mandibular Distraction Osteogenesis

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Distraction osteogenesis is a technique of gradual incremental bone lengthening that results in both an increase in bone length and volume as well as the surrounding soft tissues.[1-16] Since the first clinical introduction in 1992 by McCarthy,[17] distraction osteogenesis has undergone widespread recognition by an increasing number of clinicians.[18-25] Based on the knowledge and experience gained during this period, the quality of the results has improved significantly.

The orthodontist, as a member of the multidisciplinary team involved in the distraction osteogenesis process, participates in all stages of treatment. His or her role is critical to several temporal phases including treatment planning, predistraction orthodontic preparation, orthodontic/orthopedic therapy during distraction and consolidation, and postconsolidation orthodontic/orthopedic management.[26,27]

This chapter introduces the orthodontic considerations during craniofacial osteodistraction and outlines the details of orthodontic management and supervision during different stages of treatment with distraction osteogenesis.

TREATMENT PLANNING

Treatment planning for patients undergoing distraction osteogenesis must consider all issues related to surgical correction, as well as the potential for future skeletal growth and development, the need for overcorrection, and possible future operations. The treatment planning process begins with a thorough clinical examination to reveal all structural abnormalities and functional deviations that require correction. Accurate orthodontic/surgical records must be obtained; these may include lateral and posteroanterior cephalometric radiographs, computed tomography with three-dimensional reconstruction, photographs, and models (registration and mounting as necessary). This information is coupled with an understanding of the patient's expectations to finalize the treatment goals and predistraction, intradistraction, and postdistraction treatment objectives.

Several more specific distraction-related decisions must be made during treatment planning including osteotomy design and location, selection of a distraction device, determination of the distraction vector, duration of the latency period, rate and rhythm of distraction, and duration of the consolidation period.[28] The distraction osteogenesis team members work together to develop the treatment plan.

Distraction Device Selection

Craniofacial distraction devices have been developed for both external and internal applications.[9,29] The indications for, and therefore the capabilities of, these devices differ (see Chapter 1). Device selection is based on mechanical capabilities and patient acceptance.

External Distraction Devices. External distraction devices are placed using transcutaneous pins.[6,8,17,20,30,31] The external devices, particularly the multidirectional devices, offer excellent control of bone segment movement, and are usually available in longer lengths. They are much easier to place and maintain, and are simpler to replace during distraction if necessary, or to remove at the completion of lengthening. Disadvantages include skin scarring and poor acceptance by patients. However, placing the pins with minimal soft tissue tension and/or within the submandibular fold can minimize skin scarring.

Internal Distraction Devices. Internal distraction devices are placed either submucosally (buried) or extramucosally (intraoral).[32-42] They may be tooth-borne, bone-borne, or hybrid. Internal devices neither produce facial scarring nor have the negative psychosocial impact of the external devices. It should be noted, however, that a small external incision is sometimes necessary for activation arm access, which, if planned carefully, may be positioned aesthetically.

Unfortunately, the internal devices also have disadvantages. They are more difficult to place, especially when a vertical orientation is required, such as in the case of a hypoplastic ramus. The higher risk of injury to nerves and other anatomic structures (e.g., ducts, tooth buds) must also be considered. A second surgical procedure is often necessary to remove the devices following completion of consolidation. Another disadvantage is the lack of the majority of available internal distraction devices with multidirectional adjustment capability. New bidirectional and multidirectional devices are being developed, and as these new devices are refined, internal distraction applications will almost certainly increase.[43]

Several important factors must be considered during the selection of either an external or internal distraction device. These factors include the amount of desired lengthening and/or angular correction, the vector of distraction, and the psychosocial requirements of the patient.[9,29]

Lengthening Capabilities. In order to complete the desired amount and angulation of distraction, the appropriate length of distraction device must be selected. Although the magnitude of lengthening is registered on the distraction device, it does not always correlate to the clinically observed amount of actual bone distraction, which is usually less than anticipated and difficult to predict prior to distraction. The amount of bone distraction clinically observed during lengthening is a result of linear device activation altered by the effect of extrinsic and intrinsic biomechanical factors, which will be discussed later in this chapter. The ratio between the amount of device activation and the observed amount of bone distraction varies, but reaches as high as 2:1 in some cases.[44] When angular correction is incorporated into linear activation, the total amount of linear distraction decreases even more, further increasing the length requirement of the distraction device.

Direction of Distraction. For a simple linear advancement, a unidirectional distraction device is suitable. However, if lengthening of the jaw is planned in two or more directions, a multidirectional device is required. The multidirectional distraction device possesses mechanisms that may be adjusted in three dimensions to alter the direction that the distal (tooth-bearing) segment moves through space.[43-47]

Distraction Vector Planning

The distraction vector defines the desired direction that the distal segment must move during lengthening. Despite precise planning, the actual distal segment movement is still difficult to predict and is affected by various forces. Although controversy exists regarding the variables that affect the distraction vector, identification of the factors during treatment planning allows the clinician to compensate for, avoid, or eliminate undesirable reactive forces. Factors that affect the vector of distraction include osteotomy design and location, distraction device orientation, masticatory muscle influence, occlusal interferences, distraction device adjustment, and orthodontically/orthopedically applied forces.

Distraction Device Orientation. Although osteotomy design and location may affect the muscle tension exerted on the proximal and distal segments,[48] distraction device orientation is the primary factor that influences the vector of distraction. In order to minimize adverse biomechanical effects, devices should be placed parallel to the desired vector of distraction. Based on the orientation of the distraction vector, the distraction device can be placed vertically, horizontally, or obliquely (Fig. 15-1).[26,27,49-52]

Orientation of the distraction device parallel to the "vertical" long axis of the ramus often results in an oblique distraction vector as it relates to the occlusal

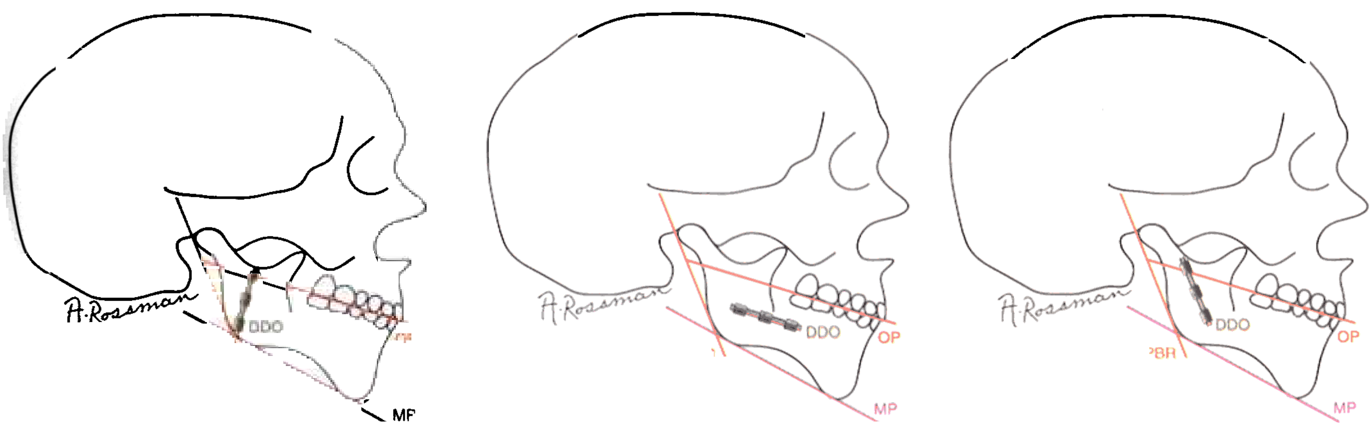

Fig. 15-1 Orientation of the distraction device. *OP,* Occlusal plane; *MP,* inferior border of the mandible or mandibular plane; *PBR,* posterior border of the ramus; *DDO,* distraction device orientation.

plane, since the ramus is not actually oriented perpendicular to the occlusal plane. If vertical elongation of the ramus and posterior occlusal bite opening is desired, it can more predictably be achieved by placing the distraction device perpendicular to the occlusal plane rather than parallel to the long axis of the mandibular ramus.

If anteroposterior advancement of the mandibular corpus is desired, placement of the distraction device parallel to the occlusal plane is recommended. When the distraction device is placed parallel to the long axis of the mandibular corpus, a divergence of the occlusion may occur, often resulting in a skeletal anterior openbite during lengthening.

Oblique distraction device orientation produces simultaneous vertical and horizontal movements of the distal segment. When an oblique device orientation is chosen, anteroposterior positional changes occur along with hyperdivergence of the mandible, resulting in clockwise rotation and anterior bite opening. In patients with a deep bite, this may be advantageous. In most cases, however, clockwise mandibular rotation results in an undesirable anterior openbite (Fig. 15-2).[52] The oblique orientation of the distraction device may be changed to either more vertical or more horizontal, depending on whether the ramus or mandibular body requires more lengthening, respectively.

Influence of Masticatory Muscles. The second factor that affects distal segment movement during distraction is the force generated by the masticatory musculature (Fig. 15-3). Patients undergoing distraction develop functional compensations for their gradually changing occlusions. In order to aid in masticatory function, these patients may posture their mandibles anteriorly or laterally to pick up occlusal contacts lost during distraction. These atypical and sometimes extreme functional positional changes represent a recurrent episodic force that may likely influence the vector of distraction. In addition, soft tissue traction due to physiologic muscle activity exerted on this segment may also contribute to distal segment directional instability.

The orthodontist must recognize forces exerted by the masticatory musculature and compensate for them with orthodontic/orthopedic measures. The surgeon and/or orthodontist may also alter this untoward distal segment movement by making adjustments in sequence and amount of activation of the multidirectional device.

Occlusal Interferences. Occlusal interferences may also alter the planned distraction vector.[26,27] With well-

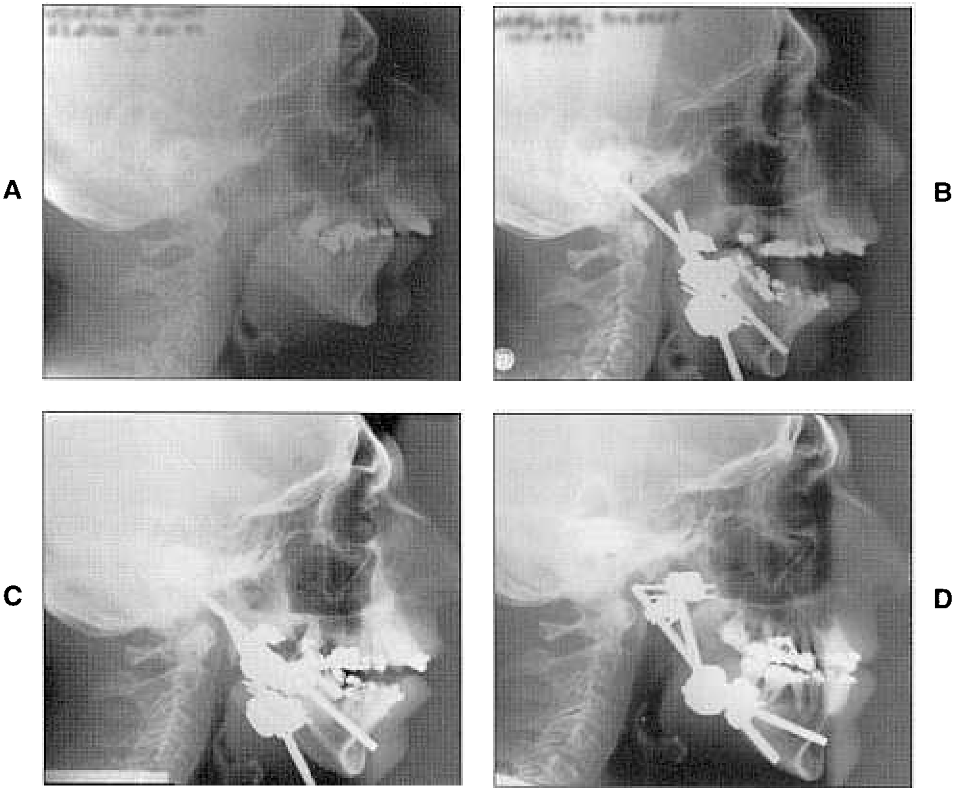

Fig. 15-2 A patient with an obliquely placed distraction device. **A,** Pretreatment lateral cephalometric radiograph. **B,** Posterior occlusal interferences during linear activation of the distraction device resulted in an anterior openbite. **C,** Lateral cephalometric radiograph after introduction of vertical elastics. **D,** Lateral cephalometric radiograph after closure of the anterior openbite.

planned and executed predistraction orthodontic preparation, occlusal interferences may effectively be recognized and eliminated in many instances.

Posterior occlusal interferences present on a patient undergoing mandibular corpus lengthening may cause clockwise rotation of the mandible, resulting in an anterior openbite (see Fig. 15-2). When these interferences are identified prior to initiation of lengthening, they may be addressed before distraction by stepping posterior teeth off of the occlusal plane, at least temporarily. If occlusal interferences are not identified prior to beginning distraction, a developing openbite can still be addressed during distraction with the utilization of biteplane or biteblock appliances, orthodontic adjustment, and/or occlusal equilibration.

Forward movement of the mandible may be restricted as a result of anterior occlusal interferences caused by the position of the maxillary anterior teeth. Advancing, proclining, or intruding the maxillary anterior teeth, when appropriate, may eliminate these interferences. A biteplane or biteblock may also be utilized to eliminate anterior interferences.

Distraction Device Activation. Depending on the dimensional capability of the device, its activation can be performed linearly and/or angularly in the sagittal and/or transverse planes.[43-47] Angular device activation in the sagittal plane produces rotation of the distal segment around the axis located in the center of the hinge. Angular rotation of the distal segment occurs in harmony with rotation of the entire mandible around the axis located at the mandibular condyle, thereby creating the ability to open or close the bite anteriorly. Angular activation reduces the anteroposterior length of the mandible and must therefore be accompanied by additional linear distraction in order to maintain the mandibular advancement achieved. Importantly, at least 10 mm of linear advancement must precede any angular activation to avoid undesirable approximation of the proximal and distal segments, potentially resulting in premature consolidation.[44]

In the transverse plane, angular activation is affected by the resistance of the temporomandibular joints posteriorly and mandibular symphysis anteriorly.[44] It should be noted that both the proximal and distal segments are affected by transverse angulation activation. Moreover, the proximal (condylar) segment is smaller in many cases than the distal segment, is less resistant to the reactive forces, and therefore is more dramatically affected by transverse activation. This may affect the temporomandibular joint anatomy as well as result in chin point deviation (Fig. 15-4). Transverse adjustment must be made with caution, always monitoring segment movement and temporomandibular joint function.

Orthodontic/Orthopedic Forces. Orthodontic/orthopedic forces may be instituted during the active distraction phase and/or during the consolidation phase to affect the distraction vector and final morphology of the neomandible. Intermaxillary elastics, headgear, functional appliances, and/or distraction stabilization appliances may deliver these forces.[26]

Future Growth and Overcorrection

Although the structural and functional result achieved with distraction is definitive for skeletally mature patients, it may only be a temporary treatment objective for growing patients. Therefore skeletal age and future growth potential must be considered in these individuals. Although the endpoint result of treatment may not be ideal relative to the current state of skeletal development, it should be ideal based on the predicted final skeletal dimensions. If future growth is expected to be deficient, overcorrection may be performed to eliminate or decrease the total number of surgical procedures. The degree of overcorrection, however, should provide the patient with a socially acceptable appearance for the

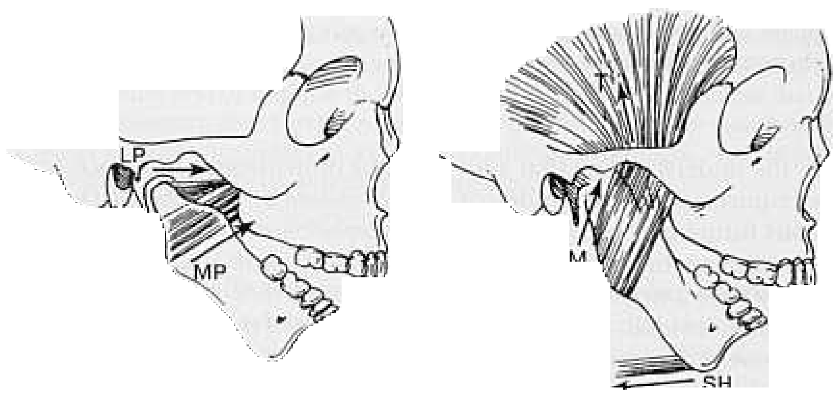

Fig. 15-3 Diagrams demonstrating vector orientation of the forces generated by the medial pterygoid *(MP)*, lateral pterygoid *(LP)*, masseter *(M)*, temporalis *(T)*, and suprahyoid *(SH)* muscles. *(From Grayson BH, Santiago PE: In Stucki-McCormick SU, editor:* Atlas of the Oral and Maxillofacial Surgery Clinics of North America, vol 7, *Philadelphia, 1999, WB Saunders.)*

A  B

C D

Fig. 15-4 Facial photographs demonstrating chin point correction. A, Pretreatment. B, Post-distraction and soft tissue augmentation. Note the overcorrection of chin point past the mid-sagittal plane. C, One year postdistraction; D, Two year postdistraction. Note overcorrection of the chin point is still evident.

most years possible, with the understanding that additional treatment may be required. Although undercorrection requiring numerous future procedures is inappropriate, extreme overcorrection to the point of creating craniofacial disharmony may have a negative psychosocial impact and should also be avoided. A balance between these two extremes is essential to accomplish final treatment objectives.

The amount of distraction required is based on a very careful assessment of the mandible followed by comparison with growth standards or norms adjusted for race, sex, and facial skeleton maturity with a calculation of the dimensional difference. Standards such as the *Bolton Standard of Dentofacial Developmental Growth*[53] or the *Cephalometric Standards from the University of Michigan School Growth Study*[54] may be used for this purpose. Multiple factors must be considered to determine the amount of correction or overcorrection. In the asymmetric patient, the affected side may be compared with the unaffected side, as well as with normative data. Growth on the affected side may be expressed as a percentage of growth on the unaffected side. Rate of growth for the unaffected mandible may be estimated at approximately 1.8 mm per year.[55] This provides a prediction for the

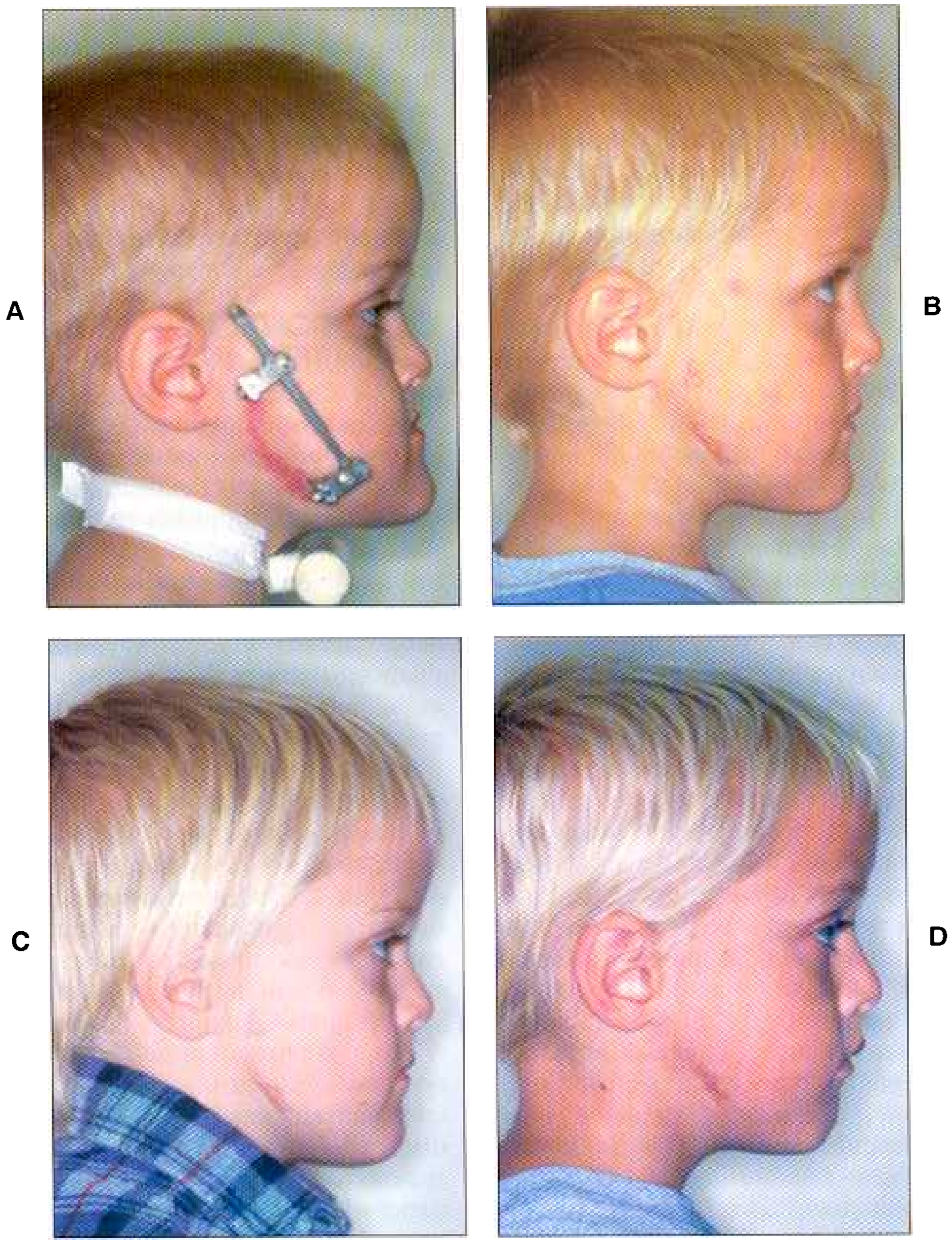

Fig. 15-5 Lateral facial photographs demonstrating reappearance of mandibular deficiency after distraction. **A,** At the end of distraction. Note overcorrection in anticipation of continuous growth deficiency and to improve the airway for decannulation. Also note that scarring was from previous surgery, not from the present distraction therapy. **B,** Six months after treatment. **C,** Twelve months after treatment. **D,** Thirty months after treatment. Note an increase in facial convexity as the patient's growth pattern resurfaces.

amount of remaining growth that the unaffected and affected sides may express by the end of skeletal maturity.

Serial growth studies of a specific individual are also beneficial for growth analysis and prediction. A documented history of past growth and symmetry is also of benefit in predicting future growth. Since these patients are often followed and treated over the course of their childhood, a protocol for record taking at routine intervals in a standardized fashion should be implemented. Growth prediction should also consider the patient's genetic predilection.[56-58] The existing growth pattern may be maintained, and the discrepancy may resurface again with time (Fig. 15-5). Alternatively, morphologic and volumetric improvements of the condyle induced by distraction osteogenesis may be maintained long-term with continued growth of the condyles.[59-62]

PRESURGICAL ORTHODONTIC PREPARATION

After the completion of comprehensive treatment planning, predistraction orthodontic/orthopedic preparation is commenced. As with other forms of orthognathic correction, well-executed presurgical orthodontics will optimize the final functional and aesthetic result. This begins with a careful evaluation of the dentition and its relation to the projected skeletal changes. Orthodontic appliances are then selected and treatment initiated consistent with the overall treatment goals of the distraction treatment planning objectives. The teeth should be moved to near-ideal positions relative to basal bone so that an ideal maxillomandibular relationship is not compromised by existing dental malpositions.

Dental malrelationships must be eliminated in order to prevent mechanical interference with the movement of the distal tooth-bearing segment during gradual distraction. For example, maxillary incisors that are retroclined or extruded would interfere with forward movement of the distal segment as mandibular incisors come forward and begin to contact the lingual of the maxillary incisors. If these interferences are not orthodontically eliminated, they may be overcome utilizing biteplane or biteblock appliances. The utilization of these appliances may be anticipated in the predistraction phase or may be added to the treatment as interferences arise. The maxillomandibular transverse relationship must also be evaluated preoperatively. The patient with severe retrognathia may have a transverse maxillary deficiency that will become evident on evaluation of the pretreatment orthodontic records.[63-65] It is appropriate to expand the maxilla either prior to or during distraction to accommodate the width of the advancing mandible. Tooth positions and maxillary width should enhance distraction, not inhibit it.

Another component of predistraction orthodontic treatment is the fabrication and utilization of distraction stabilization appliances.[64] These interarch appliances are routinely inserted prior to surgery to facilitate vector control during distraction, in order to maintain mediolateral dental interarch relationships such that lateral shifting of the distal segment is not allowed to occur during the active phase of osteodistraction. By maintaining the transverse relationship of the maxillary and mandibular dentition, the distal segment cannot be displaced laterally; hence all the length that is introduced by distraction is maintained in a vertical and/or anterior direction. These appliances may be utilized for patient populations that do not require any specific tooth movement prior to distraction, are not in full orthodontic bands and brackets, are very young, have limited compliance, or have limited teeth. The appliances consist of a banded maxillary expansion appliance[65] and a bilateral double-banded mandibular lingual holding arch. All eight bands on these appliances have symmetrically placed buccal and lingual ball hooks. This provides multiple sites to place interarch elastics for control of mandibular position during distraction, consolidation, and postconsolidation. Distraction stabilization appliances are placed prior to distraction as part of the predistraction orthodontic phase; however, they are utilized during the distraction, consolidation, and postconsolidation phases.

ORTHODONTIC MANAGEMENT DURING DISTRACTION AND CONSOLIDATION

After completion of presurgical orthodontics, the surgical procedure is performed and the latency period is observed, followed by the distraction period.[3,6,17,66] Active orthodontics/orthopedics may continue throughout the distraction and/or consolidation phases, including the utilization of bands, brackets, distraction stabilization appliances, elastics, headgear, acrylic guidance appliances, maxillary expansion appliances, or functional appliances. These appliances are used to direct the distal mandibular segment toward its planned postdistraction position, thereby improving the final treatment result.

During predistraction planning, the orthodontist evaluates and determines the desired vector of distraction based on the skeletal assessment.[17,67] However, the clinically observed vector often varies from its planned direction due to the influence of the previously mentioned factors including osteotomy location, device orientation, neuromuscular influences, occlusal interferences, device activation, and orthodontic/orthopedic intervention.

The alterations in distal segment direction and position that are affected by the orthodontist likely occur by taking advantage of the increased metabolic response that the body mounts after a surgical insult, or by what appears to be manipulation of the regenerate. The efficiency with which we can affect large distal segment positional changes via orthodontic and orthopedic force application certainly points to the capabilities of these factors. Because this time frame is limited, and because large-scale distal segment alteration is possible, close monitoring is required during this phase of treatment. Weekly or twice weekly visits are required to adjust the orthodontic/orthopedic forces that are being delivered. During the active distraction and consolidation periods, dental position, mandibular position, and maxillomandibular relationships may be rapidly altered.

There is a direct relationship between the degree of vertical placement of the distraction device and the observed vertical versus anterior distal segment movement that is seen clinically. Hanson and Melugin[68] evaluated 54 distraction device orientations; there were 37 oblique and 17 vertical. Oblique placement was defined as greater than 90 degrees of angulation between the occlusal plane and the long axis of the distraction device. Vertical placement was defined as less than 90 degrees of angulation between the occlusal plane and the long axis of the distraction device. All 37 patients with oblique device placement showed an anterior movement of the distal segment as measured at the level of the occlusion, with an average value of 2.5 mm (range 1.5 to 6.0 mm). All 17 patients with vertical device orientation had zero or negligible anterior distal segment movement as measured at the occlusion.

Multidirectional distraction devices have the capability of allowing distraction vector alteration during distraction if distal segment position is not ideal. Furthermore, they allow differential vertical, horizontal, and transverse vector components to be added or deleted as distraction progress may dictate. These vector changes are sometimes part of the original preoperative distraction plan, or may be introduced during distraction by the orthodontist or surgeon to redirect the distal segment away from its observed path and toward its planned path. At this time the orthodontist may apply external forces to control the position of the distal segment. This consists of angular, transverse, or linear activation of the distraction device and orthodontic/orthopedic manipulation of the distal segment.

It should be noted that the distraction device is a semirigid fixator that connects both the proximal and distal segments of the mandible to each other. This allows the orthodontist or surgeon to change the direction the distal segment is moving during distraction; however, proximal segment position may be altered as well. Unfavorable positional changes of the condyle/ramus (proximal) segment may occur and should be controlled if necessary.

An alternative approach to segment position manipulation has been suggested by Hoffmeister and coworkers.[69] Their technique involves the removal of the distraction device(s) before the regenerate is consolidated and is therefore somewhat malleable. The regenerate is then manipulated with orthodontic forces to the desired end-treatment position and then left to consolidate. Although this magnitude of control would be desirable, the following should be considered. Accepted principles of fracture healing require immobilization during the consolidation period to allow for complete bone healing and to prevent fibrous union. In addition, skeletal relapse has been reported in distraction patients who have had a shortened consolidation period. In the absence of data supporting this approach, its use should be cautioned.

Interarch elastic traction has been demonstrated to direct the distal segment and influence the vector of distraction in the vertical, anteroposterior, and transverse directions. Class II and Class III vector correction via interarch elastic traction is possible,[26] and is important for the control of anterior distal segment movement in excess of what is desired (as the result of excessively oblique device placement).

The most important use of elastic traction during the active distraction phase is to control laterognathism,[64] as discussed in the presurgical orthodontic section. Laterognathism is a frequently experienced phenomenon in unilateral correction of the asymmetric patient by osteodistraction[6,54,55,70-73] (e.g., hemifacial microsomia, craniofacial microsomia, and asymmetry secondary to trauma). In the unilateral patient, a canted maxillary and mandibular occlusal plane is present. Distraction osteogenesis is utilized to correct the mandibular occlusal cant[69] and normalize the vertical length of the affected ramus.[66,73] This establishes right to left vertical symmetry of the mandible as measured at the gonial angles and mandibular borders. It also results in a unilateral posterior openbite as the corrected mandibular plane diverges from the noncorrected (canted) maxillary occlusal plane. As the magnitude of unilateral openbite increases, the patient's inability to find suitable masticatory surfaces also increases. This results in functional shifting of the mandible toward the unaffected side. This is manifested by a dental midline shift away from the distracted side, a posterior buccal crossbite on the distracted side, and a crossbite on the unaffected side (Fig. 15-6). This laterognathism, if left unmanaged, would inhibit the

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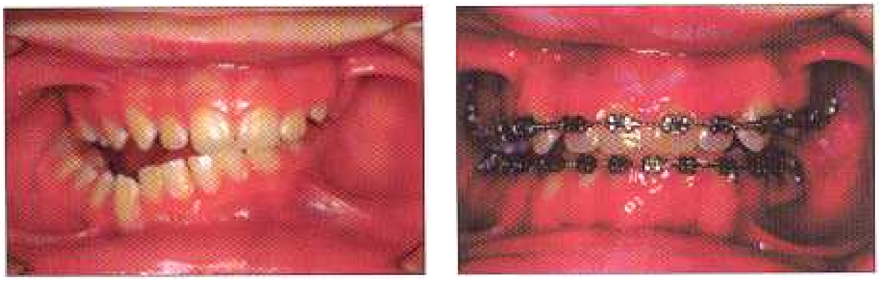

B

Fig. 15-6 Patient with left-sided vertical maxillomandibular deficiency. **A,** Intraoral photograph demonstrating laterognathism and undesirable right-sided openbite that developed during distraction. **B,** The patient's occlusion during the consolidation phase, resulting from left-sided vertical distraction, midline and transverse elastic wear, and orthodontic tooth movement.

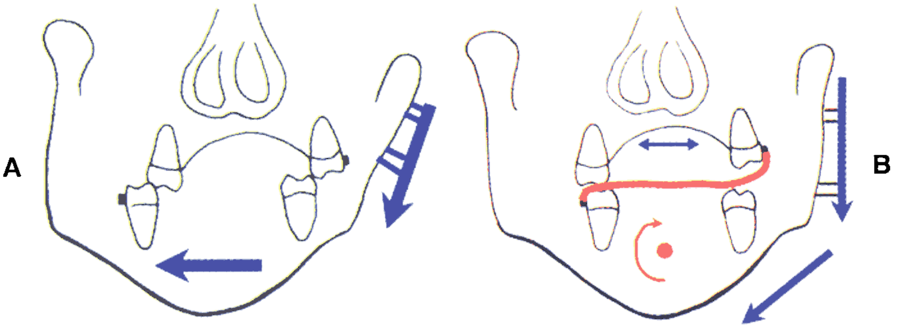

Fig. 15-7 Diagrams demonstrating the elastic and distraction force vectors during laterognathism correction using distraction stabilization appliances introduced by Dr. P.R. Hanson. **A,** Distraction force vectors during laterognathism development. **B,** Elastic and distraction force vectors during laterognathism correction. *(Courtesy Dr. B.H. Grayson.)*

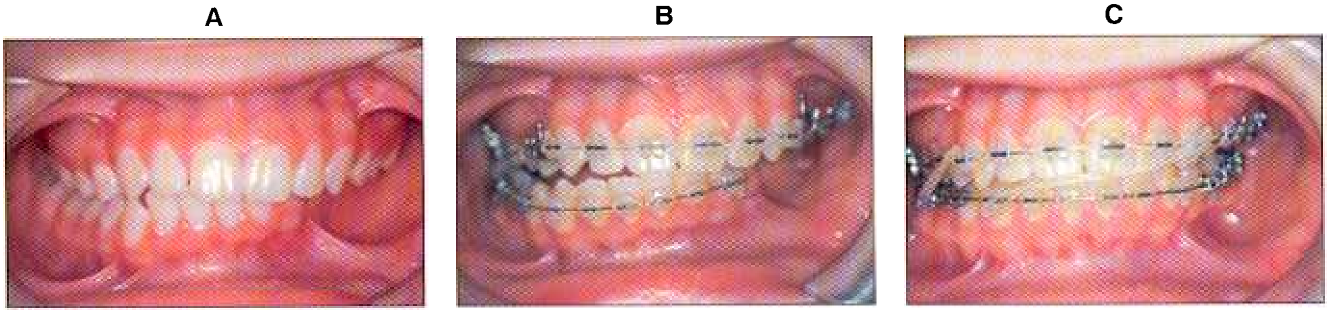

Fig. 15-8 Intraoral photographs demonstrating laterognathism correction with interarch elastic wear. **A,** Pretreatment occlusion. **B,** Skeletal and dental changes as a result of left-sided vertical distraction. **C,** Occlusion at 7 weeks postdistraction resulting from interarch elastic traction and orthodontic tooth movement.

vertical movement of the distal segment that is necessary to correct the vertical ramus length discrepancy, and would prevent the desired unilateral openbite. The orthopedic forces that are required to correct laterognathism work against the vector of distraction, however (Fig. 15-7). Therefore the forces of distraction must be greater than the forces of manipulation or the distraction goals may not be realized. The use of this opposing elastic traction may require a greater magnitude of distraction force to accomplish the distraction goal.

Hanson and Melugin[74] evaluated 22 patients who were undergoing unilateral mandibular distraction and developed laterognathism as defined above. All of the patients began to develop laterognathism as the magnitude of posterior openbite increased. The point at which laterognathism appeared ranged from 5 to 8 mm of posterior vertical bite opening. Six patients did not receive orthodontic intervention. For this group, the laterognathism increased until the end of distraction and persisted through consolidation. The remaining 16 patients underwent an active regimen of orthodontic/orthopedic control via the distraction stabilization appliances, coupled with interarch elastic wear and in some instances, maxillary expansion. All of these patients regained their midline mandibular position with development of the desired posterior vertical openbite.[74] Skeletal and soft tissue evaluation showed the attainment of the planned overcorrection of the mandibular vertical ramus symmetry with overcorrection of pogonion past the midsagittal plane.

Discrepancies in maxillary and mandibular transverse dental relations may be caused by abnormalities in arch width or skeletal position. Interarch elastics may be used to address these issues. Elastics may be worn crossarch, crossbite, and/or midline oblique (Fig. 15-8) to correct the transverse width of the dental arch, symmetry, or dental midlines (Fig. 15-9).

Elastic traction may be used to close a planned or unplanned openbite. It is not unusual for an anterior openbite to develop when performing bilateral distraction for sagittal advancement of the mandibular body. Clockwise rotation of the tooth-bearing segment during active distraction may be achieved through a combination of angular adjustments to the distraction device along with anterior vertical elastic traction. Under these circumstances, the openbite will close through a combination of counterclockwise skeletal rotation and dentoalveolar extrusion.

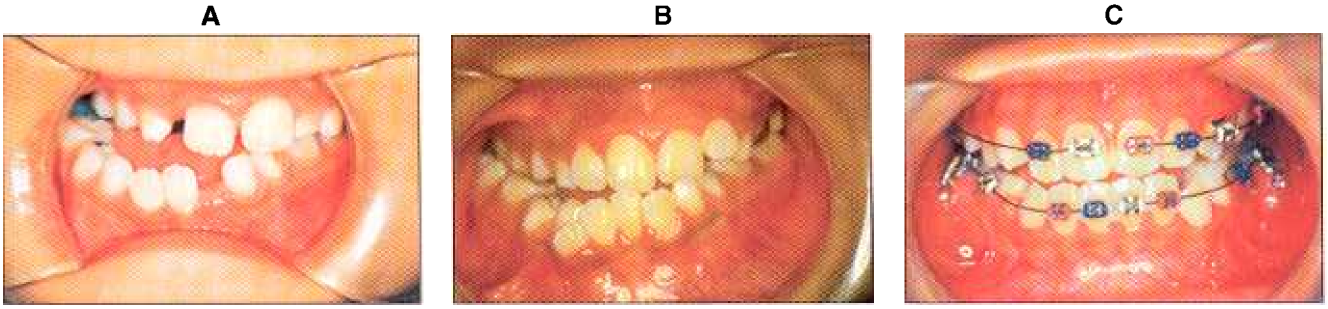

Fig. 15-9 Intraoral photographs demonstrating correction of transverse width of the dental arch, symmetry, and dental midlines. **A,** Pretreatment. **B,** After initial distraction. Note incomplete correction of asymmetry, laterognathism, and the occlusal plane with no orthodontic management. **C,** After secondary distraction with orthodontic management. Note correction of asymmetry, laterognathism, and occlusal plane.

POSTCONSOLIDATION ORTHODONTIC THERAPY

After completion of consolidation, the distraction device is removed and the tooth-bearing segment of the mandible derives its support from the new bone that was generated across the distraction gap. Postdistraction orthodontics/orthopedics are instituted to accomplish the original treatment goals and objectives. The orthodontic requirements at that time vary depending on patient age and whether mandibular distraction was unilateral or bilateral.

In the growing bilateral distraction patient, an anterior crossbite may be a temporary treatment objective in anticipation of a future mandibular growth deficiency (see Fig. 15-5). Additional treatment objectives would include guidance of eruption and alignment of the dentition over alveolar bone. Orthodontic treatment for growing children may also take into consideration future orthognathic surgery or distraction.

Although orthodontic finishing is usually completed at this time in nongrowing bilateral distraction patients, some of these patients may be scheduled for a subsequent orthognathic surgical procedure after completing mandibular distraction. In this case, these patients would undergo surgical orthodontic preparation at this time and orthodontic finishing after completion of the orthognathic procedure.

In unilateral distraction patients, the postdistraction orthodontic therapy will most likely involve occlusal plane management, correction of the dental midlines, and correction of the maxillomandibular transverse disharmony. Some of these issues may have been addressed during active distraction and consolidation. In most cases, however, unilateral mandibular distraction requires extensive orthodontic support after consolidation. Therapy includes eruption guidance, alignment of the dentition over alveolar bone, correction of laterognathism (if not previously addressed), and controlled vertical closure of the unilateral posterior openbite.

Closing the posterior openbite is achieved by selective eruption of the maxillary posterior dentition and alveolar process. The mandibular occlusal plane must be maintained in the corrected position that was achieved through mandibular distraction. Failure to do so may result in less than 100% correction of the occlusal cant. This occurs as both the maxillary and mandibular posterior dental segments undergo supereruption. Development of a maxillary and mandibular occlusal cant at this time constitutes dental compensation for the corrected mandibular skeletal anatomy. A surgical correction of the compensated occlusal plane at this stage would alter the symmetric mandibular skeleton. Bimaxillary osteotomies, which would be required to correct the occlusal asymmetry, would alter the position of the inferior border, reintroducing mandibular asymmetry. Carefully controlled closure of the openbite contributes to the stability of the surgically corrected mandibular position and may reduce the need for future treatment.

Methods of occlusal plane management include (1) an occlusal acrylic wafer that is reduced one tooth at a time to allow serial eruption of the maxillary posterior dentition, (2) a functional appliance with lingual shields (to provide lateral control of mandibular position) and a biteplane (adjusting one tooth at a time for passive eruption of the maxillary teeth), and (3) occlusal acrylic buildups that are reduced one tooth at a time to allow for serial eruption of the maxillary teeth. The addition of elastic traction to these appliances has been shown to significantly decrease the treatment time for the correction of the maxillary occlusal plane.[75] In addition, the elastic traction improves appliance retention, resulting in improved patient compliance.

Leveling of the maxillary occlusal plane may be accomplished with the use of interarch elastics utilized in combination with rapid palatal expansion, which has been shown to induce bony changes at all of the maxillary sutures.[65] Three of our craniofacial microsomia patients underwent occlusal plane correction during active distraction and consolidation phases of vertical ramus lengthening. In these patients, distraction-induced unilateral openbites of 7 mm or less were created by distracting 20 mm or less (as measured on the distraction device). The canted mandibular occlusal plane was corrected by lengthening the affected ramus with distraction. Correction of the maxillary occlusal plane was completed with elastic traction on the expanded palate. The affected side was not utilized for anchorage of interarch elastics. Crossarch/interarch elastics were worn from the buccal of the affected maxilla to the buccal of the unaffected mandible.[64,76] Predistraction and postconsolidation frontal cephalometric radiographs were compared and correction of the maxillary occlusal cant was noted.

CONCLUSION

The orthodontist plays a primary role in the planning and execution of treatment during distraction osteogenesis. The plan must be based on good pretreatment records and an appreciation of the functional and anatomic needs of the patient. Active orthodontic treatment is used before, during, and after distraction. The types of orthodontic treatment that are used with distraction range from standard orthodontic treatment modalities to orthopedic manipulations of distraction vector orientation, both of which are designed to address the unique malocclusion resulting from distraction and the changing position of the distal segment during distraction. These modalities are possible because of the unique dynamic process of distraction. Because the treatment goals are jointly developed by the orthodontist and surgeon, close follow-up by both clinicians during distraction is required. Variations from the planned distraction path must be promptly recognized and corrected so that the planned clinical outcome is achieved. If planned carefully and executed skillfully, distraction osteogenesis may provide length and volume to facial structures in a manner that is less morbid and probably more stable than alternative craniofacial procedures.

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