CASE REPORT

Surgically assisted rapid palatal expansion: Orthodontic preparation for clinical success

Steven L. Cureton, DMD, MS,[a] and Michael Cuenin, DMD[b]
Johnson City, Tenn. and Fort Gordon, Ga

Close root proximity between the maxillary central incisors presents a problem in the surgical management of a maxillary palatal expansion. During the surgical fracture of this interdental area, the possibility exists for a separation to occur between the root surface and the bone. If this does occur, it is paramount that the gingival attachment remain intact. Asymmetric separation places more stress on the mesial gingival attachment because of the anatomy of the gingival fiber apparatus. Gingival detachment results in epithelial downgrowth in an apical direction, which in turn prevents bone apposition in a coronal direction. The resulting osseous defect is difficult to treat with an osseous graft procedure, as there are few if any intrabony walls. Treatment planning should include analysis of a recent periapical radiograph of the incisor roots to determine the need for orthodontic root separation before surgery. A postsurgical periapical radiograph should be taken to determine where the interdental separation has occurred. The expansion schedule should be adjusted depending on the symmetry of the separation and the health of the gingival attachment. (Am J Orthod Dentofacial Orthop 1999;116:46-59)

Nonsurgical rapid palatal expansion (RPE) was used by Angle[1] as early as 1860 and continues to be used by orthodontists with a high rate of success for growing children. Although RPE has been relatively successful in children and adolescents, it has been fraught with failures in adults.[2-5] In adults, orthodontic RPE may result in alveolar bending, periodontal membrane compression, lateral tooth displacement, tooth extrusion, and transverse relapse, which can subsequently lead to failure of the procedure.[6,7] Historically, the midpalatal suture was thought to be the area of resistance to expansion, but Lines[5] and Bell and Jacobs[8] demonstrated that the area of increased facial skeletal resistance to expansion was not the midpalatal suture, but the zygomaticotemperal, zygomaticofrontal, and zygomaticomaxillary sutures. This stimulated the development of various maxillary osteotomies to expand the maxilla laterally in conjunction with orthodontic RPE appliances.[9-14]

INDICATIONS

Treatment in adults with dentofacial deformities is frequently complicated by the existence of discrepancies in the transverse dimension. Control of these transverse discrepancies in the correction of dentofacial deformities is extremely important for the ultimate satisfactory achievement of a stable and functional occlusion. Jacobs et al[15] divide maxillary transverse width discrepancies into two categories: real and relative. Relative implies that a horizontal discrepancy apparently exists clinically, but the study models examined in a class I canine relationship show that the apparent deficiency is in reality the result of a discrepancy of the maxilla or both jaws in the sagittal dimension. Absolute implies a true horizontal width insufficiency. Once the diagnosis of absolute maxillary deficiency has been made and it is ascertained that the need for expansion of the maxillary arch does exist, several factors must be considered to determine whether such expansion should be achieved through lateral maxillary osteotomies and rapid maxillary expansion[8,9,16,17] as an integral part of the presurgical orthodontic therapy or by segmentalizing the maxilla at the time of surgery to achieve transverse correction concomitantly with vertical and/or sagittal treatment objectives.[18-28]

In cases of minimal to moderate arch length deficiencies, rapid palatal expansion can increase arch circumference sufficiently to permit alignment of the crowded anterior teeth thus avoiding the necessity of extraction of premolars or excessive forward tipping of incisors. It may obviate the need for a second maxillary surgical procedure.

Most cases in which a transverse deficiency exists will characteristically exhibit a narrow tapering arch form. The discrepancy will, therefore, be pronounced in the canine region. In order to achieve a functional

[a]In private practice.
[b]Director, US Army Periodontic Residency Program, Fort Gordon, Ga.
Reprint requests to: Steven L. Cureton, DMD, MS, Sunset Professional Park, 801 Sunset Dr, Bldg E #5, Johnson City, TN 37604

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Fig 1. Case 1, pretreatment intraoral view.

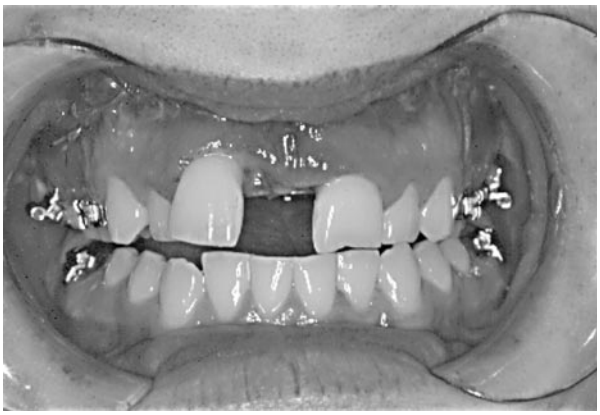


Fig 3. Case 1, 3 weeks after surgical expansion.

Fig 2. Case 1, pretreatment periapical radiograph.

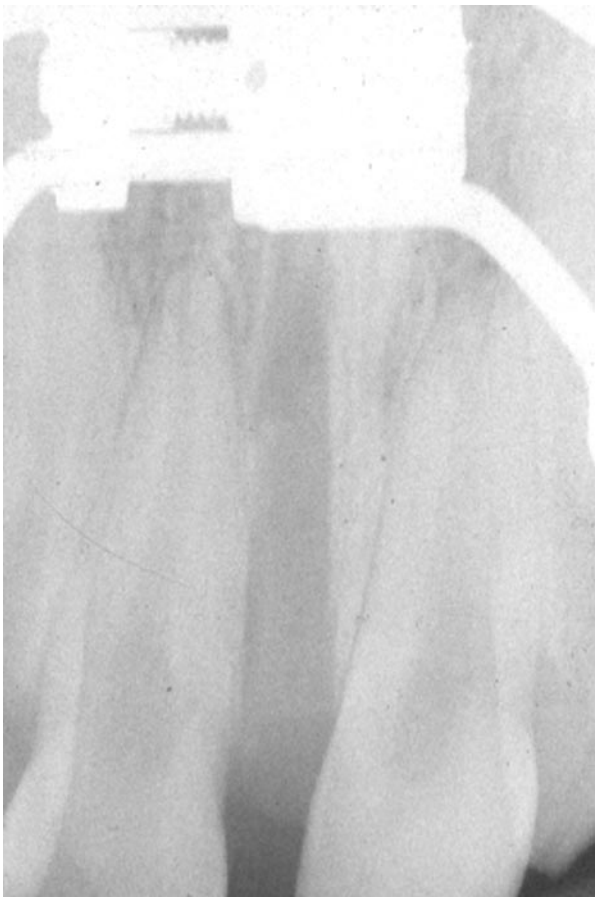


Fig 4. Case 1, periapical radiograph 1 week after surgical expansion.

occlusion in such patients, the canine width must be increased and the anterior segment flattened to the resultant normal elliptic morphology. If nonextraction orthodontic therapy is desired, lateral maxillary osteotomies and rapid maxillary expansion is the treatment of choice. The procedure is also feasible in the treatment of maxillary deficiency associated with crowded and malaligned teeth in persons who have already been treated by orthodontic means and extractions.

In those cases that do not exhibit severe constriction in the anterior region, another alternative is that of a two-piece maxillary procedure with midline osteotomy and resultant diastema to be closed postsurgically by orthodontic means. For several reasons, such an approach

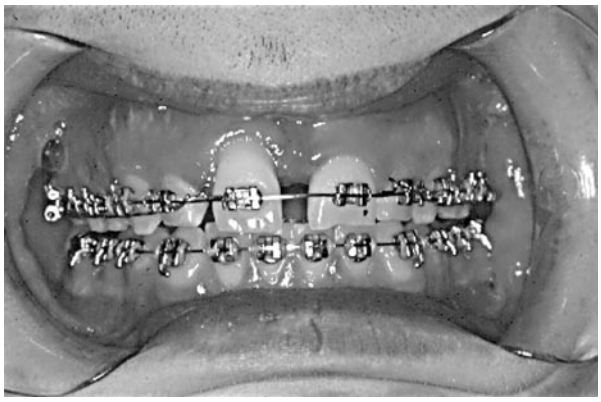


Fig 5. Case 1, 1 year after surgical expansion.

Fig 6. Case 1, periapical radiograph 1 year after surgical expansion.

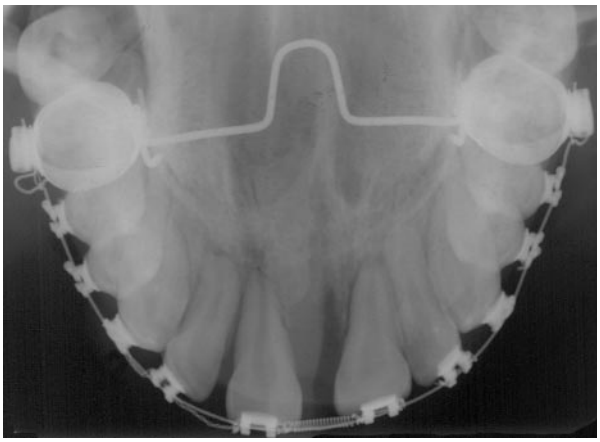


Fig 7. Case 1, occlusal radiograph 1 year after surgical expansion.

Fig 8. Case 1, 18 months after surgical expansion.

may be less than ideal. The prediction of ultimate soft tissue changes is more difficult. The maxillary incisors may move posteriorly during diastema closure and, therefore, induce posterior sagittal repositioning of the upper lip, which may or may not be esthetically tolerable. In addition, there is a chance of moving the posterior maxillary dental units forward during diastema closure. When interincisal space is excessive, the gingiva may become detached and interproximal bone may be exposed. There is a distinct possibility of devascularization and osteonecrosis of the underlying bone and consequent periodontitis in such excessive moves.[15]

Fig 9. Case 2, pretreatment intraoral view.

Fig 10. Case 2, pretreatment occlusal view.

Fig 11. Case 2, 3 weeks after surgical expansion.

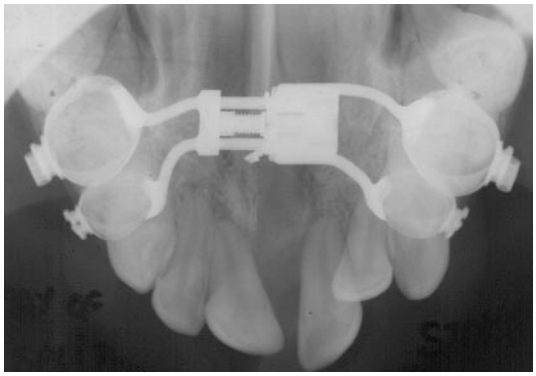


Fig 12. Case 2, postsurgical occlusal radiograph shows asymmetric fracture.

The effects of segmental alveolar osteotomy on dental tissues have been reported by many authors.[21-31] They include: (1) mobility of teeth adjacent to osteotomy sites and periodontal disease, (2) loss of teeth adjacent to osteotomy sites, (3) permanently mobile maxillary segment, (4) sloughed maxilla (entire), (5) shaving of teeth adjacent to osteotomy site, (6) massive hemorrhage, (7) postoperative infection, (8) flap dehiscence and periodontal defect, (9) relapse of segment, (10) nonvital teeth, and (11) oro-antral fistula. Very little specifically has been written about complications involving the maxillary central incisors when performing rapid maxillary expansion with lateral osteotomies.

Complications encountered after maxillary palatal expansion with osteotomies of the central incisors include osseous defects, tooth mobility, loss of vitality, external root resorption, tooth loss, interproximal blunting of gingiva, and gingival recession.

SURGICAL TECHNIQUE

Bell[32] describes his surgical technique: a rigid fixed tooth-borne appliance capable of producing orthopedic forces that is usually cemented to the maxillary first molars and first premolars before surgery. The operation may be performed with the patient under general anesthesia or local anesthesia. Local anesthesia with a vasoconstrictor is infiltrated into the labiobuccal vestibule for hemostasis. A horizontal incision is made through the mucoperiosteum above the mucogingival junction in the depth of the buccal vestibular, extending from the canine region to the second molar. A horizontal low-level osteotomy is made through the lateral wall of the maxilla 4 to 5 mm superior to the apices of the anterior and posterior teeth, on the same level as the occlusal plane extending from the inferolateral aspect of the piriform rim posteriorly to the inferior aspect of the junction of the maxillary tuberosity and pterygoid plate. The maxilla is separated from the pterygoid plate with an osteotome (this procedure is done only in selected cases where maximal expansion of the posterior aspect of the maxilla is desired). The maxillae are separated by malleting a thin osteotome between the central incisors. The forefinger is positioned on the incisive papilla to feel the redirected osteotome as it

Fig 13. Case 2, 7 months after surgical expansion.

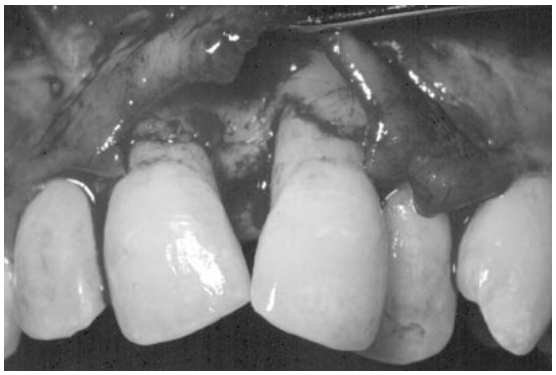


Fig 14. Case 2, osseous defect created by asymmetric expansion.

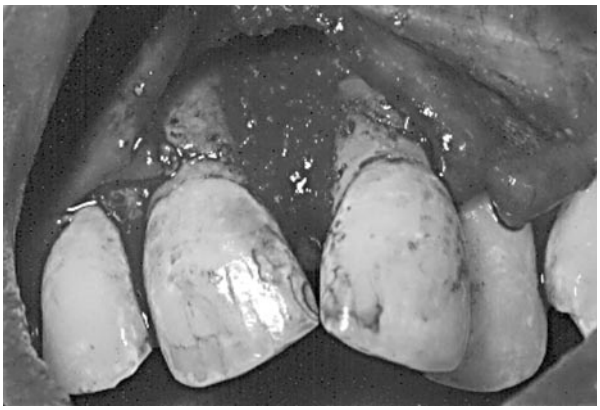


Fig 15. Case 2, human tissue allograph placed in osseous defect.

Fig 16. Case 2, gingival defect 1 year after surgery.

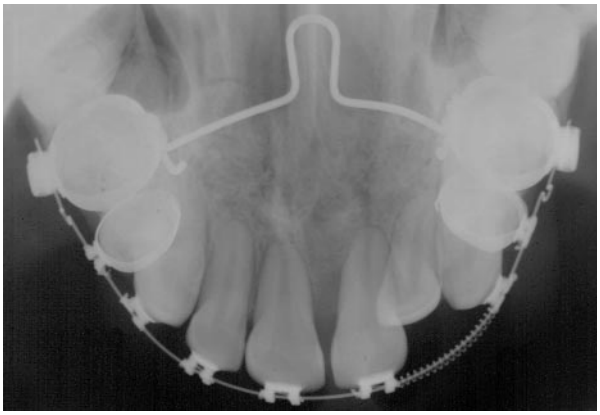


Fig 17. Case 2, 1 year after surgical expansion.

transects the deeper portion of the midpalatal suture. An osteotome is positioned in the central incisor interradicular space and manipulated to achieve equal and symmetric mobilization of the anterior maxillae.

Although alternative maxillary osteotomies that are less involved have been suggested as being adequate to effect routine orthopedic expansion of the maxilla,[33,34] our experiences are that these procedures often result in incomplete orthopedic maxillary expansion and thus inevitable secondary relapse. The stability of results, as with the integrated orthodontic-surgical approach described above by Bell,[32] is excellent so long as the

Fig 18. Case 2, gingival defect 2 years after surgical expansion.

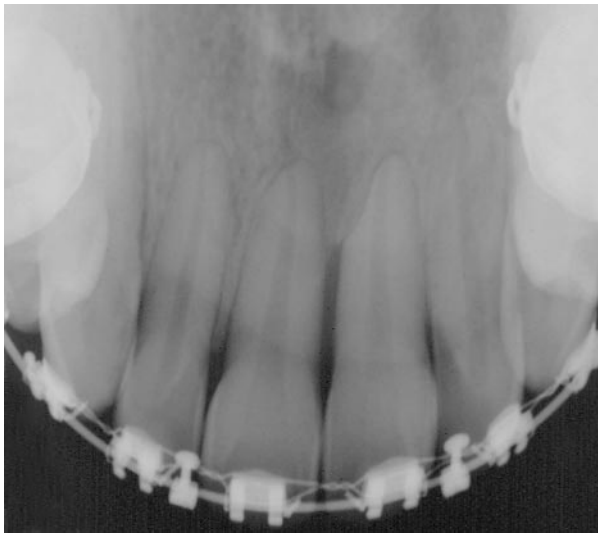


Fig 19. Case 2, occlusal radiograph 2 years after surgical expansion.

maxillary osteotomies are complete and thus true orthopedic expansion is achieved.

CASE REPORTS

Case 1

A 21-year-old man presented with a Class I malocclusion with arch length deficiency (Fig 1). The treatment plan called for nonextraction therapy using the space created by the maxillary expansion to relieve the anterior crowding. The preoperative periapical radiograph (Fig 2) shows the roots of the central incisors close together. The expansion appliance was cemented to the maxillary first molars and first premolars 2 weeks before the surgical expansion. During the expansion procedure, the oral surgery department expanded the appliance until the tissue between the central incisors blanched and then expanded the appliance 2

Fig 20. Case 2, posttreatment intraoral view.

Fig 21. Case 3, pretreatment intraoral view.

turns per day (0.5 mm) until the desired expansion was complete. The patient was seen by the orthodontist 3 weeks after the surgical procedure (Fig 3). The gingiva was detached from the mesial surface of the maxillary right central incisor; the periapical radiograph taken 1 week after surgery (Fig 4) showed an asymmetric interdental bone fracture that resulted in all of the interdental bone remaining with the maxillary left central incisor and no bone associated with the mesial surface of the right incisor. There was Class II mobility of the right central incisor. One year after the surgical procedure (Fig 5), gingival recession was evident on the facial surface of the right incisor. The periapical (Fig 6) and occlusal (Fig 7) radiographs show a large osseous defect and external root resorption associated with the mesial surface of the right incisor. He was referred to the periodontic department for an evaluation of the maxillary right central incisor. The conclusion concerning his case was that the configuration of the osseous defect was not conducive to placing an osseous graft and periodontal treatment would not improve the condition. He was also referred to the endodontist to

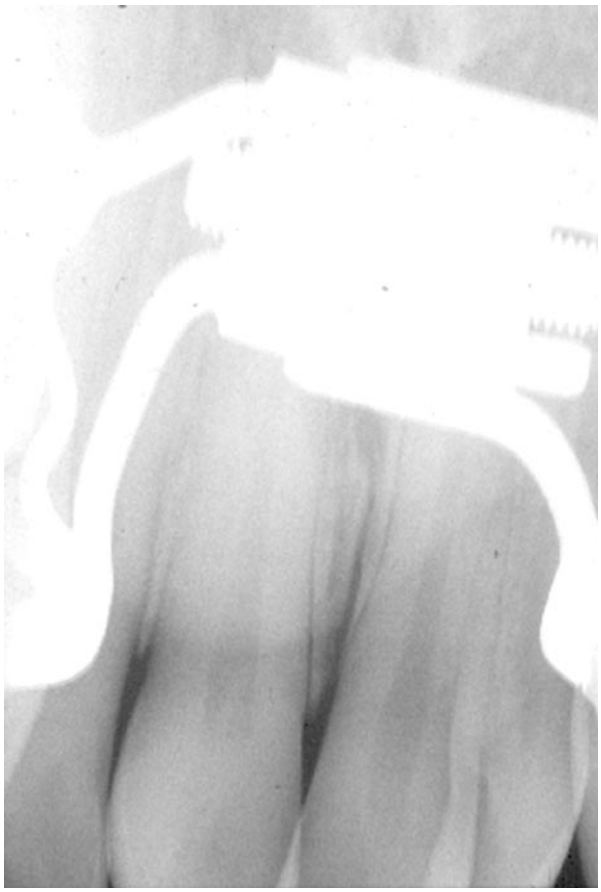


Fig 22. Case 3, pretreatment periapical radiograph.

Fig 24. Case 3, periapical radiograph 3 weeks after surgical expansion.

Fig 23. Case 3, 3 weeks after surgical expansion.

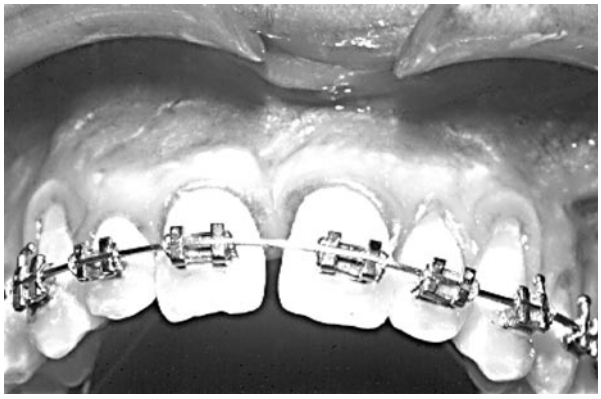


Fig 25. Case 3, 1 year after surgical expansion.

evaluate the external root resorption. The endodontist's recommendation was to monitor this tooth radiographically for progression and if the resorption did not abate, intentional root canal therapy would be recommended. The prognosis of the right central incisor was guarded. Because of these complications, it was decided that the crowns of the central incisors would be tipped toward each other without moving the roots. Eighteen months postoperatively (Fig 8), the bone level has not improved, and the resorption is still evident although not progressing. The maxillary right central incisor has Class I mobility.

Fig 26. Case 3, 30 months after surgical expansion.

Fig 27. Case 3, completed photo shows occlusion and gingiva.

Fig 28. Case 4, pretreatment intraoral view.

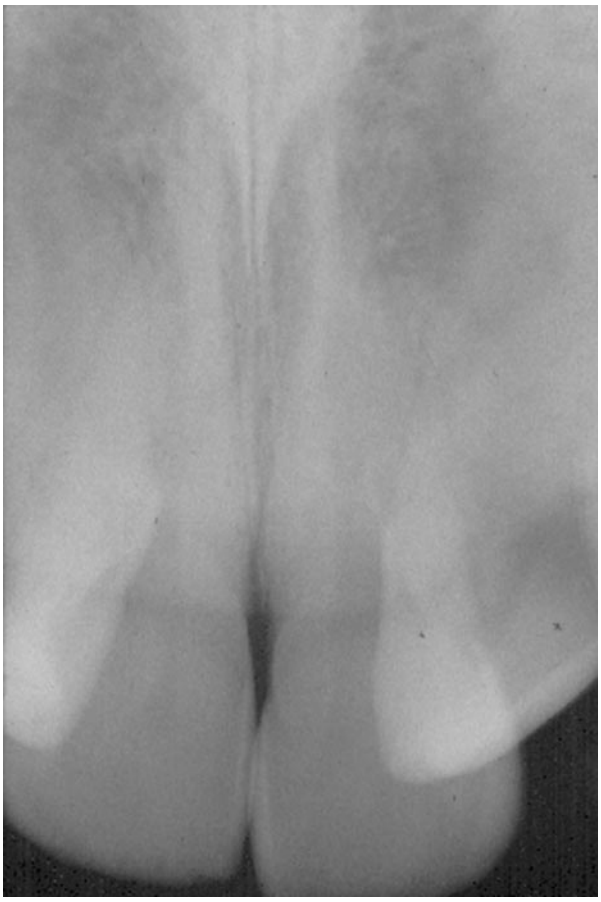


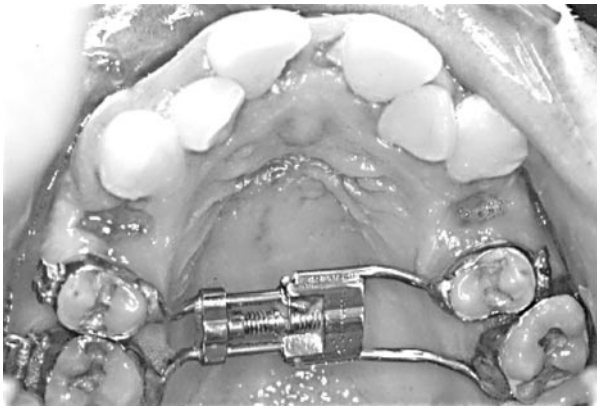
Fig 29. Case 4, completion periapical radiograph.

Case 2

A 25-year-old man presented with a Class III skeletal malocclusion and an anterior open bite with a bilateral posterior crossbite (Fig 9). All four first premolars had been previously extracted (Fig 10). An expansion appliance was cemented to the maxillary first molars and second premolars. The patient was then referred to the oral surgery department for the surgically assisted expansion procedure. The appliance was activated in the operating room until the interdental tissue blanched, and the appliance was activated two turns (0.5 mm) every day. Three weeks after the procedure,

Fig 30. Case 4, initiation of root separation.

Fig 31. Case 4, completion of root separation.



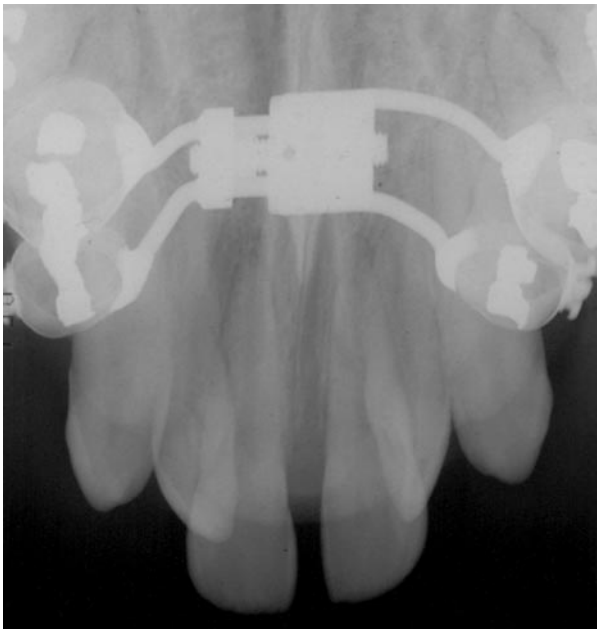


Fig 32. Case 4, 7 days after surgical expansion.

the patient was seen by the orthodontist. A gingival defect was observed associated with the mesial surface of the maxillary left central incisor (Fig 11). An occlusal radiograph (Fig 12) showed an asymmetric fracture with all of the interdental bone remaining with the right central incisor. This resulted in Class II mobility of this tooth. Seven months after the surgery (Fig 13), an osseous defect was noted on the mesial surface of the left central incisor. The patient was referred to the periodontic department where processed human

allograft bone tissue was placed in an attempt to eliminate the osseous defect (Figs 14 and 15). One year after the surgical procedure a gingival defect is still apparent (Fig 16), and the osseous defect has not improved (Fig 17). Two years after the surgical expansion, the gingival defect has not improved (Fig 18) and the occlusal radiograph (Fig 19) shows the large osseous defect associated with the mesial surface of the left central incisor. The apical one third of the left incisor has resultant root resorption, and Class II mobility remains. The final occlusion is good but the prognosis of the left central incisor remains guarded (Fig 20).

Case 3

A 27-year-old man presented with a Class III skeletal malocclusion (Fig 21). A skeletal bilateral posterior crossbite with a moderate maxillary arch length deficiency was observed. The treatment plan called for nonextraction therapy using the space created by the expansion to relieve the anterior crowding. The preoperative periapical radiograph (Fig 22) shows the roots of the central incisors close together. The expansion appliance was cemented to the maxillary first molars and first premolars 2 weeks before the surgical expansion. During the expansion procedure, the oral surgery department expanded the appliance until the tissue between the central incisors blanched and then expanded the appliance two turns per day (0.5 mm) until the desired expansion was complete. The patient was seen by the orthodontist 3 weeks after the surgical procedure (Fig 23). The gingiva was not detached from the mesial surface of the maxillary right central incisor, but the periapical radiograph taken (Fig 24) showed an asymmetric interdental bone fracture that resulted in all of the interdental bone remaining with the maxillary left central incisor and no bone associated with the mesial surface of the right incisor. There was Class I mobility of the right central incisor. Twelve months after the surgical expansion the interproximal gingiva remains healthy (Fig 25) but radiographically the bony fill appears immature and disorganized (Fig 26). When the treatment was complete (30 months after the surgical expansion) the interproximal gingiva was healthy but a slight blunting of the papilla was evident (Fig 27). Radiographically external root resorption was evident along the surface of the maxillary right central incisor. Some interproximal bone height was also lost.

Case 4

A 24-year-old man presented with a Class III skeletal malocclusion (Fig 28). A skeletal bilateral posterior crossbite with unilateral posterior open bite was observed. There was excessive procumbency associated with the maxillary incisors and a significant maxillary arch length deficiency. The treatment plan called for the extractions of the maxillary first premolars and the mandibular second premolars. The preoperative periapical radiograph (Fig 29) shows the roots of the central incisors very closely proximated. Brackets were placed on the central incisors and an 0.016 inch ss spring inserted to separate the roots (Fig 30). Once radiographic root divergence was evident (Fig 31), the expansion appliance was cemented to the maxillary first molars and second premolars. During the surgical expansion procedure, the oral surgery department expanded the appliance until the tissue between the central incisors blanched; the appliance was not expanded any more by the oral surgery department. The patient was seen by the orthodontist 7 days later. It was noted at that time that the attached gingiva had progressed apically on the mesial surface of the left central incisor, but it was not detached (Fig 32). Radiographically, the separation was symmetric with bone equally divided between the central incisors. Expansion was delayed for 10 days when it was then expanded one turn (0.25 mm) every other day. The patient was

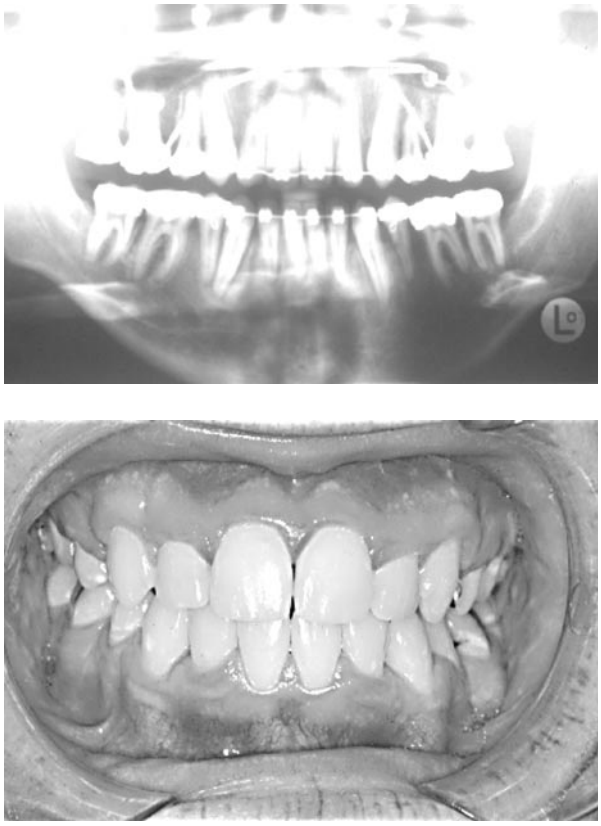


Fig 33. Case 4, panoramic radiographs and photo 2 years after surgical expansion.

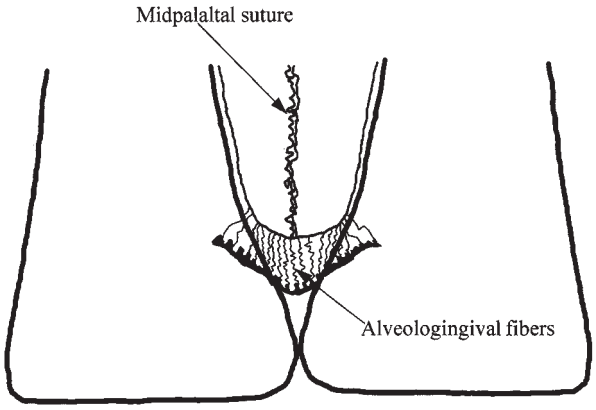


Fig 34. Alveologingival fiber attachment, preoperative.

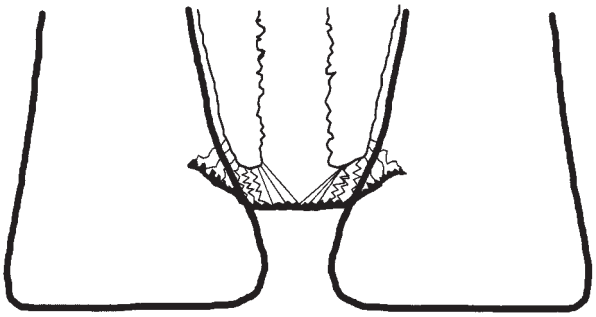


Fig 35. Alveologingival fiber attachment, symmetric fracture.

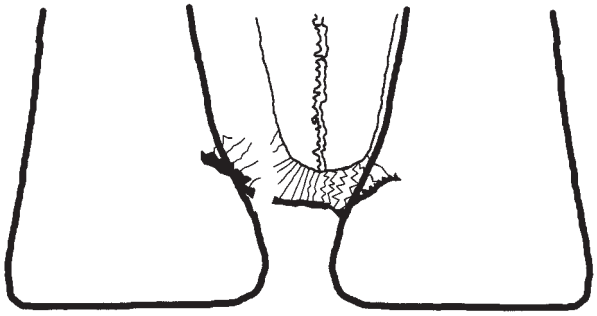


Fig 36. Alveologingival fiber attachment, asymmetric fracture.

seen every 3 days. Two years later the bone has filled in, and the gingiva is very healthy and the contours are normal (Fig 33).

DISCUSSION

Most cases requiring palatal expansion have anterior crowding with the roots of the central incisors closely approximated. Inadequate space to obtain equal separation at the midpalatal suture is usually encountered**.** If the resistance to separation at the median palatal suture between the central incisors is greater than the resistance of the facial and palatal bone of the mesial surface of either central incisor, the fracture will not occur symmetrically. It will fracture along the path of least resistance. This usually occurs mesial to the central incisor that is most procumbent and has minimal or no facial bone covering the root surface. This can readily be diagnosed immediately after the surgical procedure. The separation will be apparent between the mesial surface of the injured incisor and bone, not through the palatal suture. The radiopaque suture is usually easily seen on the preoperative radiograph. If the fracture is asymmetric, the suture will be seen on the segment of bone closest to the uninjured incisor. The radiopacity occurs between the root of the injured incisor and the area of bone that was previously adjacent to the mesial surface of the incisor.

Care must be exercised in the expansion process to insure that the attached gingiva remains healthy and intact around the injured incisor. If the gingiva is torn from the injured incisor, the epithelium can invaginate apically faster than the bone can regenerate coronally, and an osseous defect will ensue. There are four cell types involved in the healing of these defects: (1) epithelium, (2) connective tissue (CT), (3) bone, and (4) periodontal ligament. The cell kinetics are the basis for guided tissue regeneration (GTR). An excellent review on the subject was authored by Karring et al.[35] Epithelium is the fastest covering denuded CT/bone at a rate of 0.5 to 1.0 mm a day from all margins. This is the reason conventional periodontal surgery heals with long junctional epithelium. The barrier membrane in GTR blocks out epithelium and CT to allow for slower bone and PDL to enter the healing wound. Animal studies show that if the single cell type predominates the wound heals as follows: (1) epithelium..long junctional epithelium, (2)connective tissue...resorption, (3) bone...ankylosis, (4) periodontal ligament (with bone) as in GTR. Thus, if the gingiva is torn on a tooth that has had the bone removed from its root surface, epithelium grows unimpeded apically not allowing the proper healing kinetics. If the gingiva is intact under the same circumstance, then healing kinetics will be normal and the intact periosteum will be the source for new osteoblasts.

When granulation tissue derived from bone is allowed to migrate into contact with the root surface, you can expect ankylosis. If granulation tissue derived from gingival connective tissue contacts the root surface, root resorption is induced.[36,37] With an asymmetric split, the bone fractures along the long axis of the central incisor. As the fracture is opened by the

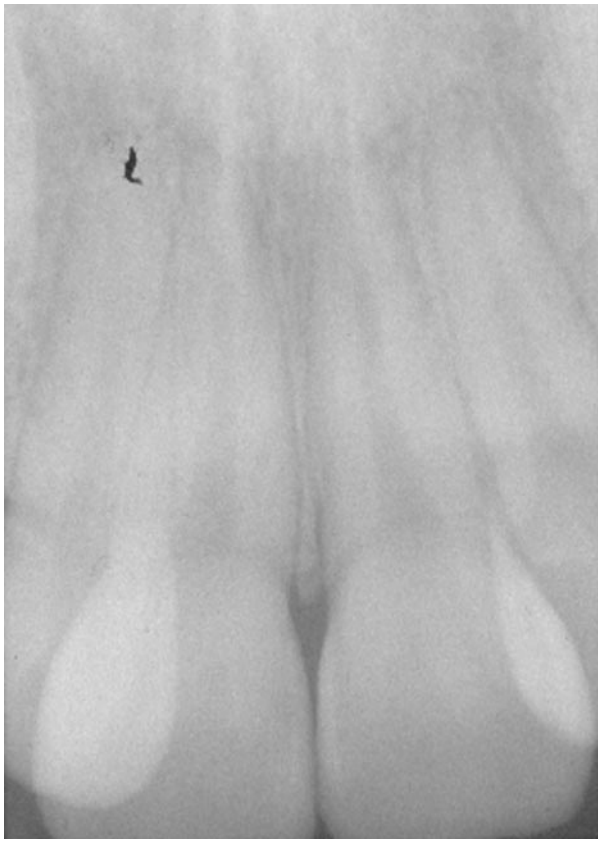


Fig 37. Pretreatment periapical radiograph.

Fig 38. Root divergence accomplished.

jackscrew, the root surface is in contact with gingival connective tissue along the entire length of the fracture line. Even without a tear in the gingiva exposing it to the oral environment, root resorption can occur as a result of connective tissue migrating along the denuded area of the root surface.

Alveologingival fibers originate from the alveolar crest and insert coronally into the lamina propria (Fig 33). When a symmetric separation through the palatal suture occurs, the fibers become overstretched near the center of the interdental papilla (Fig 34). After an asymmetric bony separation, the alveologingival fibers are overstretched near the gingival attachment on the mesial surface of the injured incisor (Fig 35). This places the mesial gingival attachment more at risk to detachment during expansion. The health of the attached gingiva surrounding the maxillary central incisor will determine the long-term prognosis of that tooth. It becomes critical to alter the expansion schedule when it is determined that an asymmetric fracture has occurred.

It is not known how long the expansion appliance can remain passive before the surgical sites heal. We have waited 2 weeks before initiation of expansion without untoward effects. Lines[5] performed adult rapid maxillary expansion with corticotomy before the rapid maxillary expansion appliance was cemented. He then waited 2 to 3 weeks before inserting and expanding the appliance to allow for the soft tissue to heal and reestablish blood supply.

PRESURGICAL PREPARATION

The orthodontist can reduce the likelihood of an asymmetric fracture by obtaining a preoperative periapical or occlusal radiograph of the central incisors. If there is inadequate space between the roots of the central incisors, brackets should be placed on these teeth as soon as practical and a small sectional wire (0.016 ss or 16 × 22 TMA) inserted to begin root divergence. This takes 3 to 4 months. It is possible that by diverging the roots of the central incisors, a tensile force is placed on the midpalatal suture making it more viable before the surgical separation. Periapical radiographs show a wider radiopaque suture area on those teeth treated by root divergence. Research needs to be done in this area to confirm this radiographic observation. The health of the gingiva is

Fig 39. Symmetric separation.

Fig 40. One year after surgical separation.

determined, and the teeth scaled if necessary. The patient is instructed on oral hygiene with emphasis on flossing. The gingiva between the central incisors should be extremely healthy before the surgical expansion. Finally, periodontal probing depths around the central incisors should be recorded in the patient's record.

The instructions to the oral and maxillofacial surgeon performing the procedure is simple and concise, "Activate the expansion appliance four one-quarter turns only during the procedure and do not activate the appliance again." The patient is to see the orthodontist in 7 to 10 days.

POSTEXPANSION EVALUATION AND TREATMENT

A periapical or occlusal radiograph is taken, and the symmetry of the bone is evaluated. The circumference of the central incisors are gently probed, and the pocket depths compared to presurgical values. Four outcomes are possible:

1. Symmetric bone on the mesial surfaces of both central incisors and the gingival attachment is intact, ie, the interdental bone was fractured through the palatal suture and equal bone exists on the mesial surfaces of both central incisors.
   - Activate the appliance one turn every day and evaluate weekly.
2. Symmetric bone on the mesial surfaces of both central incisors but the gingival attachment is poor.
   - Do not activate appliance until the gingiva is healthy.
   - Activate appliance one turn every other day and evaluate weekly.
3. Asymmetric bony separation with healthy gingival attachment.
   - Activate appliance one turn every other day and evaluate every 48 to 72 hours.
4. Asymmetric bony separation with poor gingival attachment.
   - Do not activate appliance until the gingiva is healthy.
   - Activate appliance one turn every other day and evaluate every 48 to 72 hours.

Patients should be instructed to very gently brush and floss the mesial surfaces of the central incisors and to refrain from using toothpicks or any other object that could cause detachment of the gingiva from the mesial surface of the central incisor.

CONCLUSIONS

Authors[5,9,38-40] have described postoperative expansion schedules that are accomplished entirely by the oral surgery department or expansion schedules that are begun by the oral surgery department and completed by the orthodontist. Recommended expansion rates vary from 1 mm per day to 0.25 mm every other day.

The expansion schedule should not be the same for every case. It should be tailored to the individual and adjusted appropriately depending on the symmetry of the bony fracture and most importantly, by the health of the gingival attachment.

The roots of the maxillary incisors should be diverged orthodontically before the surgically assisted expansion procedure to reduce the risk of the bone fracturing asymmetrically. A periapical or occlusal radiograph postoperatively will determine the need for this. If the bone has been fractured along the root surface instead of midpalatally, extra precaution must be used to prevent detachment of the gingiva from the injured incisor. The gingiva is more susceptible to detachment in this area because of the gingival fiber configuration. If a detachment occurs, the epithelium will invaginate and an osseous defect will result on the mesial surface of the injured root. After allowing the gingiva to heal from the surgical trauma (7 to 10 days) the orthodontist recommends an expansion schedule depending on the health of the gingiva and the symmetry of the bony separation. If an asymmetric fracture occurs the patient is seen at more frequent intervals so the health of the gingiva can be more closely monitored.

If a periapical or occlusal radiograph is taken before the surgical expansion procedure, and root divergence is accomplished, the likelihood of a symmetric interdental bony separation through the palatal suture increases dramatically allowing healthy bone regeneration without injury to the central incisors (Figs 36-39).

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