

23

Managing the Developing Occlusion

JEFFREY A. DEAN and JOHN S. WALSH

CHAPTER OUTLINE

Development of Occlusion and Timing of Interventions

Primate Spaces

Mesial Molar Shift

Leeway Space

Intervention Considerations

Early Loss of Teeth and Space Maintenance

Needs Assessment

Specific Tooth Loss Strategies

Oral Habits in Children

Bruxism

Non-Nutritive Sucking

Tongue-Thrust Swallowing

Anterior Crossbite in Primary and Mixed Dentitions

Tongue Blade/Popsicle Stick Therapy

Lower Inclined Plane

Palatal Spring Appliances (Removable Hawley or Fixed Palatal Wire)

Fixed Transpalatal Wires With Springs

Posterior Crossbite in Primary and Mixed Dentitions

Selective Equilibration

Maxillary Expansion

Eruption Problems and Eruption "Guidance"

Ectopic Eruption of First Permanent Molars

Eruption Guidance in the Lower Incisor Segment

Eruption Guidance in the Mandibular Canine And Premolar Segment

Eruption Guidance in the Maxillary Canine and Premolar Segment

Obstructive Sleep Apnea and Orthodontics

Comprehensive Orthodontics for the Developing Occlusion

Primary to Mid-Mixed Dentition (Ages 4–10 Years)

Mid- to Late Mixed Dentition (Ages 10–12 Years)

Early Permanent Dentition (Ages 12–16 Years)

The goal of every practitioner providing oral health care for children and adolescents should be to assess and guide the developing occlusion toward optimal outcomes. The Clinical Guidelines of the American Academy of Pediatric Dentistry¹ on "Management of the Developing Dentition and Occlusion in Pediatric Dentistry" illustrate this responsibility with the following statement:

Guidance of eruption and development of the primary, mixed, and permanent dentitions is an integral component of comprehensive oral healthcare for all pediatric dental patients. Such guidance should contribute to the development of a permanent dentition that is in a stable, functional, and aesthetically acceptable occlusion. Early diagnosis and successful treatment of developing malocclusions can have both short-term and long-term benefits while achieving the goal of occlusal harmony, function, and dental facial aesthetics.

Ngan et al.² illustrate this responsibility regarding contemporary practice in stating, "Pediatric dentistry has increasingly shifted from a conservative-restorative approach toward a concept of total pediatric patient care. Thus all aspects of oral health care including diagnosis, prevention, oral medicine, restoration, and correction of

malocclusion are increasingly the responsibility of the pediatric dentist." In the context of these statements, clinical decisions are presented daily that challenge pediatric practitioners in affecting outcomes in management of the developing occlusion. As defined by Moyers,³ space supervision is "when the judgment of the dentist determines that the individual patient's occlusion will have a better chance of obtaining optimum development through supervised intervention of the transitional dentition than without clinician directed intervention." Space supervision encompasses procedures such as preventive orthodontics, guidance of eruption, interceptive orthodontics, and phased "early" orthodontic treatment that should be understood in terms of its diagnostic parameters, treatment basis, and clinical applications.

Development of Occlusion and Timing of Interventions

PRIMATE SPACES

A review of studies by Baume,⁴ Moorrees,^{5,6} Bishara et al.,⁷ and Moyers and Wainwright⁸ provides an understanding

of the biogenetic course of the primary, transitional, and permanent dentitions that is critical to management of the developing dentition. Evaluating study models of the primary dentitions of 30 children obtained sequentially at various developmental stages, Baume⁴ reported two consistent morphologic arch forms of the primary dentition: either generalized spaces between the teeth were present (Type I) or the teeth were in proximal contact without spacing (Type II). The arch form in both types appears congenital rather than developmental because the original pattern exhibited upon eruption was maintained from ages 3 to 6 years. Spaced arches frequently exhibit two distinct diastemas—referred to as *primate spaces*—one between the mandibular canine and first primary molar and the other between the maxillary lateral incisor and primary canine. Baume⁴ observed that until the eruption of the permanent first molars, the sagittal dimension of the primary dental arches remained essentially unchanged, with the possible exception of a slight decrease as a result of the development of dental caries on the proximal surfaces of the molar teeth. Only minor changes in the transverse dimension of the primary dental arches occurred during 3–6 years of age unless negatively influenced by deleterious functional patterns. Given these findings, orthodontic intervention during the primary dentition up to 6 years of age is mostly directed toward maintaining inherent arch dimensions and arch integrity with preventive and restorative services. Space maintainers, when primary teeth are lost prematurely, are the next major consideration in maintaining arch dimensions. Control of functional problems such as elimination of deleterious thumb-sucking habits and correction of functional crossbites may also receive attention during the primary dentition years. While desirable, treatments for these factors are often deferred depending upon the cooperation of the child with appliance protocols.

MESIAL MOLAR SHIFT

The early mixed dentition (6–9 years of age) is a period much more prone to localized factors that may result in severe malocclusion problems if undetected. In addition to continuation of basic preventive and space maintenance issues, problems encountered during this period include dentoalveolar anterior crossbites, ectopic eruption of permanent incisors and/or first permanent molars, posterior crossbites, open bite and flared maxillary incisors associated with deleterious oral habits, and developmental anomalies (e.g., ankylosis, supernumerary teeth, and missing teeth). Baume⁴ compared models of 60 children before and after eruption of the permanent molars and found three distinct kinds of molar adjustment (Fig. 23.1). “Early” mesial shift during first permanent molar eruption occurs at the expense of any posterior spacing that might have been present to include breakdown spaces resulting from interproximal caries. Agreeing that the pattern of transition involving the straight terminal plane is normal, Moyers⁸ suggested that the occlusion forming a mesial step (distal surface of the lower second primary molar is mesial to the same surface of the maxillary molar) is most ideal for Class I development. A distal step (distal surface of the lower second primary molar is distal to the same surface of the maxillary molar) indicates a developing Class II malocclusion. Proper

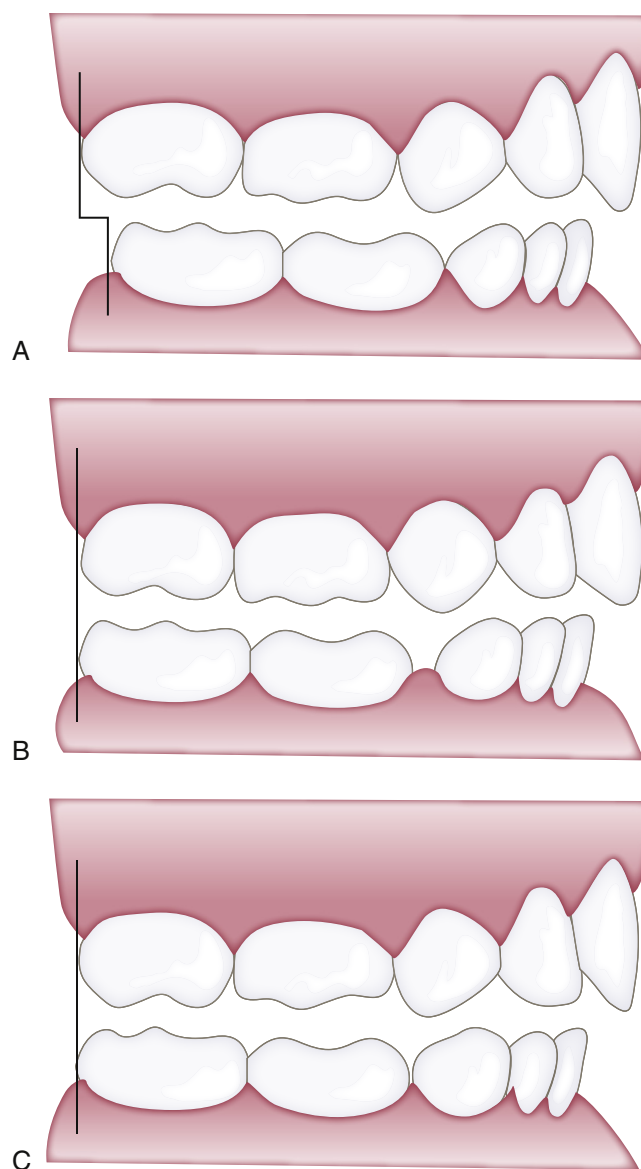


Fig. 23.1 (A) Diagram showing mesial step terminal plane that allows the first permanent molar to erupt directly into proper Class I occlusion. (B) Straight terminal plane with primary spacing. “Early mesial shift” of mandibular molars closing primary spaces will help establish proper first permanent molar occlusion. (C) Straight terminal plane without primary spacing. Permanent molars erupt into end-on position in the mixed dentition. Proper first permanent molar occlusion may be attained when the second primary molars exfoliate and a “late mesial shift” of the mandibular first permanent molar occurs.

permanent molar occlusion was achieved from a straight terminal plane by a second mesial shift of the molars as second primary molars are exfoliated. This “late” shift of the mandibular first molar, often under the additional influence of the emerging second permanent molar, occurs at the expense of the leeway space with a decrease in the attendant arch length of 2–3 mm on average.

Further evaluation by Baume⁴ indicated that a transverse widening of the intercanine width of the upper and lower dental arches occurred during eruption of the permanent incisors. The increase represented a physiologic widening by the lateral and frontal alveolar growth to provide space for the erupting permanent incisors and their greater

mesiodistal widths. The mean increase in the intercanine width was greater in the maxillary arch (3–4 mm) than in the mandibular arch (2–3 mm). In the mandibular arch, the greatest tendency to increased width was during eruption of the lower lateral incisors, whereas in the maxillary arch, it occurred primarily during eruption of the maxillary central incisors. Although the increase was slightly greater in nonspaced primary arches than in spaced arches, the arches with spaces generally resulted in a favorable alignment of the permanent incisors. About 40% of the arches without primary dental spacing resulted in crowded anterior segments. Moorrees⁵ reported similar dimensional changes concurrent with incisor transitional periods.

Bishara et al.⁷ also reported arch dimensional changes in their studies of patients from 6 weeks to 45 years of age, noting that (1) significant increases in the maxillary and mandibular arch width occurred between 6 weeks and 2 years of age; (2) the mandibular intercanine width was established by 8 years of age (i.e., after eruption of the four incisors); and (3) although the arch width increased between 3 and 13 years of age, there was a slight decrease in width, more in the intercanine than in the intermolar area, after complete eruption of the permanent teeth. In brief, incisor alignment patterns and intercanine arch dimensions are essentially established by 8 years of age. Interceptive procedures receive significantly more emphasis in this period to allow for a harmonious transition directed toward achieving alignment of the permanent incisors and 6-year molars with symmetric arch development and coincident midlines. Additionally, early recognition and elimination of deleterious oral habits or deviant functional patterns should enhance normal patterns of development while diminishing the long-term effects of atypical growth.

LEEWAY SPACE

In addition to malocclusion factors identifiable during the first molar and incisor transition, corrective measures to align and position the erupting buccal segments come into play during the late mixed dentition (9–12 years of age), when primary canines and molars are exfoliating in conjunction with eruption of the permanent canines and premolars. Epidemiologic studies demonstrate that crowding and malalignment become significantly more prevalent and exhibit greater severity between the mixed dentition period (6–12 years of age) and the adolescent young permanent dentition (12–18 years of age). This suggests that normal transitional changes do not compensate for anterior malalignment and crowding, in that the late mesial shift of the buccal segments upon exfoliation of second primary molars results in decreased arch length and arch circumference. Nance⁹ observed that in the average patient's mandibular arch, a leeway size difference of +1.7 mm per side exists, with the combined mesiodistal widths of the primary canine, first primary molar, and second primary molar being larger than the mesiodistal widths of the corresponding permanent canine and premolars. The difference between the total width of these same teeth in the maxillary arch is +0.9 mm per side of leeway space. Of interest is that Allen et al.¹⁰ found a statistically significant decrease in leeway space, from 2.45 to 2.03 mm, when comparing two similar cohorts of American whites born in

the 1930s versus the 1990s. They suggest that this 21st-century decrease may present a challenge when managing arch length inadequacies.¹⁰ The control of leeway space in terms of arch dimensional change through space supervision may offer opportunities for significant improvement in tooth size–arch size adjustments for the relief of typical levels of crowding. Gianelly^{11,12} has shown that the control of leeway space will accommodate typical levels of lower incisor crowding in approximately 75% of mixed dentition patients presenting for orthodontic treatment. As applied to the late mixed dentition, a positive excess leeway space to an overall deficiency of less than 2 mm per quadrant may be considered potential situations for space supervision programs. However, there is a drawback; Sonis and Ackerman¹³ have shown a significant increase in the mandibular second permanent molar impaction with this approach when compared with historic controls. There is a positive predictive value for such impaction in measurement of the pretreatment intermolar angulation between the first and second permanent mandibular molars. Finally, lower arch length deficiencies of more than 2–3 mm per quadrant should be considered a discrepancy beyond simple guidance procedures.

In keeping with supervision of leeway space as a fundamental concept, the vast majority of patients should be evaluated around the time of the clinical emergence of the lower canines and the lower and upper first premolars. These teeth erupt about 1 to 1½ years ahead of the final buccal segment transition. This leaves time for the practitioner to assess overall dimensional needs and plan treatment interventions for the relief of crowding, manage space to minimize future permanent tooth extractions, coordinate the transverse widths of the dental arches, and guide teeth into favorable positions that provide more stable long-term results. A second advantage for this timing in diagnosis and treatment planning is that it precedes the pubertal growth spurt in females, which in turn is approximately 2 years ahead of the pubertal growth spurt in males. If a skeletal malocclusion is noted, the opportunity for growth modification with dentofacial orthopedics, to take advantage of peak growth velocities, is available. Consultation with an orthodontist is helpful for children in whom skeletal considerations, severe growth problems, extensive crowding with pronounced tooth mass–arch length discrepancies, and dental anomalies are present that significantly compromise the child's orofacial development. Coordination will lead to more accurate identification of problems, aid in appropriate treatment decisions, and offer the potential for optimal results without having to resort to compromised treatment options in the full permanent dentition. Psychological aspects of treatment in terms of patient motivation, improved and dramatic dentofacial change, a social desire for treatment, and generally cooperative age group result in improved well-being for the child, and parents are good practice builders with timely coordinated management.

INTERVENTION CONSIDERATIONS

One should recognize that certain disadvantages involved in “early” treatment must be factored into the equation on whether to intervene in an individual patient. These include: (1) the reality that overall treatment time is likely

prolonged; (2) multiple problems often arise in individual patients; (3) untoward responses may occur given the variability of growth dynamics; (4) there is potential for iatrogenic damage to the developing teeth; (5) some children cannot cope with treatment demands; and (6) patient and parent burnout can occur given that overall management is rarely a one-shot operation. Parents must have realistic perspectives of treatment goals and be willing to assume the financial and appointment obligations involved in treatment. While things happen slowly during the development of the occlusion, timing is critical for certain procedures, in that there are many problems that can occur and jeopardize successful outcome. In the decision-making process for an individual patient, the clinician involved in early orthodontic procedures should ask two key questions, each with its own subset of questions:

1. *What is the specific problem?* How did it happen? Is the etiology resolved? What will happen without treatment? Will it stay the same, get worse, or go away on its own? Simply put, not every child can or should be treated with interceptive procedures. Roughly half of patients fall into an area of real or absolute need in requiring corrective treatment for functional and aesthetic problems that will potentially lead to deterioration of the occlusion if untreated. Even though some children may benefit from interceptive treatments, there should be understanding that later comprehensive treatments will most likely be necessary to achieve acceptable results.
2. *What will the likely result of interceptive treatment be?* The remaining estimate of up to 50% of children is the population group that might benefit from early orthodontic interventions in the developing occlusion years. This group involves malocclusion factors in which treatment intervention will potentially eliminate or minimize the need for future orthodontic treatment. At the least, interceptive treatments should enhance long-term treatment options and outcomes without compromising future needs. So a subset of questions should be asked. Is treatment justified in terms of improvement in aesthetics and function while eliminating or minimizing the need for future treatment? Will the intervention correct a problem at the optimal time to enhance later options and outcomes? Can treatment methods be used to advantage such that the skill and experience of the clinician intersect with patient needs? Does treatment meet socioeconomic issues? Does the treatment present an outcome that can be easily realized in conjunction with later comprehensive care that will be required anyway?

For these questions to be answered, a thorough clinical examination supported by appropriate diagnostic records should be obtained before treatment interventions are initiated. The clinical examination should assess the patient's overall health status, extraoral facial patterns (profile, facial symmetry, and area of discrepancy), occlusion from an aesthetic and functional standpoint, temporomandibular joint function, neuromuscular patterns, growth patterns, and nasopharyngeal airway patterns. A form similar to the one depicted in [Fig. 23.2](#) is helpful in composing clinical findings and formulating the patient's diagnosis, problem list, and treatment plan summary. In terms of diagnostic records beyond clinical findings, necessary records may range from

simple photos or study models for the treatment of a functional posterior crossbite to a complete set of orthodontic records for a patient with a skeletal malocclusion or severe crowding. More comprehensive records may include an eight-film series of extraoral and intraoral photographs, orthodontic study models, a full-mouth series or panoramic radiographs, lateral and anteroposterior cephalograms, and, when indicated, temporomandibular diagnostic views such as corrected axis tomograms or magnetic resonance imaging. Supplemental diagnostic procedures can also include a detailed tooth size–arch size space analysis ([Chapter 20](#)) and a cephalometric analysis ([Chapter 21](#)). Finally, cone beam computed tomography should be considered in special cases, such as patients with impacted teeth or craniofacial anomalies.

Early Loss of Teeth and Space Maintenance

If arch integrity is disrupted by early loss of primary teeth, problems may arise that affect the alignment of the permanent dentition. Opposing teeth can supraerupt, more distal teeth can drift and tip mesially, and more forward teeth can drift and tip distally ([Figs. 23.3 and 23.4](#)). Altered tooth positions may include a “symptomatic” space deficiency with loss of arch length and circumference, blocked or deflected eruption of permanent teeth, unattractive appearance, food impaction areas, increased caries and periodontal disease, and other negative aspects of malocclusion. The altered occlusal relationships may evidence traumatic interference and untoward jaw relationships. When early primary tooth loss occurs, corrective measures such as passive space maintenance, active tooth guidance with space regained, or a combination of both may be needed to optimize the normal process of occlusal development.

Miyamoto et al.¹⁴ observed the effects of the early loss of primary teeth by measuring crowding and malalignment in the permanent dentition of 255 schoolchildren aged 11 years or older. Children who had premature loss of one or more primary canines or molars were more likely to receive orthodontic treatment in the permanent dentition, with the need being more than three times greater in children who had lost one or more primary teeth through 9 years of age than in the control group. Premature loss of primary molars was especially associated with major malalignment of permanent teeth. No differences were observed in effects between the loss of first and second primary molars. Crowding of anterior teeth was directly affected by the premature loss of primary canines.

NEEDS ASSESSMENT

A review of the clinical literature by Owen¹⁵ revealed the following general factors that should be considered in assessing the implications of premature loss of primary teeth for arch development, the development of a malocclusion, and the need for a space maintainer.

1. *Incidence of space loss:* Almost all cases of early primary molar loss show some decrease in arch length (i.e., mesial movement of permanent molars, distal movement of

4. Attach computerized cephalometric tracing and appropriate analysis.

5. Diagnostic and Arch Length Analysis Summary and Problem List

6. Treatment Plan or Objective Sequence

7. Mechanics Plan—Appliance Selection—Retention

8. Projected Treatment Time (with Good Compliance), Treatment Fees

9. Faculty Authorization to Start Treatment:

Signature

Date

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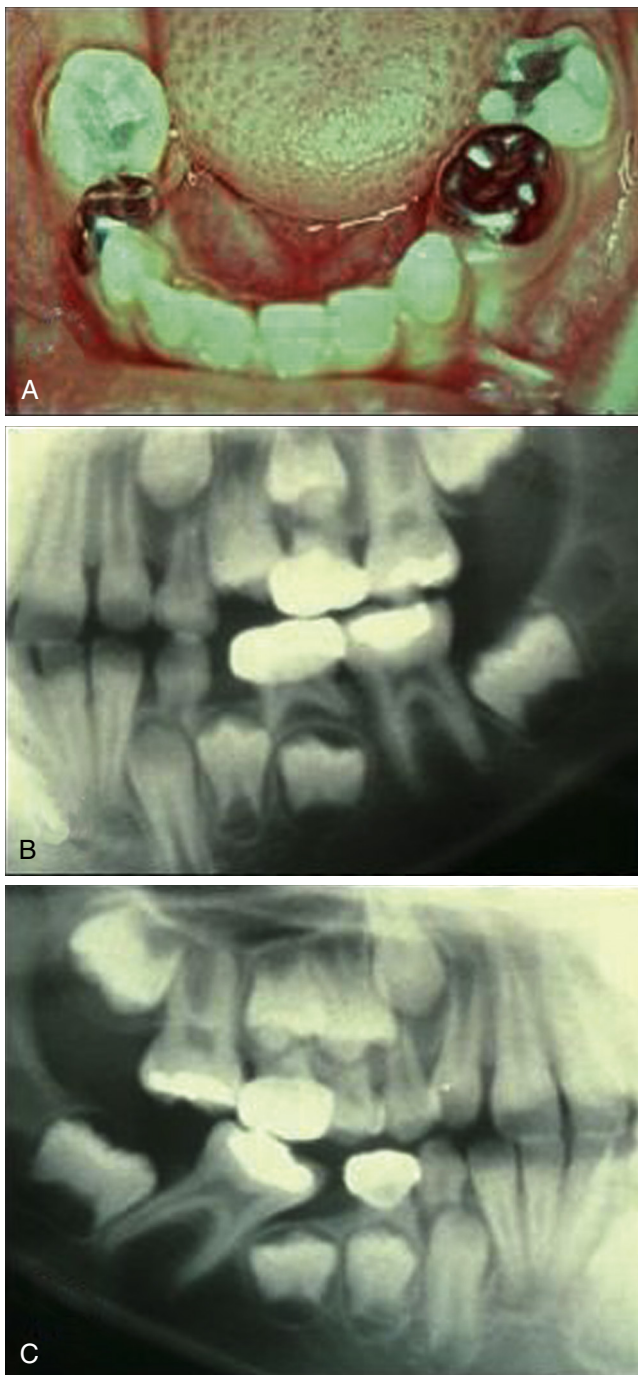


Fig. 23.3 (A) Space loss and occlusal changes associated with early loss of lower primary molars. (B) Radiograph of left segment with loss of first primary molar. Note some distal movement of primary canine. (C) Radiograph of right segment with loss of mandibular second primary molar and associated space loss approximating 4–6 mm. Note the pronounced mesial tipping of permanent first molar crown without notable bodily movement.

anterior teeth). The amount of closure is affected by numerous variables (e.g., tooth involved, time of loss).

2. *Time elapsed since loss:* Most of the space loss usually occurs during the first 6 months after the primary tooth is lost, and space closure tends to occur more rapidly in the maxillary arch than in the mandible. Thus when a primary tooth is removed and factors indicate the need

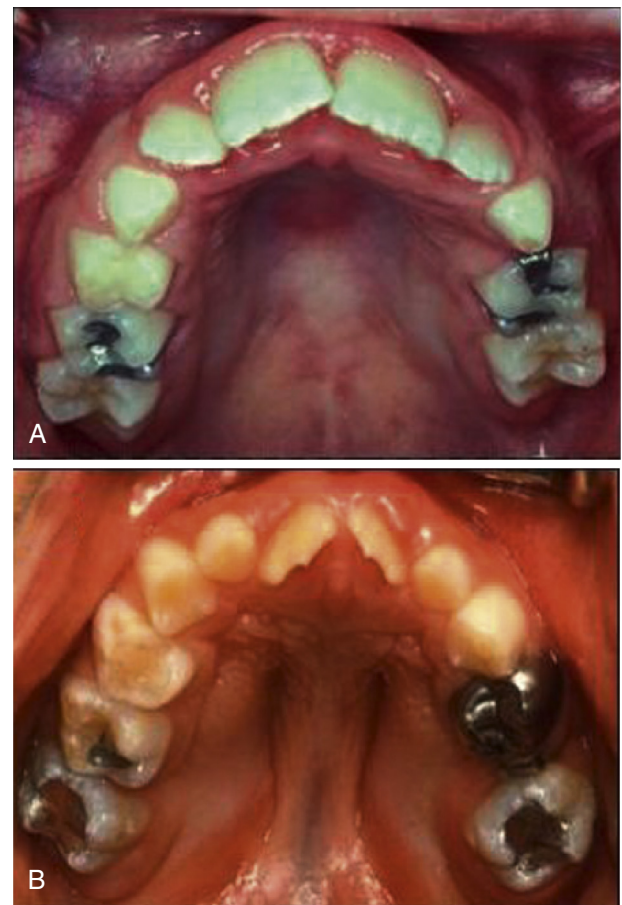


Fig. 23.4 Loss of upper primary molars in association with the eruption of first permanent molars and space loss. (A) Loss of upper left first primary molar with space loss approximating 4–6 mm. (B) Loss of upper left second primary molar with space loss approximating 6–8 mm. Note the rotation of first molar in conjunction with more bodily movement.

for space maintenance, it is best to insert an appliance as soon as possible after the extraction.

3. *Stage of development/dental age of the patient:* In general, more space loss is likely to occur if teeth are actively erupting adjacent to the area left by the premature loss of the primary tooth. Significant space loss is most influenced by the stage of eruption of the first permanent molars, with the potential particularly high if a primary molar is lost just before or during eruption of the first permanent molars. The amount of space closure is usually less if the permanent molars are fully erupted into occlusal interdigitation at the time of primary tooth loss. A similar situation exists if the first primary molar has been lost prematurely and the permanent lateral incisor is in an active state of eruption. The eruption of the permanent lateral incisor may result in distal movement of the primary canine and encroachment on space available. This condition is frequently accompanied by a shift in the midline toward the area of the loss. In the mandibular arch, a lingual “collapse” of the anterior segment may occur, with a resulting increased overbite. Another factor is in terms of available abutments for securing a space maintainer at the time of the primary tooth loss. A second primary molar lost at 5 years of age requires different abutment considerations than one lost during

the mixed dentition when first permanent molars have erupted. Also, teeth actively erupting adjacent to the edentulous area have a greater effect on the amount of space lost than do fully erupted teeth. For example, if the first primary molar is lost during the time of active eruption of the first permanent molar, a strong forward force will be exerted on the second primary molar that causes it to tip into the space required for eruption of the first premolar. Changes may extend anteriorly with shift of the dental midline and retrusion of the anterior segment after early loss of a first primary molar.

4. *Amount of space closure:* Loss of maxillary second primary molars results in the greatest amount of closure—up to 8 mm of space loss in a quadrant (Fig. 23.4B). Loss of mandibular second primary molars shows the next greatest amount—up to 4 mm in a quadrant (Fig. 23.3A and C). Loss of upper or lower first primary molars shows almost equal amounts of space closure when compared with one another; the amount is most affected by timing of the first primary molar loss (Fig. 23.4A). Space loss potential is particularly high if the primary molar loss occurs in approximation to first permanent molar eruption, irrespective of which primary molar is lost and in which arch the loss occurs. After the first permanent molars have erupted into occlusion, loss of second primary molars may still result in significant space closure. Loss of the first primary molar with retention of the second primary molar shows minimal amounts of space closure because the second primary molar serves to buttress the first permanent molar positions after occlusion is established.
5. *Direction of closure:* Maxillary posterior spaces close predominantly by mesial bodily movement and mesiolingual rotation around the palatal root of the first permanent molars. Only minimal mesial crown tipping of the first molar is usually noted. In contrast, mandibular spaces close primarily by mesial tipping of the first permanent molars, along with distal movement and retroclination of teeth anterior to the space (Fig. 23.3C). Bodily movement of first molars is not typically notable in the lower arch as seen in the upper arch. Lower molars also tend to roll lingually in conjunction with their mesial crown tipping during space loss movements.
6. *Eruption timing of permanent successors:* On evaluating the emergence of permanent teeth, Grøn¹⁶ found that teeth normally erupt when three-fourths of the root is developed, regardless of the child's chronologic age. However, the eruption timing of a permanent successor may be delayed or accelerated after premature loss of a primary tooth depending on the developmental status, bone density of the area, and nature of the primary tooth loss. Very early loss before significant root formation of the permanent successor usually results in delayed eruption timing that may alter normal transitional adjustments in the arch length, arch width, and arch circumference. Several studies have indicated that loss of a primary molar before 7 years of age leads to delayed emergence of the succedaneous tooth, whereas loss after 7 years of age leads to early emergence. The magnitude of any timing change in eruption is affected by age at the time of tooth loss. If a primary molar is lost

at 4 years of age, the emergence of the premolar could be delayed by as much as 1 year, with emergence occurring at root completion. If the loss occurs at 6 years of age, a delay of about 6 months is more likely, with emergence seen when root development approaches completion. Primary tooth loss within 6 to 12 months of normal exfoliation time may result in acceleration in eruption timing of the underlying permanent tooth. Individual permanent teeth are often observed to be delayed in their development and, consequently, in their eruption timing. Impacted permanent teeth or deviations in eruption paths may be reflected in abnormally delayed eruption times. In such cases, it is generally necessary to extract the primary tooth, construct a space maintainer, and allow the permanent tooth to erupt and assume its normal position (Fig. 23.5). The exact timing of permanent tooth eruption is less important in overall occlusal development compared with its greater significance relative to sequencing, site of eruption, and adequate space for subsequent eruption.

7. *Amount of bone covering the nonerupted tooth:* Prediction of eruption based on the timing of primary tooth loss and stage of root development is not reliable if the bone covering the permanent tooth has been destroyed by infection. Emergence is then usually accelerated. If there is bone covering the tooth, it can be predicted that eruption will not readily occur. A guide is that premolars usually require about 4–6 months to move through 1 mm of bone, as measured on bitewing radiographs.
8. *Abnormal oral musculature:* Strong mentalis muscle patterns may have a pronounced negative effect after the loss of mandibular primary molars or canines, with collapse of the arch and the distal drifting of the anterior segment that is often exhibited. Thumb or finger habits may similarly produce abnormal forces in initiating collapse of the dental arches after untimely loss of primary teeth.
9. *Congenital absence of the permanent tooth:* Before space maintenance, the presence of a normal successor must be ensured before space maintenance through radiographic evaluation. Should the succedaneous tooth be congenitally absent or significantly malformed, it is challenging to decide whether to hold the space for many years until a permanent prosthesis can be provided or to allow space closure with the likelihood of orthodontic treatment to achieve proper alignment.

When utilized, a space maintainer must fulfill the fundamental role of preventing untoward mesial migration of buccal segments and lingual collapse of anterior segments in maintaining the mesiodistal dimensions of the prematurely lost primary tooth. The appliance should neither interfere with masticatory function nor inhibit/deflect normal growth changes. It should be simple to construct and maintain; durable, strong, and stable; passive in not imposing pressures on remaining teeth that might affect orthodontic movements; and easily cleanable without enhancing dental caries or soft tissue pathology. Beyond these fundamental roles, space maintainers may be designed to prevent supraeruption of teeth opposing the space, improve a esthetics, and assist in speech (i.e., anterior space maintainers in control of oral habits).

When a primary tooth is lost prematurely, a space maintainer need not be automatically necessary or desirable.

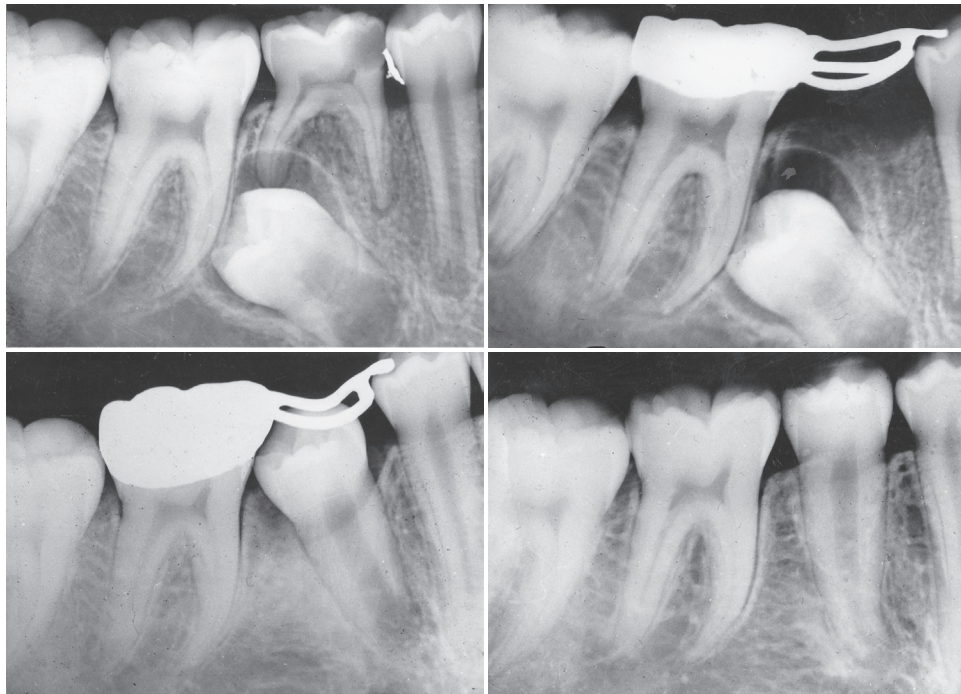


Fig. 23.5 Extraction of the second primary molar and space maintenance were indicated because of prolonged retention of the primary tooth and impaction of the second premolar. The second premolar eventually erupted into its normal position.

The decision to place a space maintainer and the choice of design to use are affected by the following: the specific tooth that was lost, from which arch, at what time, whether the permanent successor is present and developing normally, the patient's overall oral health status and motivation, and the status of existing arch length to accommodate the permanent teeth. If analysis indicates a positive arch length or deficiency of less than 1–2 mm per quadrant, a space maintainer may be beneficial in holding tooth positions. If the space is not held, the total arch length may be further decreased and lead to possible premolar extraction requirements. Holding the space may allow the permanent premolars and canines to erupt and utilize leeway space to alleviate anterior crowding. However, if the arch length deficiency is 2–3 mm or more per quadrant, a significant discrepancy exists where space regaining, serial extraction, and/or comprehensive orthodontic treatment may be indicated. If there is no question that permanent teeth will have to be removed to obtain a favorable occlusion, space maintenance may not be desirable because the space would need to be closed during orthodontic treatment anyway. In less obvious extraction cases, holding the space to allow teeth to erupt and prevent impactions can be a valuable service. As related to the premature loss of specific primary teeth, the arch involved, and developmental timing, the following recommendations are made with regard to placement and design of space maintainers.

SPECIFIC TOOTH LOSS STRATEGIES

Loss of Primary Incisors

Early loss of lower primary incisors is generally due to ectopic eruption of the permanent incisors in reflecting excessive incisor liability. Given the potential for increased

intracanine width during permanent incisor eruption, the clinician should monitor development in the lower incisor area and generally not intervene. Individual circumstances may indicate extraction of the antimere primary incisor to enhance incisor positioning and midline symmetry. The loss of lower incisors in other circumstances, such as trauma, advanced caries, or extraction of a neonatal tooth, may result in anterior space loss if it occurs before primary canine stabilization is realized.

Premature loss of maxillary primary incisors does not generally result in decreased upper intracanine dimensions if the incisor loss occurs after the primary canines have erupted into occlusion at approximately 2 years of age. The support of the mandibular occlusion “holds” the maxillary anterior intracanine width dimensions. Baume type I spaced primary dentitions have significant latitude to resist arch dimensional changes. If the anterior primary teeth were in contact before the loss or there is evidence of an arch length inadequacy in the anterior region, space adjustments in alignment after the loss of one of the primary incisors is a potential factor in space maintenance (Fig. 23.6). The major consequence of early loss of maxillary primary incisors is most likely delayed eruption timing of the permanent successors as reparative bone and dense connective tissue cover the site. In addition, unattractive appearance and potential development of deleterious habits (e.g., tongue-thrust swallow, forward resting posture of the tongue, improper pronunciation of fricative sounds such as “s” and “f”) may be of concern following premature loss of primary maxillary incisors. An anterior appliance incorporating artificial primary teeth may be considered to satisfy aesthetic and functional needs. Acrylic partial dentures have been successful in the replacement of single (Fig. 23.7) and multiple (Fig. 23.8) maxillary primary incisors. Given the demands of cooperation in wear and frequent appliance

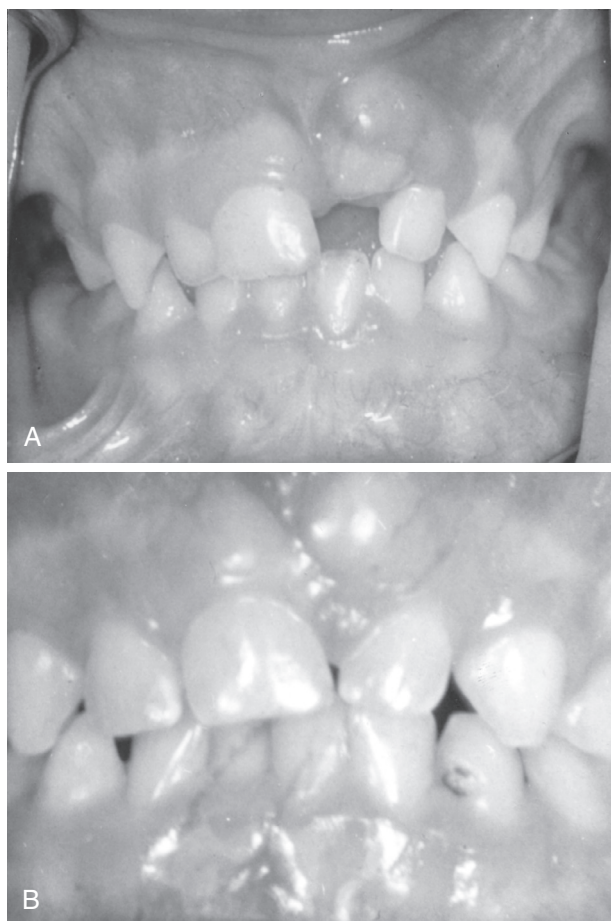


Fig. 23.6 (A) Child with some loss of space in the primary incisor area that was observed at the time of the first examination. (B) Space closure continued and was accompanied by drifting of teeth throughout the anterior area, including the canines.

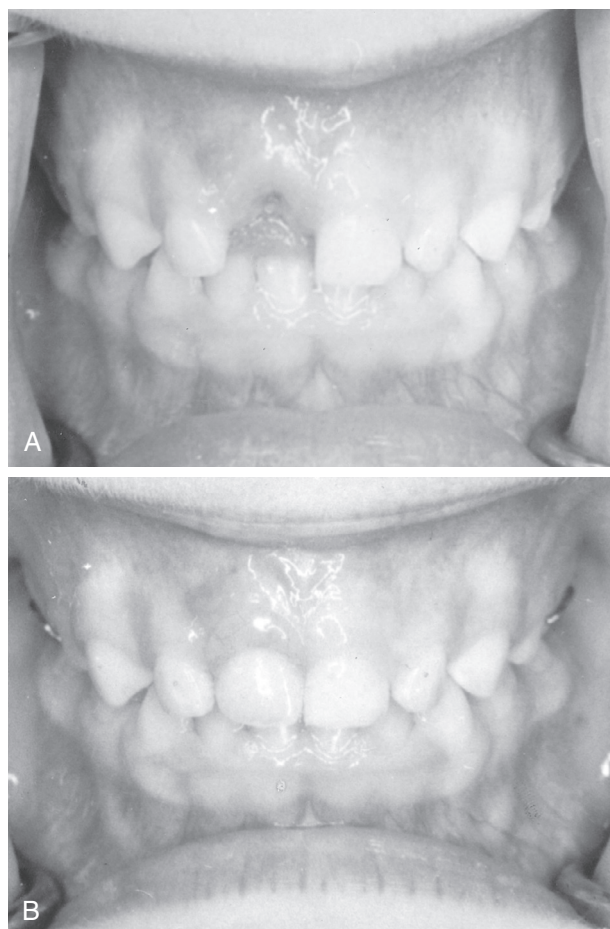


Fig. 23.7 (A) This 3½-year-old child has lost a primary incisor as the result of trauma. (B) A removable palatal retainer with a primary central incisor pontic has been constructed to prevent space closure and to restore normal appearance.

loss or damage, such removable appliances can be problematic in preschool-aged children.

A fixed option using primary incisor denture teeth secured from a rigid stainless-steel wire (0.036 or 0.040 inch) extended to bands or stainless-steel crowns on the primary molars, a so-called “Hollywood” bridge, may be a more predictable option (Fig. 23.9). One can obtain additional stabilization in keeping the wire from flexing by placing an occlusal rest on the first primary molar, using a Nance button, or by covering the ridge with acrylic resin. Use of such an appliance incorporating artificial primary anterior teeth is an option for addressing primarily aesthetic demands rather than specific space or functional management concerns.

Loss of Primary Canines

Most often due to ectopic eruption of permanent lateral incisors, early loss of a mandibular primary canine is a significant indicator of a tooth size–arch size discrepancy. Unilateral loss of a lower primary canine is frequently followed by a shift in the dental midline toward the side of loss, lingual collapse of the incisor segment, and possibly deepening of the bite (Figs. 23.10A and B). The asymmetric disruption in arch integrity complicates normal eruption of the permanent canines and premolars toward the affected side.

If ectopic eruption involves bilateral loss of both the lower primary canines, pronounced lingual inclination and distal drifting of the permanent incisors, deepening of the overbite, increased overjet, and significant loss of arch perimeter are likely to be the alignment results (Fig. 23.10C and D).

If one primary canine is lost during incisor eruption, it may be desirable to extract the contralateral primary canine to help maintain arch symmetry. Although extraction of the contralateral primary canine may improve the appearance of incisor alignment and midline integrity, crowding problems requiring such intervention strongly indicate a significant arch length deficiency that will likely become grossly evident upon permanent canine and premolar eruption. Some clinicians recommend a lingual holding arch with spur attachments to control incisor positioning and prevent encroachment on permanent canine eruption positions when primary canines are lost prematurely. Even though this may be feasible in some cases, the asymmetric positioning and displacement of the incisors typically contradict simple placement of a lingual holding arch at this stage without first aligning the incisors with active appliance therapy. The inherent questionable prognosis relative to arch length–tooth size considerations brings into question simple appliance therapy at this point in development. Regardless of the individual decision, the prognosis related

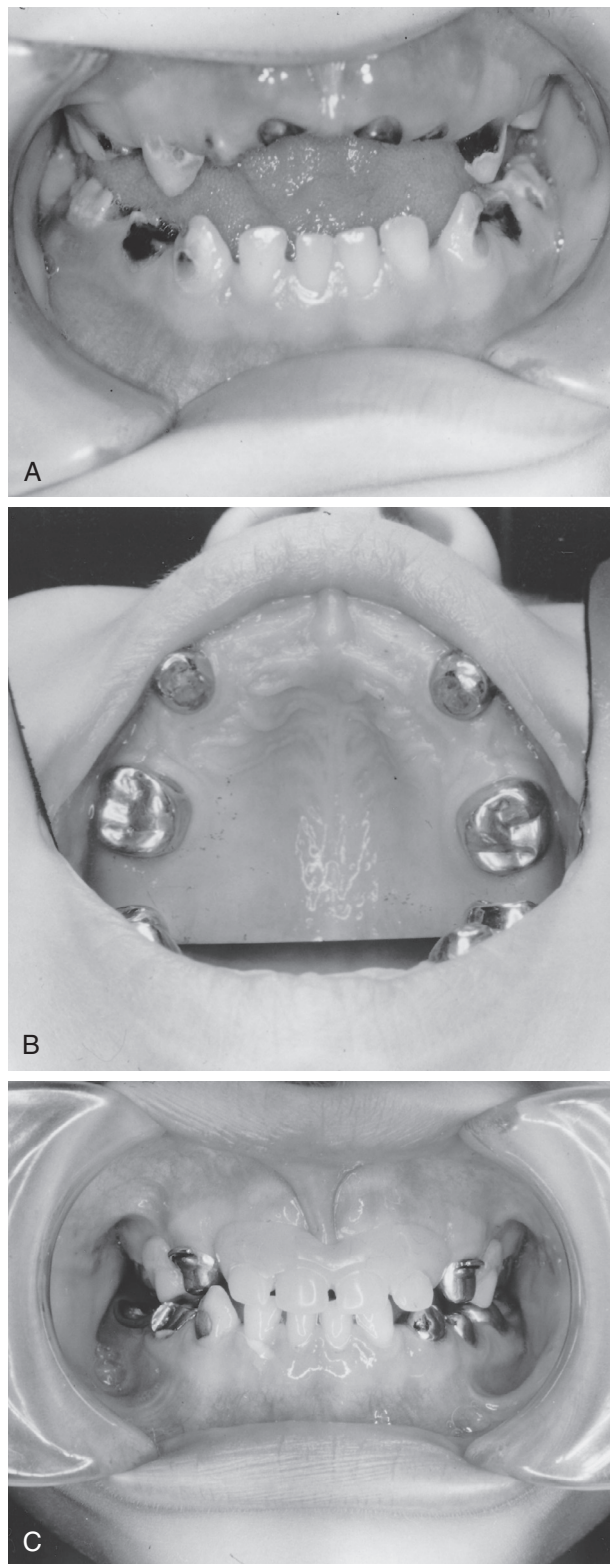


Fig. 23.8 (A) This 4-year-old child required removal of nonrestorable maxillary primary incisors and first primary molars. (B) Stainless-steel crowns were placed on the primary canines and second molars. (C) A maxillary removable partial retainer with incisor pontics maintains space, improves appearance, and reduces the possibility of a tongue thrust.

to ectopic loss of primary canines is generally not good concerning the status of long-range occlusion.

The ectopic loss of maxillary primary canines occurs less frequently than does mandibular loss, given more favorable space adjustments for incisor liability. When it occurs, the ectopic loss of a maxillary primary canine typically reflects a very distal eruptive displacement of the permanent lateral incisor and not necessarily a significant tooth mass problem. Atypical upper anterior alignment may occur, with resultant crowding and blockage of the permanent canine because it erupts so late in normal transition. Early loss of maxillary primary canines is an indicator for early orthodontic treatment with an understanding that the child is a definite candidate for comprehensive orthodontic intervention.

Loss of First Primary Molars

The effect of premature loss of first primary molars in both arches is mostly dependent on the state of eruption of the first permanent molars. If the primary first molar is lost during the primary dentition from 3 to 5 years of age, there should be little or no space loss associated with mesial movement of the second primary molar. However, as first permanent molars erupt from 5 to 7 years of age, a strong force is exerted that pushes the second primary molar forward into the first primary molar space (Fig. 23.3B). This results in a loss of posterior arch length within the quadrant that can lead to crowding as the canines and premolars erupt in later stages. In addition to posterior effects, the mandibular arch length may be further compromised by distal and lingual shifting of anterior teeth toward the side of first primary molar tooth loss. Therefore the loss of a first primary molar in either arch, approximating eruption of first permanent molars, indicates that the use of a space maintainer is generally desirable to stabilize second primary molar and canine positioning.

If the first primary molar is lost after first permanent molars have erupted into occlusion and the second primary molar is still in position, minimal space loss should be evidenced in either arch. This is particularly applicable when the first permanent molars are positioned in a full Class I or Class II cuspal interdigitation. If the first permanent molars are in an end-to-end relationship, the location, by arch, of the missing first primary molar may be a factor in potential molar adjustments. If the first primary molar loss occurs in the upper arch, untoward shifting from the end-to-end occlusion may result in Class II molar positioning. To ensure that this does not happen, a space maintainer for the upper arch may be considered. If the first primary molar loss occurs in the lower arch, any molar shift would be in the direction of a Class I relationship. Space maintenance would be less likely unless absolute preservation of leeway space was indicated until permanent canines and premolars erupt.

A unilateral fixed space maintainer called a *band or crown and loop* is usually the appliance of choice for early loss of first primary molars (Video 23.1). The appliance incorporates a band or crown on the second primary molar with a soldered wire-loop extension extending forward to come into contact with the distal-cervical surface of the primary canine in the

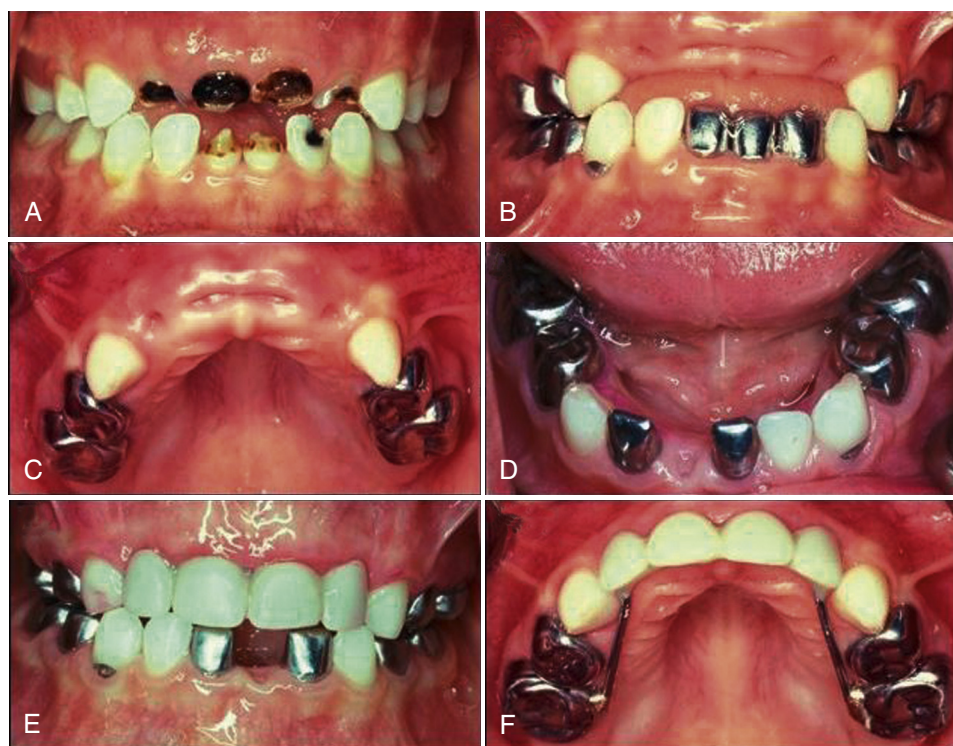


Fig. 23.9 Early loss of maxillary primary incisors in a 4½-year-old child. (A) Pretreatment caries with nonrestorable maxillary primary incisors. (B), (C), and (D) Postrestorative appearance with multiple stainless-steel crowns. While interdigitation should hold anterior intercanine space, the parents and patient requested cosmetic incisor replacement. (E) and (F) A fixed space maintainer with a “Hollywood” bridge fulfills aesthetic demands as an elective treatment. Appliance used one-size-larger crowns fitted over restorative crowns on second primary molars as abutments.

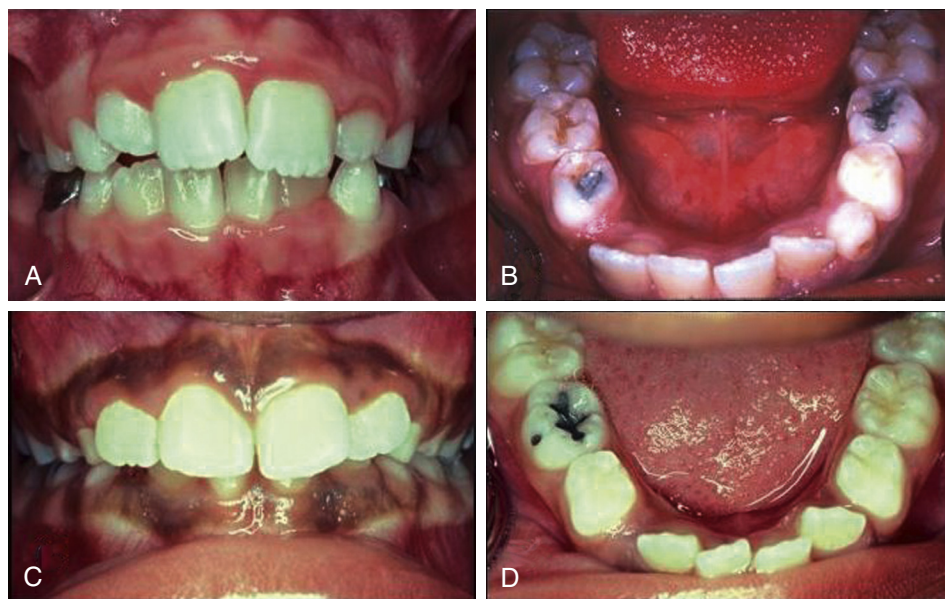


Fig. 23.10 Ectopic loss of lower primary canines in association with permanent lateral incisor eruption. (A) and (B) Unilateral canine loss results in asymmetric arch dimensions as the incisors shift toward the side of loss and lingualize their positioning. (C) and (D) Bilateral ectopic loss of canines allows for maintenance of arch symmetry, but results in significant lingual retroclination and supraeruption of lower incisors, increased overjet, deepened overbite, and reduction in lower arch dimensions.

quadrant (Fig. 23.11). The loop uses 0.036- or 0.040-inch stainless-steel wire strong enough to withstand biting forces while ensuring a rigid abutment contact in stopping forward movement of the second primary molar and distal movement of the primary canine. Wire design approximates the gingival contour of the extraction space to avoid occlusal

interference and is wide enough to allow the permanent tooth to erupt. A modification of the design is use of a single-wire extension “arm” rather than a full loop from the posterior abutment to come into contact with the anterior abutment (Fig. 23.12). The single arm of a 0.036- or 0.040-inch stainless-steel wire is rigid enough to hold the space while reducing

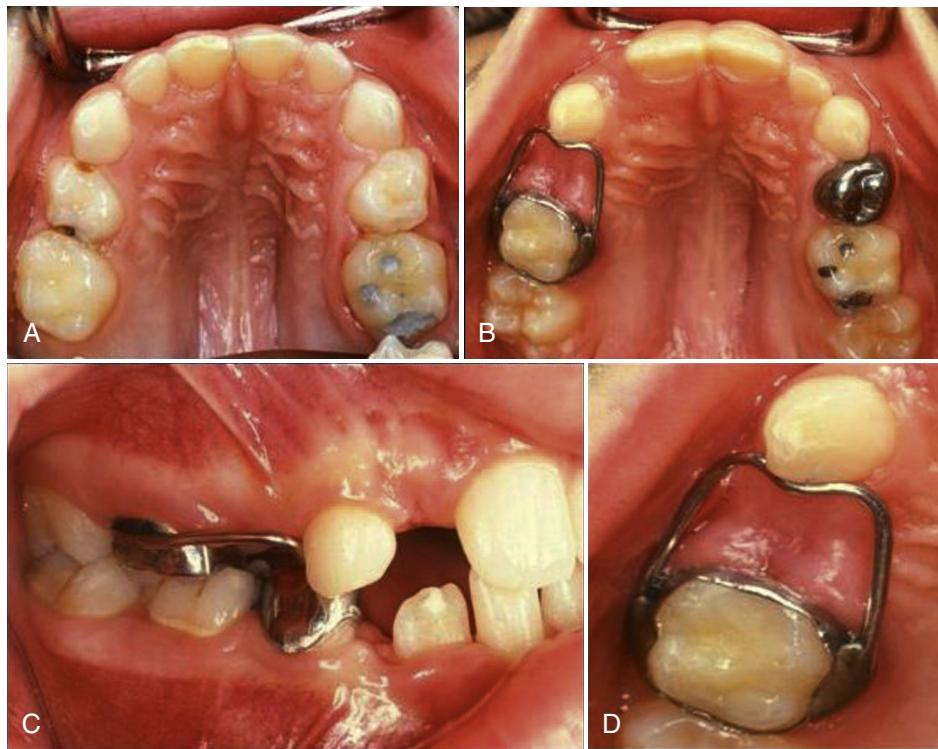


Fig. 23.11 (A) and (B) Pretreatment at 4½ years of age and follow-up at 7 years showing value of properly fitted and designed band-and-loop appliance to hold space for an extracted first primary molar. (C) Buccal occlusion showing proper relationship of erupted first permanent molars. (D) Close-up of design shows that loop is sufficiently large to allow for the eventual eruption of the permanent tooth.

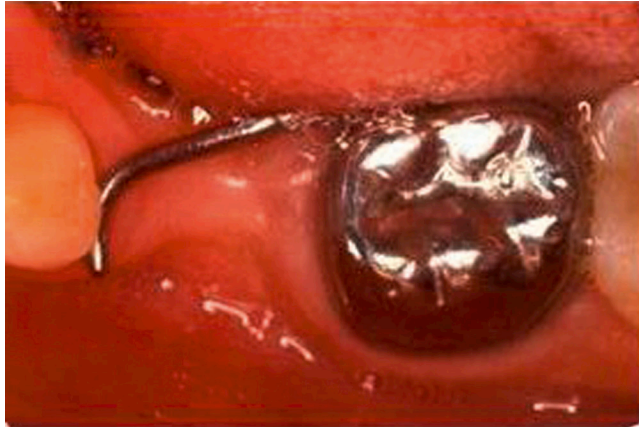


Fig. 23.12 Close-up of unilateral crown and arm space maintainer.

by half possible interference with eruption of the underlying tooth. Neither the loop nor the arm design restores chewing function or prevents eruption of opposing teeth, a possible consideration in some cases. Furthermore, the wire may inhibit primary canine distolateral movement as permanent incisors erupt, particularly in association with lower lateral incisor eruption. Therefore, the status of permanent incisor eruption sequencing, symmetry, and positioning should be monitored and guidance steps taken to optimize normal incisor eruption.

Video 23.1 Space Maintenance: fabrication of immediate band and loop

The use of a band as the abutment attachment makes it easy and economical to construct, takes little chair time, and adjusts readily to accommodate the changing

dentition. The use of a stainless-steel crown as the abutment base (Fig. 23.13) offers the advantage of increased stability and retention. A crown is used if the second primary molar has extensive caries or if the tooth has had vital pulp therapy. The steel crown should be prepared as described in Chapter 12: an impression is made, the crown removed from the tooth and seated in the impression, and a working model prepared on which to fabricate the loop. Because it is difficult to remove the crown (converted to a band) to make adjustments, adapting a band or crown one size larger over a cemented crown restoration or constructing a conventional band-and-loop appliance is another alternative to address unilateral space maintenance (Fig. 23.14).

If the first primary molars are lost bilaterally within a lower arch and the second primary molars are retained, two separate unilateral loop appliances are generally indicated until the first permanent molar and incisor eruption is complete. Bilateral lingual holding arch designs should not be placed before eruption of the permanent incisors because the lingual wire may interfere with incisor positioning during eruption. Additionally, primary incisors as anterior stops do not offer sufficient anchorage to prevent loss of arch length in most cases. Either of the loop or arm designs is relatively effective as long as the clinician realizes that the appliances are dependent on abutment teeth that may exfoliate before the need for space maintenance is complete. After the permanent incisors have fully erupted and as the primary canines and molars exfoliate, a second appliance that stabilizes final permanent molar position and arch length may be necessary to prevent subsequent space loss.

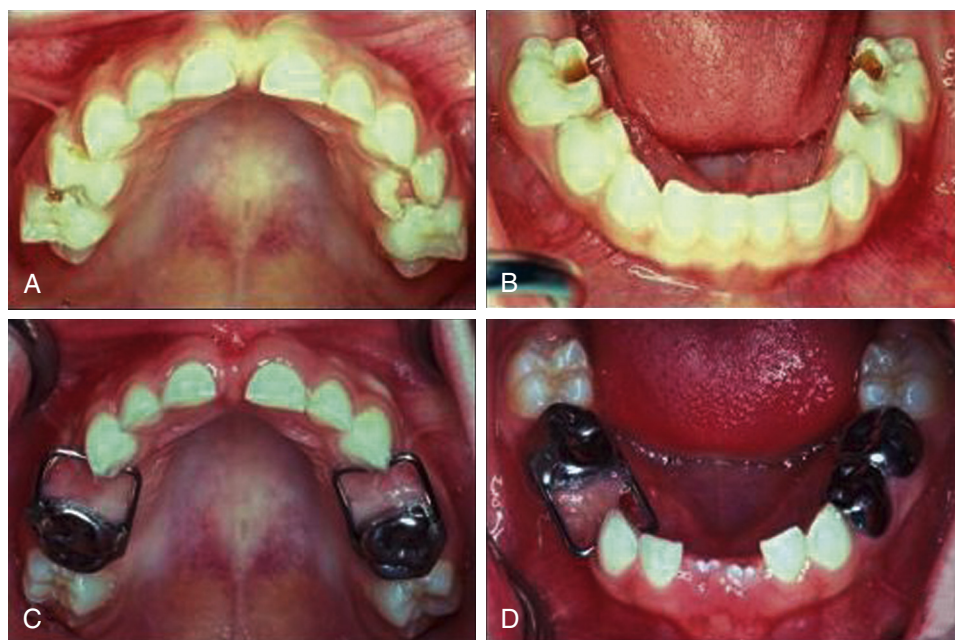


Fig. 23.13 (A) and (B) Pretreatment of upper and lower arches with caries and pulp involvement of primary molars. (C) and (D) Same upper and lower arches with crowns and loops placed for early loss of three first primary molars. Note the erupted first permanent molars with proper positioning.

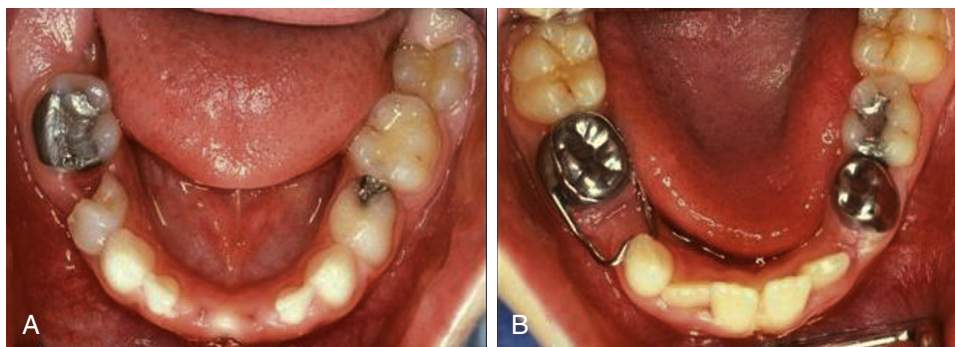


Fig. 23.14 (A) Pretreatment of lower arch with caries and pulp involvement of primary molars. (B) Same lower arch with band and loop placed over a restored crown on the second primary molar for early loss of right first primary molars. The band was fabricated from the next-larger-sized crown by removing the occlusal surface and shortening the cervical portion of the crown. Note the erupted first permanent molars with proper positioning.

Loss of Second Primary Molars

If a second primary molar is lost in a child 2–5 years of age, no space loss should occur while the first permanent molar is in the basal bone. The options for managing such early loss are very limited due to lack of retention elements for fixed appliances and difficulties with patient cooperation in the use of appliances at this age. As first permanent molars erupt, however, considerable loss in arch length can occur if no second primary molar is present as an eruptive guide (Fig. 23.15). Space loss of as much as 8 mm in a maxillary quadrant has been documented as the first permanent molar displaces forward through bodily crown-root movement and mesiolingual rotation around the palatal root. Early loss of lower second primary molars in conjunction with first permanent molar eruption timing results in up to 4–6 mm of space loss during transition. The lower first molars move forward by pronounced mesial tipping of the crown, with more modest bodily tooth movement expressed in molar adjustments. Distal movement and retroclination

of teeth anterior to the space are also a likely consequence of early loss in the lower arch. If the loss of the second primary molar occurs after the first permanent molars have fully erupted and normal cuspal interdigitation has been established, the degree of space loss should be less dramatic than earlier during molar transition, regardless of the arch involved. However, mesial movement of the permanent molar through lack of buttressing support from the missing second primary molar usually results in space loss that may be significant. Quadrant space loss of 2–3 mm without the buttressing support of the second primary molar may be realized—easily enough to compromise positioning of the permanent canines and premolars.

Given the findings regarding space loss with second primary molars, a space maintainer is generally indicated in most patients to control permanent molar positions. If the loss occurs just before eruption of the first permanent molar, that is, when the first molar crown is still covered with oral mucosa and a thin partial covering of bone, a space maintainer to guide the positioning of the first permanent molar

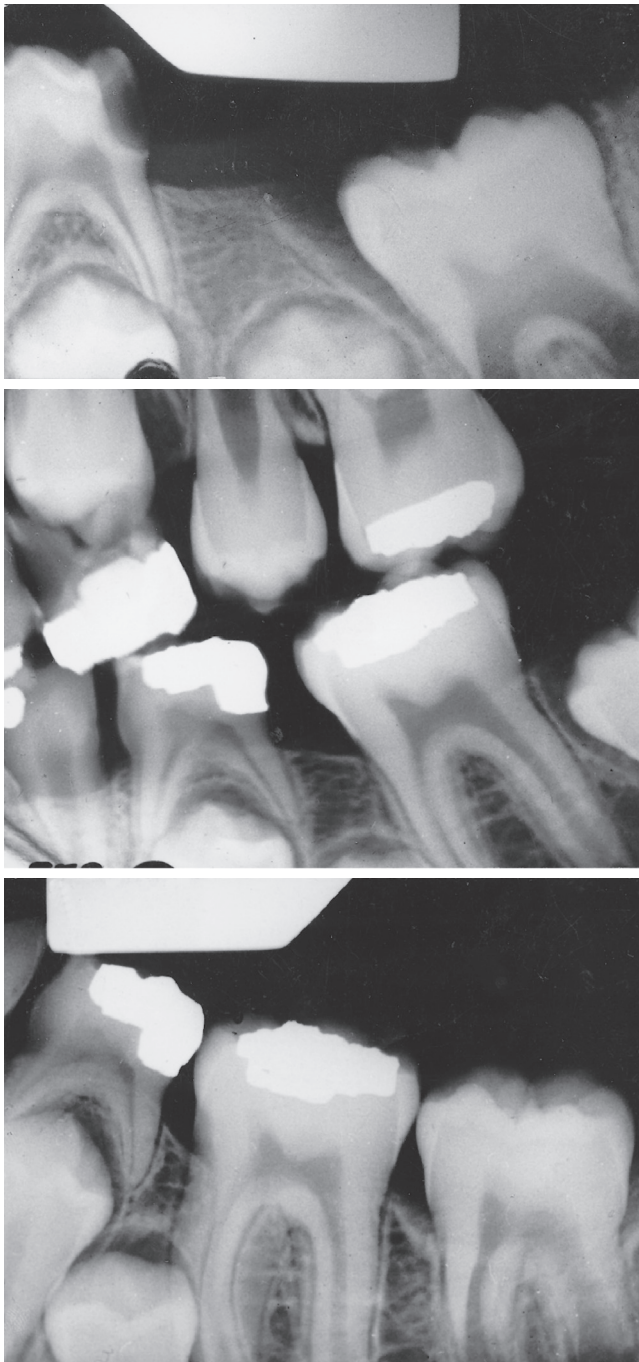


Fig. 23.15 A sequence of three radiographs showing early loss of a lower second primary molar and mesial movement of the first permanent molar before eruption. Eventually there was complete closure of the space needed for the second premolar.

into normal occlusion is desirable. The appliance of choice is a distal shoe for both the maxillary (Fig. 23.16) and mandibular arches. The appliance incorporates a posterior wire-loop extension from the first primary molar that supports a vertical tissue blade positioned to come into contact with and guide the erupting permanent molar into normal position. The depth of the intragingival extension should be about 1.0–1.5 mm beyond the mesial marginal ridge of the molar to “capture” the surface as the tooth erupts vertically. Gauged in length to represent the missing second

molar, accurate placement is critical to ensure that the distal shoe neither extends too far distally over the first molar and block its eruption nor be too short and not maintain the space occupied by the lost second primary molar. It has been observed that the soft tissue tolerates the blade extension well, although a small metallic “tattoo” in the gingiva may result.

The first primary molar is first prepared with a stainless-steel crown or well-adapted band that provides a retentive base for the distal shoe. An impression is made to prepare a working model. If the primary second molar has not yet been extracted, it is cut off the model and a hole made with a bur that simulates the position of the distal root of the tooth. If the second primary molar has been removed previously, the positioning of the tissue extension may be determined with measurements on bitewing or periapical radiographs or by measurement of the mesiodistal width of the contralateral second molar. The extension blade is contoured and extended distally into the prepared opening on the model, and the loop is soldered to the band or crown. An alternative design is the use of an adjustable Gerber extension involving a trombone-type attachment with the sleeve portion tack welded or soldered to the band or crown (Fig. 23.16). The sliding extension can be positioned into the tube sleeve and the posterior length adjusted to the proper spacing with the blade extension positioned directly into the extraction space or a surgical incision made just at the mesial contact area of the erupting first permanent molar. Crimping of the sleeve tube holds the length of the established extension loop. Ideally, the tack-welded area should be supported with additional solder to reinforce the appliance’s resistance to occlusal forces. Before final placement, a radiograph of the distal shoe in position should be made to determine whether the extension is in proper relationship with the unerupted first permanent molar. Final adjustments in length and contour may be made to ensure that mesial contact of the first permanent molar is provided. In describing chairside fabrication procedures, Brill^{16,17} presents the distal shoe as an efficient and cost-effective appliance for guiding the unerupted permanent first molar into position, with success rates relatively equal to those reported from studies of the longevity of other space maintainers.

Several conditions contraindicate the use of distal shoe appliances. Given the extent of caries involvement, there may be lack of abutments to support a cemented appliance. Poor oral hygiene or lack of patient and parental cooperation greatly reduces the possibility of a successful clinical result. Histologic studies show that the distal shoe does not become lined with the epithelium and is associated with a chronic inflammatory response. Therefore certain medical conditions such as blood dyscrasias, immunosuppression, congenital heart defects, history of rheumatic fever, and diabetes contraindicate the use of the appliance. If the distal shoe is contraindicated, two possibilities for treatment exist: (1) allow the tooth to erupt and regain space later, or (2) use a removable or fixed appliance that does not penetrate the tissue but places pressure on the ridge mesial to the unerupted permanent molar (Fig. 23.17). Carroll and Jones¹⁸ reported regarding a pressure-type appliance successfully used to guide the permanent molar as it erupted. Given that the first permanent molars are guided in their eruption by the distal-cervical aspect of the second primary molar, the acrylic or pressure extension usually serves as an ineffective guide for eruptive positioning. The removable

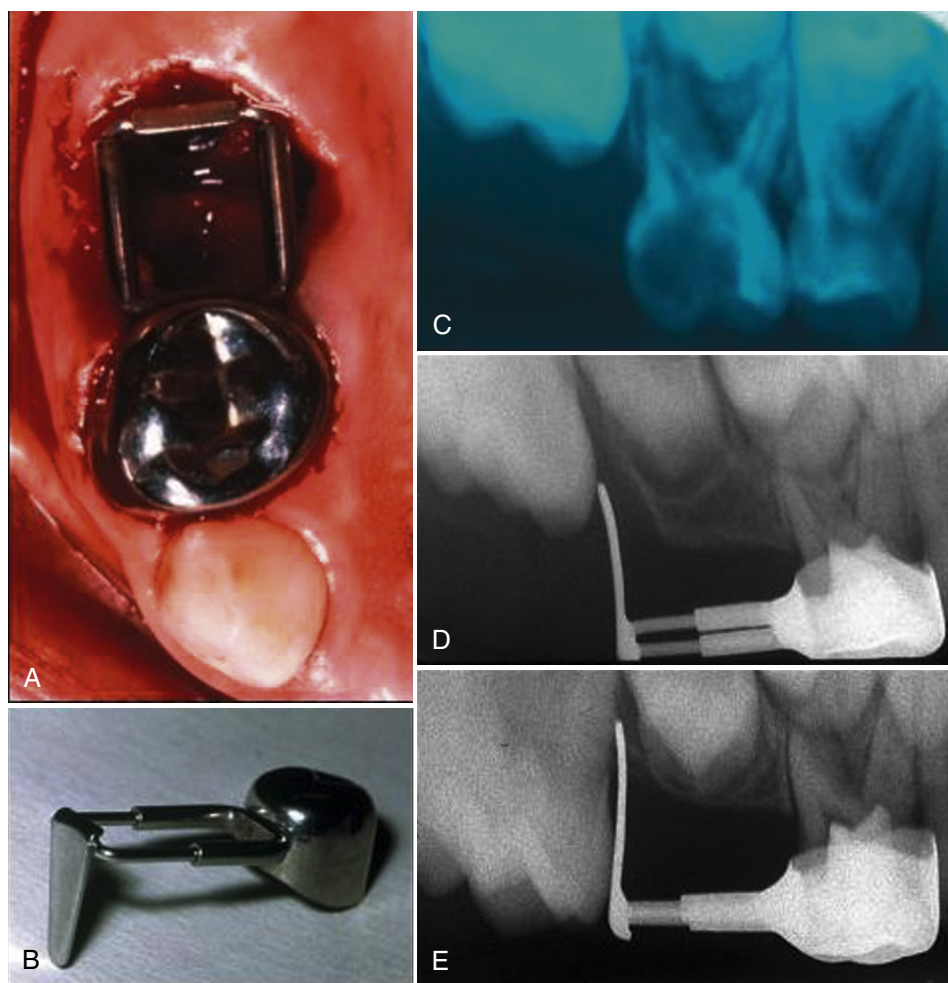


Fig. 23.16 (A) The second primary molar is nonrestorable and must be extracted. A crown with a distal shoe extension to help guide the first permanent molar has been placed. (B) Picture of a prefabricated crown with Gerber-type distal shoe extension as used in the case. (C), (D), and (E) Progress can be seen on radiographs in guiding the eruption of the permanent molar over 12 months.



Fig. 23.17 A modified distal shoe "pressure" appliance to provide bilateral space maintenance and eruption guidance for the first permanent molars. The permanent molars are erupting properly, and the intragingival extensions may be removed.

extension is more likely to work in the lower arch if the eruption bulge area of the first permanent molar can be engaged with the acrylic. If several teeth are missing, the removable appliance can serve to restore function and prevent supereruption of the opposing teeth.

After the first permanent molar has been guided into position, a distal shoe is usually indicated for replacement with a different appliance. Continued vertical development will usually result in tipping of the permanent first molar over the top of the blade extension, with resulting space loss and tissue complications. One option is to remove the intragingival extension and replace it with a reverse band and loop using an occlusally directed extension to prevent the molar from tipping over the wire. Exfoliation of the first primary molar as an abutment may also occur before eruption of the second premolars. Therefore once the first permanent molars have erupted sufficiently to be banded, a more preferred option for the replacement of a distal shoe is the use of a bilateral space maintainer such as a mandibular lingual holding arch, maxillary transpalatal bar, or maxillary Nance appliance. These same bilateral space maintainers are the method of choice to provide stability to the first permanent molar positions whenever the second primary molars are lost and first permanent molars have erupted into occlusion. Even after first permanent molar occlusion is established, the loss of second primary molars will potentially result in significant amounts of closure without the buttressing effect of the primary second molar.

The classic bilateral mixed dentition space maintainer in the mandibular arch is the soldered lingual holding

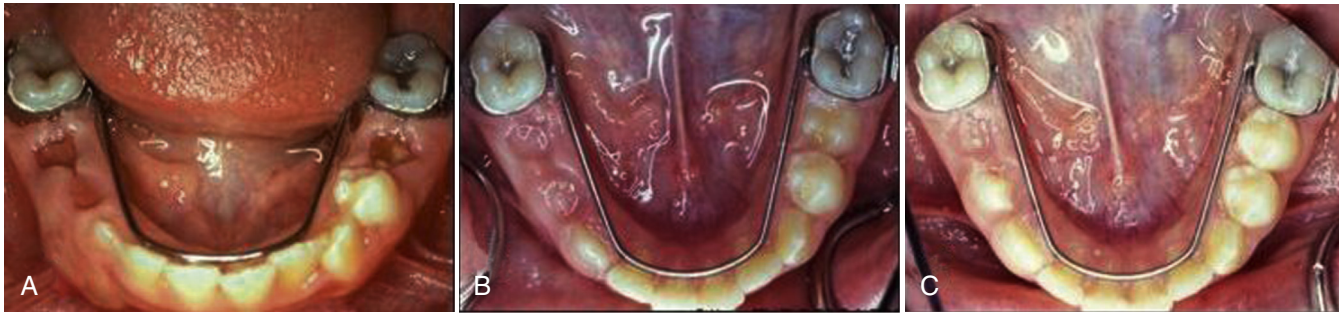


Fig. 23.18 Lingual holding arch for bilateral space maintenance and guidance of buccal segment eruption patterns. (A) Initial appliance placement in conjunction with primary molar extractions. (B) Eruption transition at 6 months after extractions. (C) Eruption status at 1 year. Note the improvement in anterior and buccal segment alignment.



Fig. 23.19 Proper design of a passive mandibular soldered lingual holding arch positioned with wire contact at the cingulum area of the permanent incisors. The wire offsets and contours to position the wire away from the eruption path of buccal segment teeth and to avoid tongue irritation. Note the excess “leeway” space in the premolar area secondary to the appliance, preventing a late mesial shift of the permanent molars.

arch (Fig. 23.18). With bands fitted to the first permanent molars, a 0.036- or 0.040-inch stainless-steel wire is contoured to the arch and extended forward to make contact with the cingulum area of the incisors (Fig. 23.19). The design stabilizes lower molar positions from moving mesially and incisor relationships from retroclining lingually in sustaining the canine-premolar segment space (i.e., leeway space). The lingual wire must simply be contoured not to interfere with normal eruption paths and provide an anterior arch form so that the incisors have an opportunity for alignment. In the mixed dentition, the soldered lingual holding arch should present minimal problems with breakage, minimal oral hygiene concerns, minimal interference in eruptive movements of permanent canines and premolars, and no concerns about whether the child is wearing the appliance. Importantly, the bilateral design and use of permanent teeth as abutments allow for application during the full transitional dentition period of the buccal segments. As stated earlier, lower lingual arches should not be placed before the eruption of the permanent incisors because of their frequent lingual eruption path. The lingual wire may interfere with normal incisor positioning if the appliance is in position before lateral incisor eruption. Additionally, abutting against primary incisors as anterior stops

does not offer sufficient anchorage to prevent significant loss of arch length.

Used in the maxillary arch to stabilize molar positions bilaterally, the soldered transpalatal bar incorporates a transverse palatal wire of 0.036- or 0.040-inch stainless-steel wire soldered to molar abutments (Fig. 23.20A). The rigid transverse wire prevents the two main space loss patterns of upper first permanent molars: mesiobuccal rotation and anterior bodily displacement. While the appliance may allow some minor mesial tipping of the upper molars, this is generally considered insignificant in terms of overall space loss in the maxillary arch. The simple transpalatal contour of the connector wire offers the main argument for this appliance: It is easy to fabricate and offers minimal irritation to the palatal tissue or tongue. The Nance appliance uses a contoured rigid wire with an acrylic “button” in contact with the palatal shelf as an anterior stop for bilateral molar stabilization in the maxillary arch (Fig. 23.20B). Providing the same molar rotation and bodily movement control as transpalatal bars, the added bracing of the acrylic button against the anterior palatal vault offers some additional resistance against forward tipping movements of the molars. Although the bilateral stability of the transpalatal appliance appears adequate in most situations, the resistance of the Nance with its acrylic palatal stop is preferred by some clinicians. Tissue irritation beneath the button does not appear to be a clinical problem in most cases if proper hygiene is performed.

The fixed space maintainers as described have the distinct advantage that they are stable, not easily broken, and wear is not dependent on the child. Ensuring that the appliance is passive and does not cause unwanted tooth movement is generally the greatest concern. Proper design should minimize eruption interference and the effects of unfavorable abutment loss or impingement of soft tissues. Poor band fit or defective cement may serve as a locus for debris accumulation and subsequent decalcification. Steps to prevent this include adapting a band that contours tightly to the tooth surface and extends beneath the gingival margins, providing a thorough prophylaxis before cementation, keeping the tooth thoroughly dry during cementation, using glass-ionomer cements, and teaching the child and parent proper oral hygiene practices to include the use of fluoride rinses. Closely checking the appliance at 6-month intervals to monitor potential problems is the standard protocol.

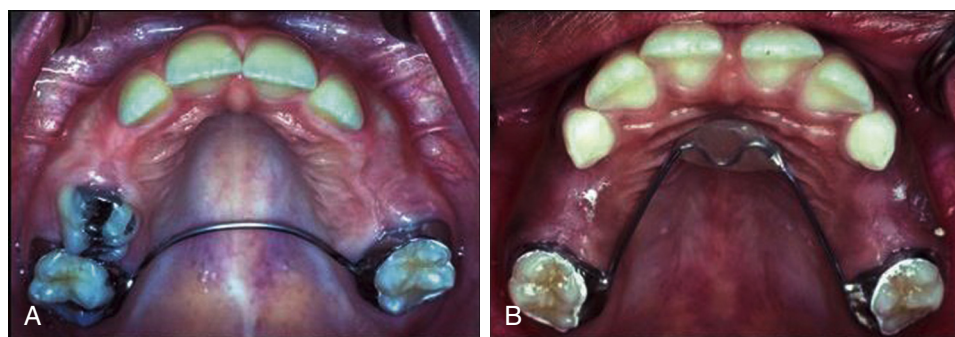


Fig. 23.20 Bilateral fixed space maintainers for maxillary molar control. (A) Soldered transpalatal bar with 0.036-inch stainless-steel wire contoured to traverse the palatal contour. The appliance prevents forward bodily movement and rotation of molars around palatal roots. (B) Nance appliance incorporates a 0.036-inch stainless-steel wire that traverses the arch with a midline acrylic button positioned against the anterior palatal contour. The design prevents molars from forward bodily movement, rotation around the palatal roots, and mesial tipping.

Areas of Multiple Primary Molar Loss

Loss of multiple primary molars may lead to mutilation of the developing dentition unless an appliance is constructed to maintain relationships of the remaining teeth and to guide eruption of the developing teeth. In addition to arch dimension concerns, reduced masticatory function is undesirable from a nutritional standpoint. Removable acrylic partial dentures have been used successfully in either arch after the loss of multiple teeth. If artificial teeth are included, an essentially normal degree of function and acceptable aesthetics can be restored. The disadvantages lie in their unpredictability outside the clinician's control because the appliances require patient cooperation and can be easily lost or broken during wear. During the transitional stages of exfoliation and eruption, stability of removable appliances is often difficult to sustain with the loss of abutments. The wire clasps and resin contact areas may present "food traps" for plaque accumulation, with increased potential for soft tissue irritation and dental caries.

If the loss of one or both of the second primary molars occurs a short time before the eruption of the first permanent molars, the acrylic removable appliance may be considered in preference to one of the distal shoe maintainers described previously. An acrylic partial denture with a distal extension may be used to guide the first permanent molars into position (Fig. 23.21). The teeth to be extracted are cut away from the stone cast, and a depression is cut into the stone model to allow for fabrication of the acrylic extension. The acrylic will extend into the alveolus after removal of the primary teeth. The extension may be removed after eruption of the permanent tooth. It is occasionally necessary to recommend extraction of all the primary teeth in a preschool child. Although this was more common in the prefluoridation era, some children even today must have all of their teeth removed because of widespread oral infection and because the teeth are nonrestorable. Preschool children can wear complete dentures successfully before the eruption of permanent teeth (Fig. 23.22).

Loss of First Permanent Molars

The first permanent molar is unquestionably the most important unit of mastication and is essential in the development of a functionally desirable occlusion. A caries lesion may develop rapidly in the first permanent molar

and occasionally progress from an incipient lesion to a pulp exposure in a 6-month period. The loss of a first permanent molar in a child can lead to changes in the dental arches that can be traced throughout the child's life. Unless appropriate corrective measures are instituted, these changes include diminished local function, drifting of teeth, and continued eruption of opposing teeth.

The second molars, even if unerupted, start to drift mesially after the loss of the first permanent molar. A greater degree of forward bodily movement will occur with loss of the first permanent molar in 8- to 12-year-old children. In older children, if the loss occurs after eruption of the second permanent molar, more exaggerated mesial tipping of the second molar can be the expected outcome. Although the premolars undergo the greatest amount of distal drifting, all the teeth anterior to the space, including the central and lateral incisors on the side where the loss occurred, may show evidence of movement. Contacts open and the premolars, in particular, rotate as they fall distally. There is a tendency for the maxillary premolars to move distally in unison, whereas those in the lower arch may move separately. When the maxillary first permanent molar loses its opponent, it erupts at a faster rate than the adjacent teeth. The alveolar process is also carried along with the molars and causes problems when prosthetic replacements are needed. The treatment of patients with the loss of first permanent molars must be approached on an individual basis. A superimposed existing malocclusion, abnormal musculature, or the presence of deleterious oral habits can affect the result, as in the case of the premature loss of primary molars.

Loss of a first permanent molar before the eruption of the second permanent molar presents problems in both anteroposterior space control and vertical eruption control of opposing molars. Although it is possible to prevent overeruption of a maxillary first permanent molar by placing a lower partial denture, there is no completely effective way to influence the path of eruption of the developing second permanent molar other than the use of an acrylic distal shoe extension on a partial denture as described previously. The second molar drifts mesially before eruption when the first permanent molar has been extracted. Repositioning this tooth orthodontically is possible after its eruption. However, the child must then be considered for prolonged space maintenance until the time when a more

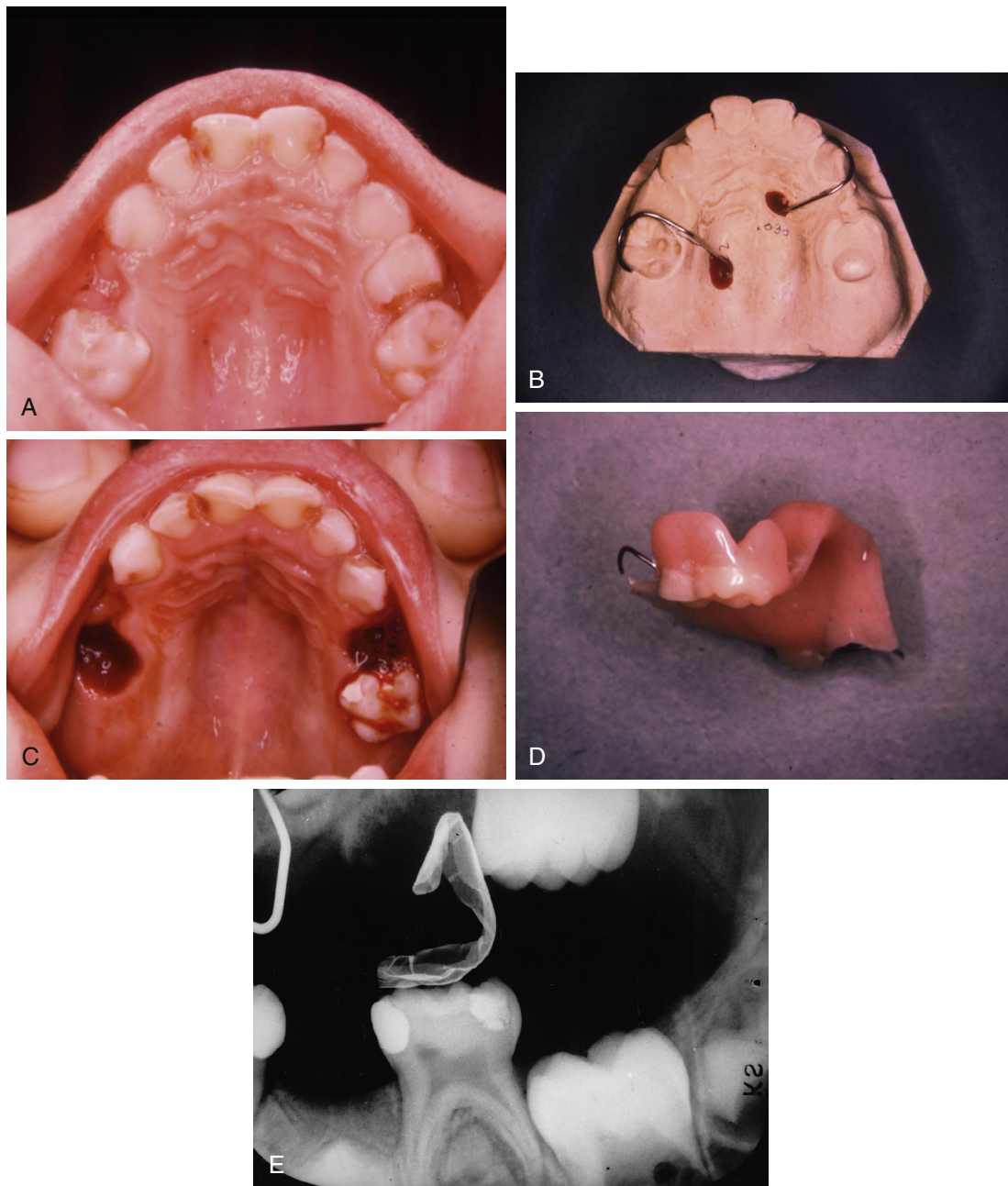


Fig. 23.21 (A) Clinical and radiographic examination revealed the need for extraction of both maxillary first primary molars and the left second primary molar at 6 years of age. (B) The teeth indicated for extraction are cut away from the stone model, and a depression is made in the second molar area for an acrylic distal shoe-type extension. (C) The primary teeth have been extracted in preparation for the placement of the partial denture. (D) The acrylic distal shoe extension. (E) Lead foil has been placed over the tissue extension to determine, with the aid of a radiograph, whether the acrylic is positioned properly to guide the eruption of the first permanent molar. (Courtesy Dr. Paul E. Starkey.)

permanent tooth replacement can be inserted. The removal of the opposing first permanent molar, even when the tooth appears to be sound and caries-free, is sometimes recommended in preference to allowing it to extrude or to subjecting the child to prolonged space maintenance and eventual fixed replacement.

If the first permanent molars are removed several years before eruption of the second permanent molars, there is an excellent chance that the second molars will erupt in an acceptable position (Fig. 23.23). However, the axial inclination of the second molars, particularly in the lower arch, may be greater than normal.

The decision whether to allow the second molar to drift mesially or to guide it forward in an upright position may be influenced by the presence of a third molar of normal size. If there is a question regarding the favorable development of a third molar on the affected side, repositioning the drifted second molar and holding space for a replacement prosthesis are usually the treatment of choice.

When the first permanent molar is lost after the eruption of the second permanent molar, orthodontic evaluation is indicated, and the following points should be considered: Is the child in need of corrective treatment other than in the first permanent molar area? Should the space be maintained

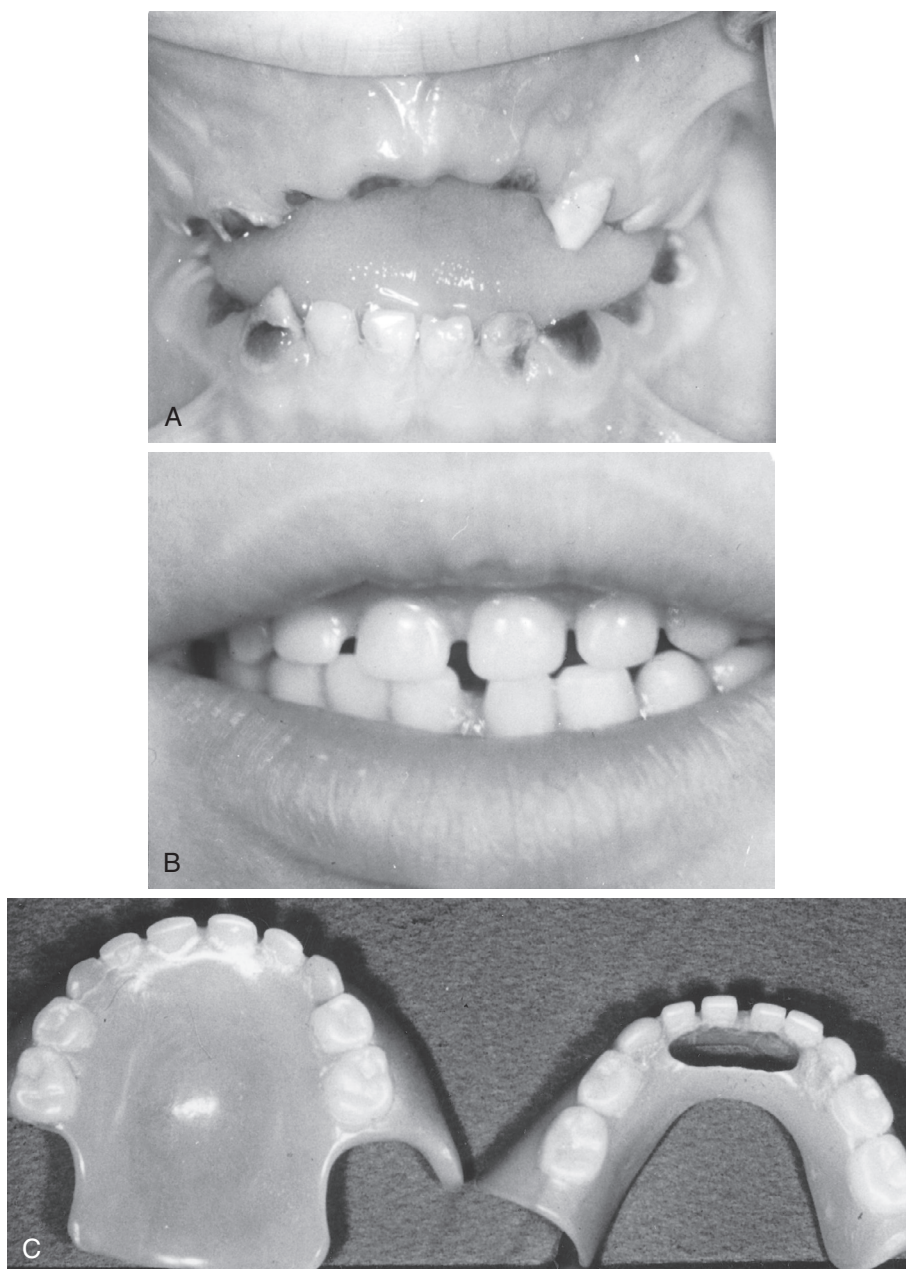


Fig. 23.22 (A) Primary teeth with rampant gross caries and pulpal involvement. (B) Complete dentures in place after the extraction of all primary teeth. (C) Modification of the dentures after eruption of the upper first permanent molars and lower permanent incisors.

for replacement prosthesis? Should the second molar be moved forward into the area formerly occupied by the first molar? The latter choice is often the more satisfactory, even though there will be a difference in the number of molars in the opposing arch. A third molar can often be removed to compensate for the difference. Without treatment, the second molar will tip forward within a matter of weeks (Fig. 23.24).

Another option to consider is autotransplantation of a third molar into the first molar position (Fig. 23.25).¹⁹ According to Bausset al.,²⁰ autotransplantation has become a well-established treatment modality in cases of early tooth loss or aplasia. For third molars with partly developed roots, transplantation success rates have been reported to range from 74% to 100%.

Oral Habits in Children

BRUXISM

Defined as nonfunctional grinding or gnashing of teeth, bruxism has been reported in up to 15% of children and young adults. Usually occurring at night, bruxism can result in significant abrasion of primary and permanent teeth if continued over a prolonged period (Fig. 23.26). A vinyl bite guard that covers occlusal surfaces of all teeth can be worn at night to prevent continued abrasion. The occlusal surface of the bite guard should be flat to avoid occlusal interference. A mouth guard of the type described in Chapter 25 may also help in overcoming the habit. Ramfjord²¹ believes that occlusal interference may trigger bruxism if

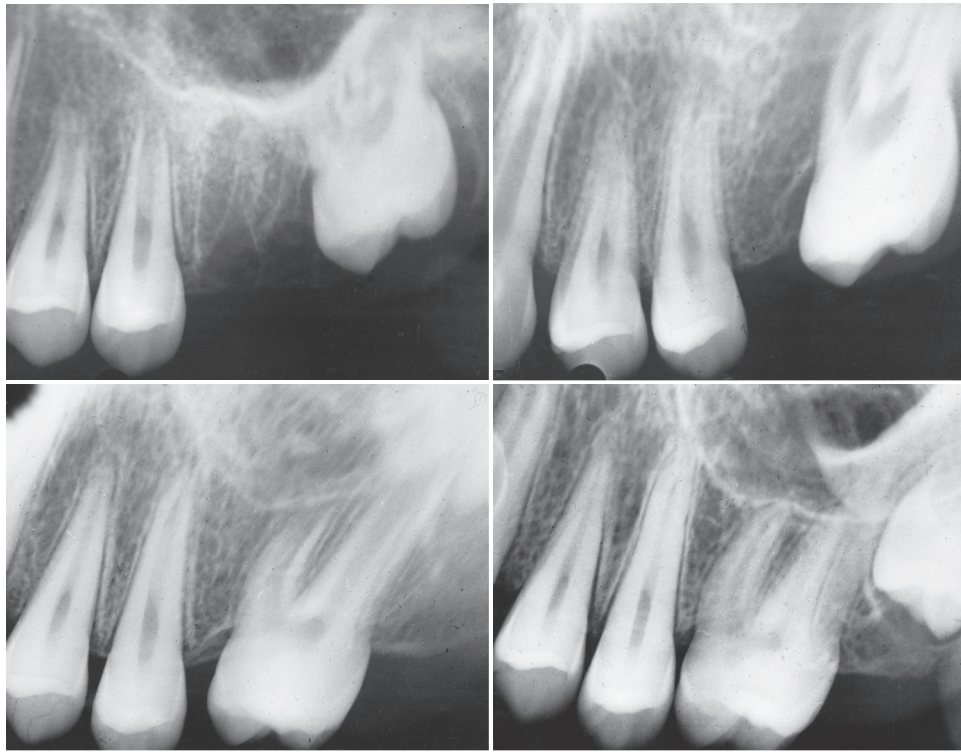


Fig. 23.23 Radiographs taken at 6-month intervals after a maxillary first permanent molar was lost before the eruption of the second permanent molar.



Fig. 23.24 Radiographs taken at 6-month intervals after the loss of a mandibular first permanent molar. Notice the degree of tipping of the second molar and distal drifting of the premolars.

combined with nervous tension. Therefore occlusal equilibration can be used to help the problem if obvious interference is present. Sheppard²² recommends construction of an anterior bite plate that allows for continued eruption of the posterior teeth if they have been abraded by the habit. When bruxism continues into adulthood, periodontal disease and/or temporomandibular joint disturbances can result. Finally, there is a comorbidity between obstructive sleep apnea (OSA) and nocturnal bruxism, and bruxism is included among the sleep-related movement disorders in the International Classification of Sleep Disorders (see section on Obstructive Sleep Apnea later in this chapter).

NON-NUTRITIVE SUCKING

Many children suck their thumbs or fingers for short periods during infancy or early childhood, with the habit considered normal during the first 2 years of life. If present at such an early age, parents should be advised to periodically observe the nature and intensity of the habit. If the child demonstrates gradually diminishing activity, it is probable that the habit will cease without intervention. Traisman and Traisman²³ reported that the average age at which digit sucking stopped was 3.8 years, although other studies indicate a persistent incidence of up to 20% at 4 years of age. These studies indicate that changes in the anterior

occlusion caused by digit sucking are temporary, with little likelihood of long-term effects if the habit is discontinued by the age of 3–4 years.

If the intensity of the habit persists or increases and adverse dental and skeletal changes are noted beyond 4 years of age, corrective measures may be needed to avoid undesirable occlusal problems (Fig. 23.27). By the age of 6–7 years, estimates indicate that approximately 10%–15% of children have a persistent digit-sucking habit that runs the gamut from incidental sucking at bedtime to pronounced habits that seems to be almost constant. Almost all authorities recognize that persistent digit-sucking habits extending into the incisor transition period can cause a malocclusion or aggravate an already existing one (Box 23.1).

On evaluating 34 children with digit-sucking habit by cineradiography, Subtelny^{24,25} reported that 82% children exhibited tongue-thrust activity during swallowing. Dental findings included protruded maxillary incisors, anterior open bite, and increased maxillary arch length as a result of atypical muscular forces from the thumb, the perioral musculature, and forward positioning of the tongue. The child with a persistent digit-sucking habit that results in an open bite typically exhibits a convex profile with hypotonic upper lip, hypertonic lower lip with marked mentalis muscle activity, and tongue thrusting.

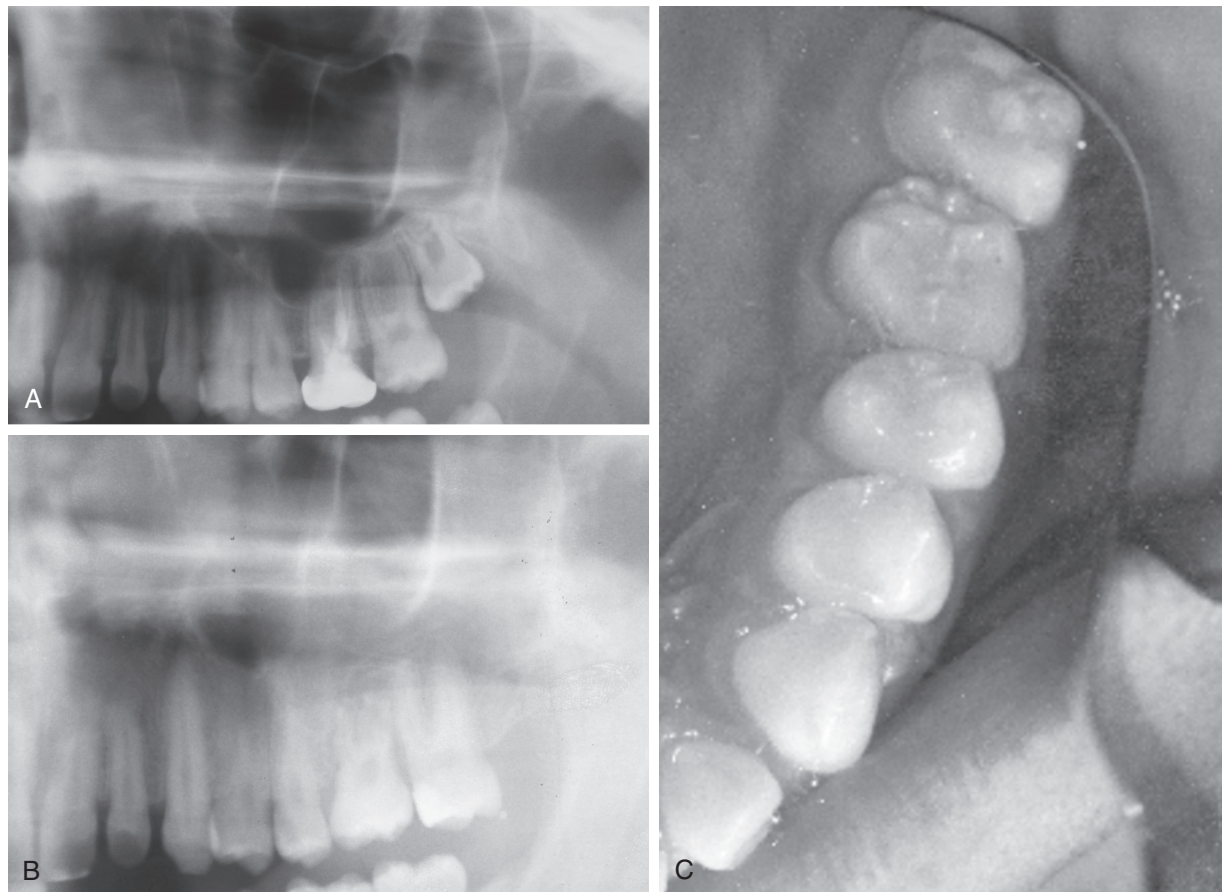


Fig. 23.25 Third molar autotransplantation. (A) Radiograph showing failed attempt at maintaining first permanent molar and minimal root development of third permanent molar. (B) Radiographic and (C) clinical views of third molar 15 months after autotransplantation. Note the continued root development.



Fig. 23.26 Bruxism resulting in severe abrasion of the maxillary primary anterior teeth. (A) Frontal view. (B) Occlusal view.

The effect of prolonged digit sucking on posterior relationships is less clear. Strong muscle contractions of the circumoral musculature with the highest force levels approximating the maxillary canine area have been documented with extraoral habits. These may result in a relative constriction in maxillary arch width that has been associated with an increased development of functional posterior crossbites in children whose habits persist beyond the age of 4–5 years. While not as profound, associations between distal-step primary molars and Class II permanent molars have been suggested in children whose habits extend into the transitional dentition period. Popovich and Thompson²⁶ observed 1258 children at the Burlington Growth Centre, representing approximately 90% of the pediatric population of Burlington, Ontario. Many of the children were seen annually from 3 to 12 years of age, with their oral habits and occlusal status recorded at 3, 6, 9, and 12 years of age. There was a significant association between

Box 23.1 Occlusal changes secondary to persistent non-nutritive sucking

1. Labial flaring and protrusive spacing of maxillary anterior teeth
2. Lingual inclination of the lower incisors
3. Increased overjet
4. Maxillary alveolar process remodeling and anterior open bite
5. Increased open bite and overjet may lead to tongue protrusion during swallowing as an adaptation to the anterior space
6. Class II malocclusion

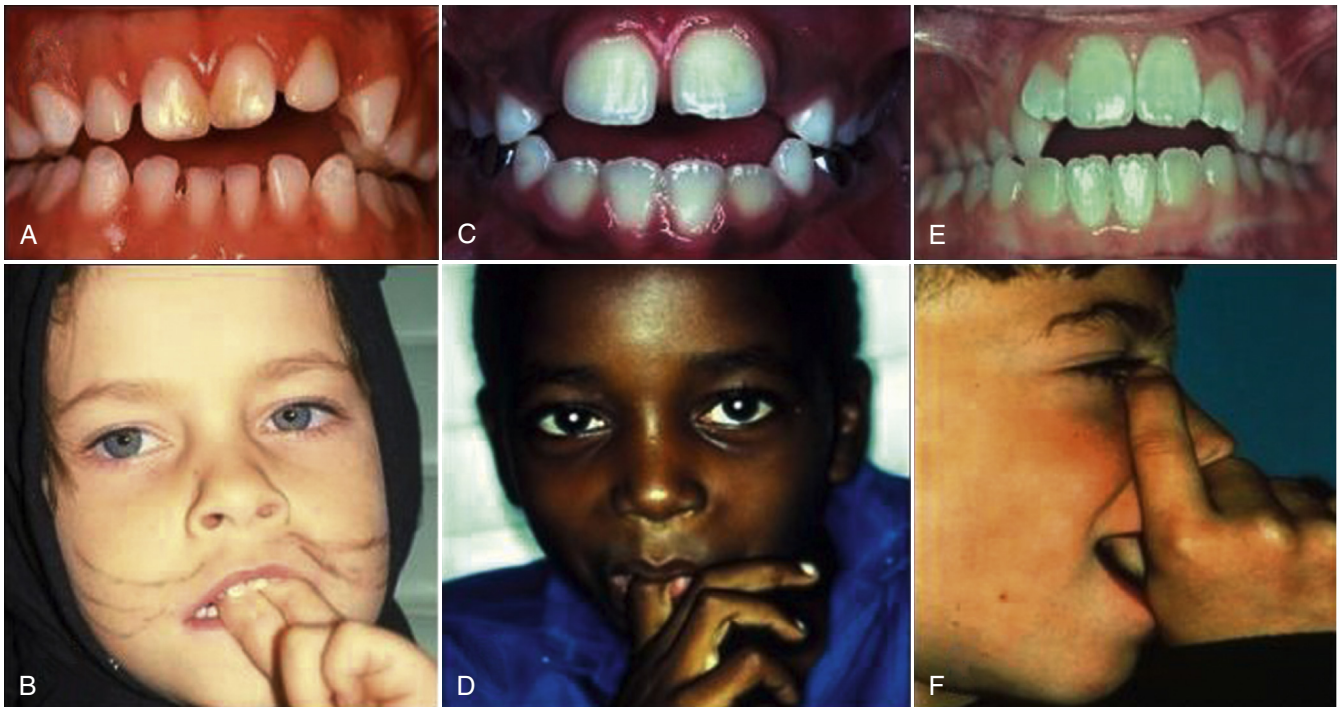


Fig. 23.27 Occlusion of three children with different patterns of digit-sucking habits. (A) and (B) An open bite in the primary dentition caused by the child placing two fingers between the anterior teeth. (C) and (D) An open bite with flared maxillary incisors in the mixed dentition caused by an index finger-sucking habit. (E) and (F) An open bite with maxillary constriction produced by thumb-sucking as presented. The maxillary constriction resulted in a posterior crossbite with a functional shift of the mandible on closure.

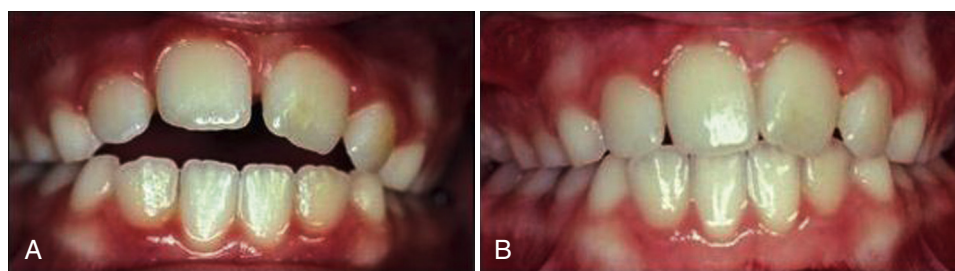


Fig. 23.28 (A) Open bite with some maxillary constriction evident in the mixed dentition of an 8-year-old child with a persistent thumb-sucking habit. (B) The child was encouraged to discontinue the habit through a positive rewards system. There was self-correction of the open bite and transverse relationships by 9 years of age, when the dysfunctional habit was discontinued.

the prevalence of Class II malocclusion and persisting digit sucking in the different age groups. Class II malocclusion increased from 21.5% at 3 and 4 years of age to 41.9% at 12 years of age, and the probability of a Class II malocclusion increased as the duration of the habit increased. If the habit was stopped before 6 years of age, the effects on occlusion were often transitory. In contrast, no child who stopped a habit after 6 years of age had a normal occlusion at 12 years of age. Interestingly, children who used a pacifier had a significantly lower rate of digit sucking. However, del Conte Zardetto et al.²⁷ pointed out that similar occlusal and myofunctional alterations have been detected among children who have prolonged pacifier habits (either conventional or physiologic pacifiers) compared with those who have no sucking habits. Children who used a pacifier were significantly more likely to show open bite, posterior crossbite, increased overjet, and alteration in cheek mobility than habit-free children.

Interceptive treatments to stop a digit-sucking habit depend upon the patient's age, emotional and psychological state, cooperative motivation of the parents and child, nature of occlusal changes, and associated functional adaptations. An age-based approach provides a foundation for treatment, although individual patient findings may result in a more aggressive approach to intervention or, more likely, may cause greater caution and actually delay or defer treatment. These age-based concepts are as follows:

1. *Before 4 years of age:* If one accepts the premise that a digit-sucking habit will usually stop by 4 years of age, and that the effects on the occlusion are probably not permanent, then direct intervention before this age has questionable merit. Additionally, the child's level of understanding complicates cooperation with any of the intervention options.
2. *4–6 years of age:* Psychological ploys and reward systems may help some children to cease digit sucking in this age group. In conversation with the child, the dentist discusses the problem and its effect on the teeth. The parent and child are asked to keep a daily record of episodes of digit sucking and to report on the child's progress in stopping the habit. A decrease in the number of times the habit is practiced is evidence of progress and indicates that the child will likely discontinue the habit. A positive approach involves cooperation of the parents who are often overanxious about the habit. This anxiety may result in nagging or punishment which often creates greater tension and may even intensify the habit.
3. *The school-age years:* Although reward techniques may work in some children aged 6 years or older, the persistent habit may be so ingrained as to present unlikely successful stoppage with such ploys. This is the child who has "tried to stop, but just cannot get it done." The transition of the permanent incisors and the ingrained nature of the habit often require direct appliance therapy, not only to stop the habit but also to enhance proper tooth eruption and alignment by influencing any acquired muscular patterns. A palatal crib appliance that prevents the offending digit from being placed in the sucking position and acts to restrain the tongue from forward positioning is a valuable adjunct in habit therapy during the mixed dentition years (Fig. 23.29). Palatal crib designs generally use the first permanent molars as anchorage abutments with a major connecting wire of standard 0.040-inch stainless-steel orthodontic wire, ensuring a strong and stable appliance that is resistant to both digit and tongue pressures. The crib approximates the cross-arch level of the upper canines, with

The parents should consent to disregard the habit and not mention it to the child for a more successful outcome. A timed reward system may also help. For each day the child refrains from the habit for a set period of time, a star is placed on a calendar. In week 1, the child receives some reward or prize predetermined by the parent if the child refrains from non-nutritive sucking for say, 10 minutes. With each day of success during this timed period, the child is praised individually and also through positive comments to family friends and relatives. In week 2, the goal is increased to 20 minutes each period without non-nutritive sucking. In weeks 3 and 4, the time is increased to 30 minutes or longer each day. The prizes are progressively enhanced in value for the child. The goal is positive reinforcement of the child's control over the urge to suck. If the child continues to successfully control the habit for 3 months, the long-term chances of stopping the habit and enhancing occlusal development are good (Fig. 23.28).

Negative reinforcers such as mittens, bandages, and bitter-tasting medicaments applied directly to the offending digit can occasionally affect a stoppage of the habit. Many practitioners have been successful using "thumb guards" that the child wears on the thumb as a reminder not to use the thumb. These approaches meet greater success in children who express a desire to quit and just need a little help—the "reinforcers" are viewed as reminders rather than punishment.

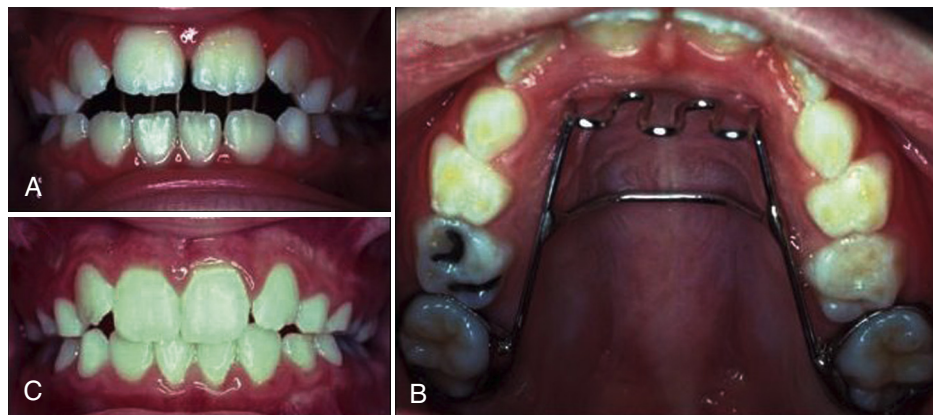


Fig. 23.29 Palatal crib appliance in the mixed dentition to help the child stop a thumb-sucking habit, control forward tongue positioning, and allow for eruptive “self-correction” of the anterior open bite. (A) Pretreatment incisor open bite at time of appliance placement. Note crib appliance’s vertical extension to level of lower incisors. (B) Palatal crib appliance of 0.040-inch stainless steel. (C) Posttreatment closure of open bite after 6 months of crib therapy. The habit stopped within 1 week of appliance placement.

the “fence” extending vertically to about the level of and just lingual to the lower incisors. Positioning should ensure no occlusal interference in all functional excursions and allow clearance for upper incisors to lingualize into normal inclinations. The posterior transpalatal wire provides further rigidity and prevents constriction of maxillary intermolar width through pressures placed on the “fence” by the tongue or digit.

Palatal crib appliances are particularly effective in promoting a favorable environment for self-correction of incisor open bite if applied when incisors are in active eruption phases. Labial flaring of the incisors should be reduced by the action of the upper lip when the digit and the tongue are no longer acting as opposing forces. Most children accommodate to the palatal crib in a short time, and rarely are any problems lasting ones. Haryett et al.²⁸ reported that, upon insertion of palatal crib appliances, nearly 80% of patients stopped sucking their thumbs within 7 days after insertion of the appliance. They also reported that if the appliance was removed 3 months after insertion, the chance of the habit recurring was likely. The best chance of lasting success occurred when the appliance was left in place for 6–10 months. Therefore it is recommended that treatment planning must include the fixed palatal crib to be worn for a period of 6–8 months.

The child’s cooperation should be obtained when a palatal crib appliance is placed. The function of the appliance is to “help” and to “remind” the patient—the appliance cannot break the habit by itself without the child’s cooperation. Failure to gain at least tacit cooperation will usually result in failure because the child resorts to new habit postures, complains, and causes such a commotion that the parent demands removal or the child even physically removes or distorts the appliance deliberately. Because cooperation and motivation are critical to success, the child should be told that the appliance is being used to help him/her to stop sucking the thumb that has affected the position of the teeth. Some temporary difficulty with speech and eating should also be anticipated upon placement, with most children accommodating in a short time. Some patients present with palatal irritation of the crib at about a month into

appliance wear. This is usually attributable to pressures from the tongue pushing the appliance upward and is more common if second primary molars are used as anchorage abutments. Simple adjustment with intraoral three-pronged pliers can be used to bend the anterior crib away from the tissue. This adjustment is usually necessary only at the initial first-month check because the tongue soon adapts and “reprograms” from forward positioning.

Positive changes in open bite and overjet should be notable by 3 months into treatment, and self-correction should be achieved by 6 months of the appliance protocol. If protrusion of the maxillary incisors and anterior open bite have not “self-corrected” after the habit and tongue thrust are controlled, the discrepancy should be reevaluated to ensure that other problems (e.g., lip sucking) are not factors. In these situations, additional orthodontic treatment may be indicated to align the protruded and flared incisors into normal overbite and overjet positions. Older children in the late mixed or young permanent dentition stage, with more established occlusal relationships, prolonged atypical functional patterns, and less eruptive potential, are less likely to demonstrate self-correction. They usually require corrective orthodontic treatment with Edgewise bracketing techniques.

Variations of the palatal crib, ranging from simple wires contoured to the palate without vertical extensions, to appliances incorporating reminder aspects (e.g., rollers on the Bluegrass appliance, a removable Hawley-type appliance), to the use of “rakes,” “spurs,” or “spikes” extending from the crib wire or bands, have been advocated by various clinicians. A removable partial retainer with a series of smooth loops placed lingual to the incisors has proved successful in helping a child overcome a habit (Fig. 23.30). However, because a child may have a strong physical and emotional urge to continue the habit and not a strong resolve to quit, the use of a removable crib appliance is much less likely to succeed compared with a fixed palatal crib. The Bluegrass appliance (Fig. 23.31) incorporates a modified, six-sided roller constructed to spin around a 0.045-inch stainless-steel wire when rolled by the tongue. Haskell and Mink²⁹ reported successful stoppage of thumb sucking in children using the appliance with a program of positive reinforcement. The use of rakes and spurs in habit therapy has also

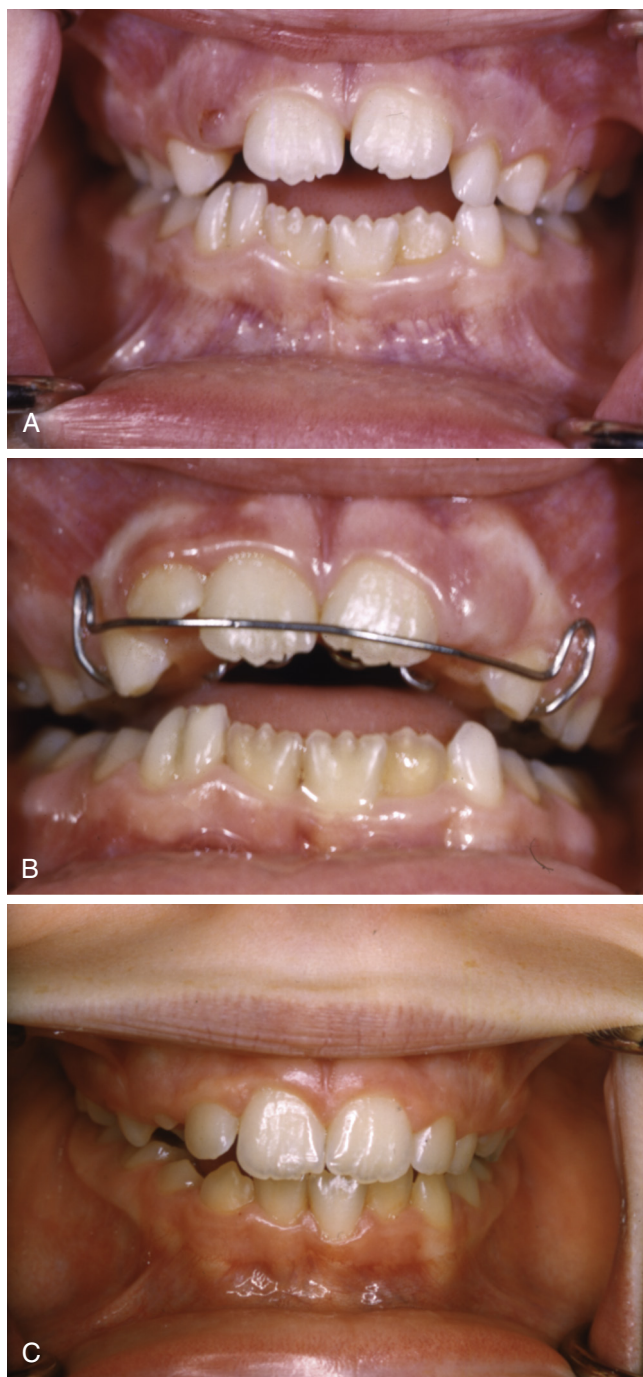


Fig. 23.30 (A) Anterior open bite caused by a thumb-sucking habit. (B) A Hawley-type reminder appliance was constructed after other problems in the patient's life were recognized and treated. (C) The occlusion 18 months after the child had overcome the habit.

been reported with success; however, Haryett et al.²⁸ found that 27% of children wearing a “rake” had transitory sleep disturbances compared with only 8% of children wearing a palatal crib. They also found that 14 (21.2%) of 66 children being treated developed mannerisms that persisted even after appliance therapy was discontinued. These included nail biting, chewing of hair or clothing, scratching of the body, and cracking of knuckles, but no enuresis. Thus there was no greater substitution of mannerisms when a habit was treated with an appliance than when a habit was not treated. With no considerable advantages in treatment

effectiveness seen by other designs in the context of early intervention, the basic palatal crib appliance remains the recommended appliance design of choice for treating digit-sucking habits in the transitional dentition.

TONGUE-THRUST SWALLOWING

Three major problems are usually associated with abnormal forward tongue positioning—anterior open bite, protrusion of the incisors, and lisping. Proffit et al.³⁰ suggest two major reasons for a relatively high prevalence of anterior tongue positioning in children, related to physiology (maturation) and to anatomy (growth). Infants normally position the tongue forward and down in the mouth at rest and during swallowing to help establish an airway for respiration. An infant's swallow is characterized by strong lip activity, placement of the tongue tip against the lower lip, and relaxation of the elevator muscles of the mandible. Physiologic transitions in swallowing patterns begin during the first year of life as teeth erupt and continue over the next several years as oral function matures. There is a gradual activation of the elevator muscles of the mandible in swallowing so that a mature swallowing pattern is characterized by relaxation of the lips, placement of the tongue behind the maxillary incisors, and elevation of the mandible until posterior teeth come into contact in occlusion. This is usually observed before a child is 4 or 5 years of age.

An abnormal swallowing pattern prolonged into the mixed and permanent dentitions is characterized by protrusion of the tongue between the anterior dentition, lack of molar contact, and excessive circumoral muscle activity. Studies have shown the prevalence of tongue thrust to be much greater than the prevalence of anterior open bite. Using cineradiography, Subtelny^{24,25} demonstrated that tongue-thrust activity between the incisors with incomplete contact of the molars during swallowing occurs in as many as 40% of adults with clinically acceptable occlusion. Fletcher³¹ reported that in 1615 children from ages 6 to 18 years, 52.3% of the 6- and 7-year-old children thrust their tongue. The incidence rates reduced with age; 34% of the 10-year-olds and almost 25% of the 16- to 18-year-olds showed tongue-thrust patterns. Hanson and Cohen³² found a similar incidence and age distribution of the tongue protruding between the teeth during swallowing. Despite these high numbers for tongue-thrust patterns, random samples of 8000 schoolchildren show an overall open-bite incidence of 5.7% in US schoolchildren. African Americans have a much higher prevalence of an open bite greater than 2 mm than whites (9.6% and 1.4%, respectively). From the data, it becomes obvious that tongue thrust does not necessarily coincide with open-bite malocclusion, and deviations from “normal” swallowing are not necessarily detrimental to the occlusion.

Given the high percentages of tongue thrust in children, the decreasing prevalence in older age groups, and the lack of direct cause-and-effect relationships with open-bite malocclusions, it seems reasonable to conclude that most tongue-thrust patterns are normal transitional occurrences. The adaptation to the more typical adult swallowing pattern appears to be related to an increase in the functional space for tongue activity during adolescent growth changes. The mandible follows skeletal growth patterns that allow space

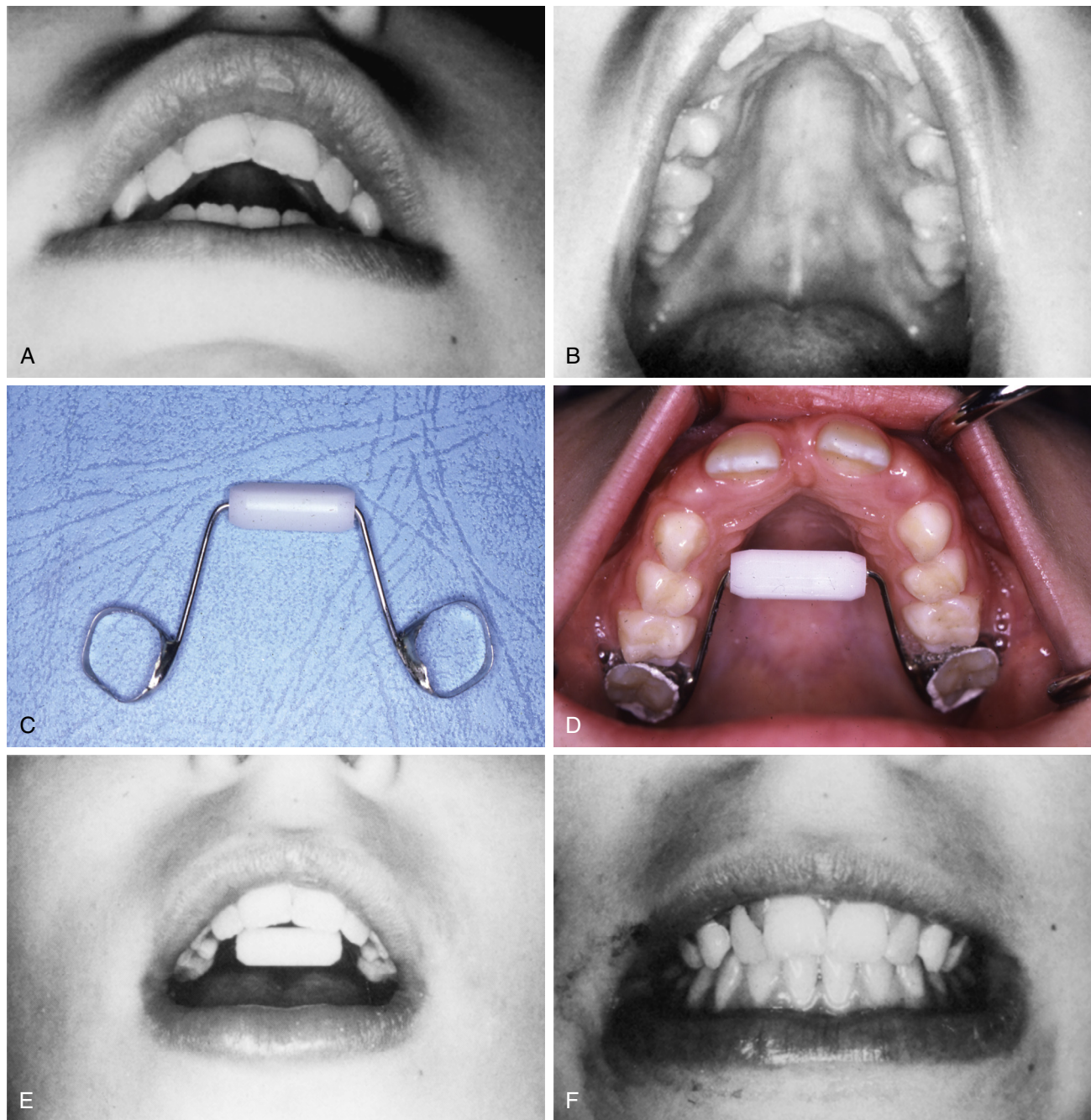


Fig. 23.31 (A) and (B) Anterior open bite and palatal configuration in the mixed dentition associated with a thumb-sucking habit. (C) Bluegrass appliance with occlusal view of the appliance in place. (D) Anterior view of the appliance in place. (E) Frontal view of appliance in place. (F) Correction of the anterior open bite. (Courtesy Dr. John R. Mink.)

for a downward and backward accommodation of the tongue. Concurrently, the tonsillar and adenoid lymphoid tissue mass is reduced to allow greater oropharyngeal air space. Vertical growth of the dentoalveolar structures of the mandible and maxilla contributes to an increase in the oropharyngeal space that allows the tongue to assume a more posterior position as the child proceeds through puberty.

Transition toward adult swallowing patterns may be affected by a prolonged digit-sucking habit or by a skeletal malocclusion in which anterior open bite or incisor protrusion exists between the dental arches (e.g., Class II division 1). In these individuals, continued functional tongue protrusion during deglutition is viewed as an adaptation that maintains the anterior open bite and is not a primary

etiological factor in causing the open bite. Proffit³³ has shown that there is no “equal balance” of forces on the dentition produced by the tongue versus the lip musculature during functional activity. The expansive forces of the tongue are significantly greater than and not balanced by the containing forces of the lips. The shape of the dental arches and position of the teeth do not appear to be overwhelmingly influenced by the horizontally directed pressures of the lips and tongue during normal functional activities such as swallowing and speaking. Proffit³³ reported that tongue pressures decrease as the size of the arch increases, patients with protruding incisors have fewer lingual tongue pressures than do those with normal occlusion, and when incisors are retracted, the tongue pressures increase to normal

values. These findings are the reverse of what would be expected if tongue pressure had pushed the teeth into protruded positions. However, stronger relationships with the patient's arch form and the resting pressures of the tongue and lips have been found. An anteriorly positioned tongue "at rest" can impede vertical eruption of the teeth and result in an open bite. This may be reflected in the findings that most habit-related open bites are self-correcting when digit sucking is eliminated and tongue positioning is controlled.

The controversy concerning tongue-thrust swallowing extends into treatment approaches that include palatal crib-type appliances, full orthodontic therapy, myofunctional therapy, or combinations of the above. The occurrence of an open bite is often initially related to a thumb- or finger-sucking habit and then retained by the tongue being thrust forward or the tongue merely occupying the space. In appliance therapy for digit-sucking habits, a vertical crib "fence" helps modify forward tongue positioning associated with the anterior open bite. With stoppage of the habit, the tongue assumes more normal swallowing patterns as muscular functions reflect adaptation to the corrected anterior open bite. But what about the child who presents with an anterior open bite and does not have a history of a digit-sucking habit? Will this child benefit from a palatal crib appliance to restrain the tongue? Or should other approaches be taken in managing the open bite? The answer lies in understanding our previous discussion on normal swallowing patterns and the implications of tongue thrust to occlusion. In the school-aged child without a documented digit-sucking habit, palatal crib therapy directed specifically toward tongue-thrust swallowing as a "causative" factor seems questionable. This is based on the reasoning that, without a documented extraoral habit, the most likely causative factors would be either a significant airway obstruction with habitual mouth breathing or a skeletal open-bite pattern. Both of these situations require a much more comprehensive approach than simple interceptive appliance therapy. In fact, placement of a tongue-restricting palatal crib appliance could exacerbate airway problems by forcing the child to keep the mandible open to accommodate the appliance. The palatal crib design could actually make things worse. The same applies to a skeletal open bite with the usual implications of a vertical growth pattern. Moreover, the variability of normal swallowing patterns in relation to malocclusion, coupled with the spontaneous improvement in tongue-thrusting patterns and anterior open bite that is evidenced in 80% of children by the age of 12 years, argues against tongue thrust-directed therapy as a stand-alone treatment for open bite.

Myofunctional therapy is the conscious retraining of the tongue and strengthening of the lip muscles through a specially designed exercise program. Promoted with the expectation that training muscles to function properly will reduce abnormal pressures, successive steps in the training program include acquainting the patient with the abnormal swallowing pattern, teaching the correct pattern of swallowing using various exercises, and reinforcing the correct patterns. While all are admirable goals, myofunctional therapy remains controversial. Koletsi et al.³⁴ conducted a systematic review and meta-analysis regarding the effect of orthodontic management and oral facial muscle training protocols on the correction of myofunctional and myoskeletal problems in developing dentitions. Of the 265 initial search articles, 15 were included in the review, 8 were randomized controlled trials, and 7 were

controlled clinical trials. Only two of the included randomized controlled trials allowed for quantitative synthesis. The authors concluded that although early orthodontic management and myofunctional treatment in the primary and mixed dentition appears to be a promising approach, the quality of the existing evidence is questionable.³⁴

Regardless, training exercises involve proper tongue tip placement against the roof of the mouth and not between the teeth, masseter muscle isometrics to ensure swallowing with the molar teeth in contact, and lip exercises to correct mentalis and facial muscle activities. One technique requires the patient to practice swallowing correctly 20 times before each meal. Holding a glass of water in one hand and facing a mirror, the child takes a sip of water, closes the teeth into occlusion, places the tip of the tongue against the incisive papilla, and swallows. This is repeated, followed each time by the relaxation of the muscles until the swallowing progresses smoothly. The use of a sugarless mint may also help in muscle training. The child is instructed to use the tip of the tongue to hold a mint against the roof of the mouth until it melts. As the mint is held, saliva flows and makes it necessary for the child to swallow. Treatments are usually programmed to take 7–10 weeks of exercises until the oral environment is stabilized. Most therapists prefer to wait until the child is about 9 years of age before beginning treatment because normal developmental changes occurring around this same time allow for more favorable positioning of the tongue. After the patient has trained the tongue and muscles to function properly during swallowing, an acrylic palatal retainer with a "fence" may be constructed as a reminder to position the tongue properly during swallowing (Fig. 23.32).

In patients with tongue-thrust swallowing and a speech problem, referral to a speech therapist is the most appropriate course of action. If a malocclusion is also present, the coordinated use of myofunctional therapy by the speech therapist and orthodontic treatment may be undertaken to take advantage of each service. Generally, any therapy aimed at altering the tongue positions during swallowing and speech should be done in conjunction with or after the orthodontic treatment rather than preceding it. If mouth-breathing postures are identified with clinical symptoms of airway blockage, the dentist should refer the child to an otolaryngologist for appropriate medical consideration. Patients who are obligate mouth breathers secondary to hypertrophic adenoid tissue or allergic conditions can have corresponding poor postural relationships that can influence the developing skeletal face. With proper diagnosis and management, the airway interference may be reduced or eliminated to influence occlusal development and orofacial musculature in a positive direction. In patients with tongue thrust alone and no malocclusion, speech, or airway problems, there is no reason to recommend any interceptive orthodontic treatment.

Anterior Crossbite in Primary and Mixed Dentitions

Dentoalveolar anterior crossbite represents a linguoversion of one or more maxillary anterior teeth with resultant "locking" behind the opposing mandibular teeth in full closure (Fig. 23.33). The anterior crossbite is usually an acquired malocclusion resulting from local etiological factors (e.g.,

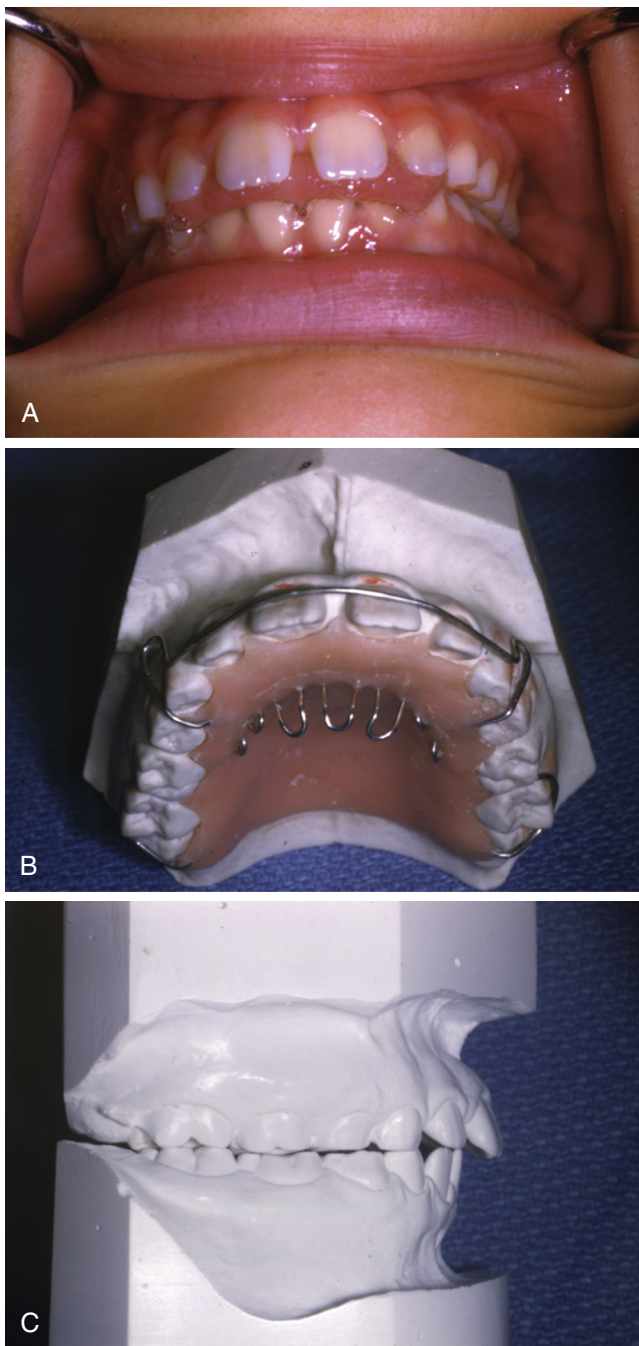


Fig. 23.32 (A) Anterior open bite resulting from a tongue-thrust swallowing pattern. (B) A removable retainer with a crib like component helped “retrain” the tongue from being thrust forward during the swallowing process. (C) The tongue-thrust pattern has been overcome and the occlusion is greatly improved.

arch crowding) that interfere with the normal eruptive positioning of the maxillary anterior teeth. In some cases during closure movements, premature contacts due to the lingual malpositioning may result in a forward mandibular deviation to effect full closure that “locks” the anterior segment in a crossbite posture involving multiple teeth. Such an acquired muscular pattern is referred to as a pseudo-Class III malocclusion as the mandible shifts from Class I to Class III relationships during closure (Fig. 23.34). In most cases, localized dentoalveolar anterior crossbites with or without mandibular displacement should be treated as soon as they are discovered. Delayed treatment can lead to serious complications such as loss of arch dimensions and asymmetric midlines, traumatic occlusion with stripping of gingival tissue on the labial aspect of the lower tooth, wear facets on involved incisors, and untoward growth patterns if a functional shift is involved. Importantly, at later developmental stages, not only does differential diagnosis become more difficult, but also the mechanics for correction become more complex with less predictable results. Simple appliance designs are usually adequate to achieve correction of dentoalveolar anterior crossbites. Diagnoses should be made with consideration of the following clinical findings.

1. *Number of teeth involved:* Involvement of one or two incisors usually represents a dental crossbite, although the chance of functional displacement is increased as more teeth are involved. Suspicion of a skeletal malocclusion grows in proportion to the number of teeth in crossbite.
2. *Inclinations of maxillary and mandibular incisors:* Dentoalveolar and functional crossbites usually exhibit lingual inclination of the maxillary incisors and normal to slight labioversion of the lower incisors in response to incisal interference. In a true skeletal Class III malocclusion, lower incisors are retroclined, whereas maxillary incisors usually exhibit normal to proclined inclinations.
3. *Mandibular closure pattern and facial profile:* In a dentoalveolar crossbite, the facial profile and buccal occlusion should present a neutroclusion at rest, first contact, and full closure, with the soft tissues masking the dental malpositioning. Any displacement of the mandible should be observable because a shift from neutroclusion to Class III buccal patterns “worsens” a normative profile at rest to an apparent prognathism in full closure. If the child can readily bite to an edge-to-edge incisor position without directed jaw manipulation, evidence of a forward shift of the mandible is confirmed. A Class III skeletal malocclusion should close in a smooth pattern without anteroposterior disruption. A mesiocclusion of molar positioning and prognathism of the profile should persist at all times.



Fig. 23.33 Examples of dentoalveolar anterior crossbites with lingually locked maxillary central incisors. The malpositioning with traumatic occlusion results in forward displacement of the lower incisor and stripping of the gingival tissues.



Fig. 23.34 Lingually displaced central incisors may produce occlusal interference on closure that results in a functional anterior shift of the mandible (pseudo-Class III malocclusion). (A) Maximum intercuspation after anterior shift of mandible. (B) First contact with edge-to-edge incisor interference. (C) Maxillary incisors malpositioned lingual to arch form.

TABLE 23.1 Anterior Crossbite Correction Methods: Pros (+) and Cons (–)						
	Cost	Compliance	Fabrication Ease	Practitioner Control	Effectiveness	Efficiency
Tongue Blade	++	--	++	--	–	++
Inclined Guideplane	+	–	–	+	–	+
Removable Spring	–	–	--	–	+	+
Fixed Spring	–	++	--	++	++	++
Anterior Brackets (2" × 6")	--	++	–	+	++	++

4. *Familial appearance:* If similar dentofacial conditions exist, the probability increases that the case involves a skeletal problem that is genetic in origin rather than a localized malocclusion.
5. *Cephalometric analysis:* Assessment of lateral cephalograms can usually confirm impressions of the clinical examination (see [Chapter 22](#)). Realizing that anterior displacement may demonstrate cephalometric measurements indicating mandibular prognathism when the cephalogram is obtained in full occlusion, the clinician should analyze centric relation cephalograms or overlay analysis of rest position and full occlusal tracings to determine true skeletal relationships. The inclination patterns of the upper and lower incisors are key factors in this assessment.

Diagnosed in the transitional dentition, dentoalveolar anterior crossbites with or without mandibular displacement are usually approached from the viewpoint that the primary discrepancy involves one or more maxillary anterior teeth in linguoversion. Any labial inclination of lower incisors is in response to the upper malpositioning. This simplifies treatment in that correction is directed toward labial movement of displaced maxillary incisors to “jump” the bite. After normal maxillary incisor positions are achieved, the proclination of lower incisors is usually self-correcting with the establishment of normal overbite and overjet. Studies have shown that gingival recession in the lower anterior segment improves spontaneously after crossbite correction. In most cases, removal of the traumatic occlusion allows normal attachment levels to be sustained without the need for specific periodontal treatment procedures. If it can be assumed that local etiologic factors such as over-retained primary incisors have been eliminated, one of several treatment methods may be selected. This is done after an evaluation of biomechanical decision factors such as the following:

1. *Incisor positioning and available space:* If space is available, options can be directed toward simple labially directed

- tipping movements of the involved maxillary incisors. This particularly applies if the root of the lingual tooth is in the same relative position as it would occupy in normal occlusion. If space is not available or with greater bodily tooth displacement, Edgewise appliances may be required to create space and provide controlled orthodontic movements.
2. *Stage of eruption:* If the displaced maxillary incisor is in active eruption, the treatment may use simple leveraging techniques to redirect the tooth forward into acceptable position. If the tooth is fully erupted, the forces of occlusion will usually not allow simple leveraging of eruption paths. Directed forces to effect labial repositioning of the involved maxillary anterior teeth will be required.
3. *Degree of overbite:* During treatment, occlusal bite planes are often proposed to remove overbite interference during labial movement. Whereas this is desirable in the use of removable appliances and those incorporating labial bracketing of involved teeth, the 3- to 4-mm freeway space at rest position and the use of directed lingual applied forces from fixed appliances negate the need for bite opening to achieve successful labial movement in most clinical situations. The overbite has greater impact on retention; positive overbite will maintain positioning of the incisors once corrected.

In addition to these factors, cooperation of the patient and parent and personal preference of the clinician are considerations in treatment mechanics. Treatment approaches are of two general types: (1) passive incisal guides that, during mandibular closure, redirect or “leverage” maxillary anterior inclinations in a labial orientation; and (2) active appliances that use directed orthodontic forces to achieve labial repositioning of the maxillary anterior teeth ([Table 23.1](#)).

TONGUE BLADE/POPSICLE STICK THERAPY

Cooperative children can often correct a localized anterior crossbite using the wedging effect of a tongue blade

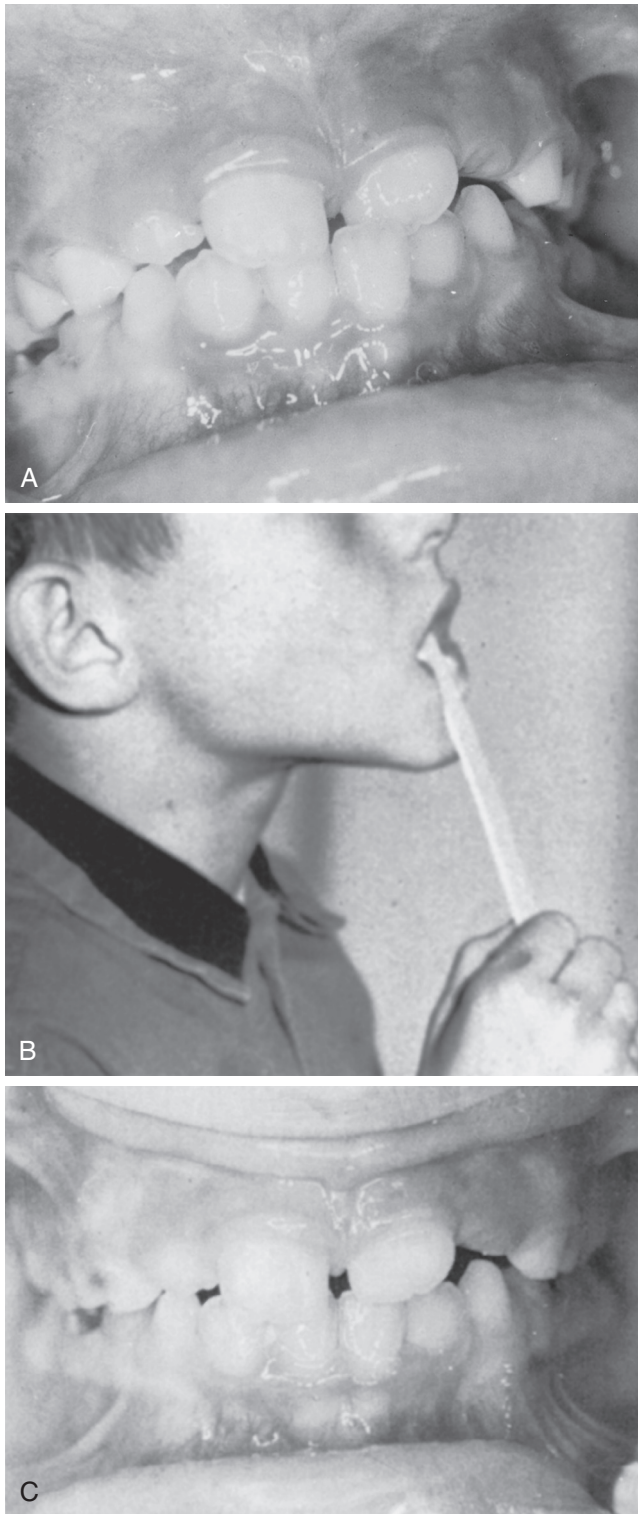


Fig. 23.35 (A) Partially erupted central incisor with a minimal degree of overbite and lingual locking. (B) A tongue blade was used to exert labially directed pressure on the lingually locked incisor. (C) Correction of the crossbite accomplished with the tongue blade.

or popsicle stick (Fig. 23.35). Teeth in initial eruption with a minimal degree of locking can often be repositioned within 24 to 72 hours. The child is instructed to place the stick behind the locked tooth and, using the chin as a fulcrum, exerts pressure on the tooth in the labial direction.

The procedure is done in 15- to 30-minute increments at a time for at least several hours of engagement. The obvious advantage of the technique is that “self-correction” avoids the expense and time involved with appliance therapy. The technique is highly dependent upon the frequency, duration, and accuracy with which the child uses the leverage stick against an erupting incisor. While it is still possible to correct an established crossbite with intense tongue blade therapy, the treatment is very unlikely if the tooth is erupted into full crossbite.

LOWER INCLINED PLANE

An acrylic extension from the lower anterior teeth designed to engage the incisal edges of lingual displaced maxillary teeth during closure applies pressure upon patient closure that will direct the engaged tooth labially into normal bite position (Fig. 23.36). Prerequisites for an inclined plane are adequate space in the maxillary arch, a normal or excessive overbite, and sufficient mandibular teeth for retention of the acrylic. The inclined plane is constructed using self-curing resin on a working model to enclose the lower canine-to-canine anterior segment. This maximizes stability while preventing excessive lingual movement of the lower incisors. The acrylic should engage only the upper tooth or teeth in crossbite and incorporate approximately a 45-degree incline to the long axis of the lower incisors. The inclined portion should extend about $\frac{1}{4}$ inch posteriorly such that the patient cannot readily bite behind the inclined plane.

At placement, the inclined plane is tried in the child's mouth before cementation to ensure that only the locked upper incisor is in contact with the acrylic and the plane does not touch palatal tissue. The posterior “bite opening” should be slightly beyond the rest position (not more than 2–3 mm) to avoid excessive muscle fatigue. This bite opening limits the time the appliance can be worn because eruption of posterior teeth may occur within 2 weeks and a tendency to an anterior open bite may result. The physical activities of children with bite planes should be restricted to minimize the possibility of avulsion or luxation of the teeth that occlude on the plane from a blow to the chin. Follow-up should be made at 1 week, with adequate bite jumping usually achieved within this time. If not “jumped” after 1 week, the inclined plane may be continued no more than an additional week. The appliance design and upper spacing should be evaluated for any interference to correction before the therapy is continued. If the situation is not corrected in this time, either the original diagnosis may be in error or more controlled mechanics are indicated. Once correction is achieved, the appliance should be carefully removed to allow for final positional adjustments with the natural vertical overlap providing retention of the corrected positions.

The advantages of the inclined plane lie in ease of fabrication, simplicity of action, rapid correction time, and possible use when there is insufficient eruption to engage active appliances. Disadvantages include discomfort associated with forced bite opening, poor aesthetics, limitations on diet, potential for gingival irritation, possibility of creating an open bite, and, of particular concern, the risk of traumatic injury if the child hits his/her chin while the inclined

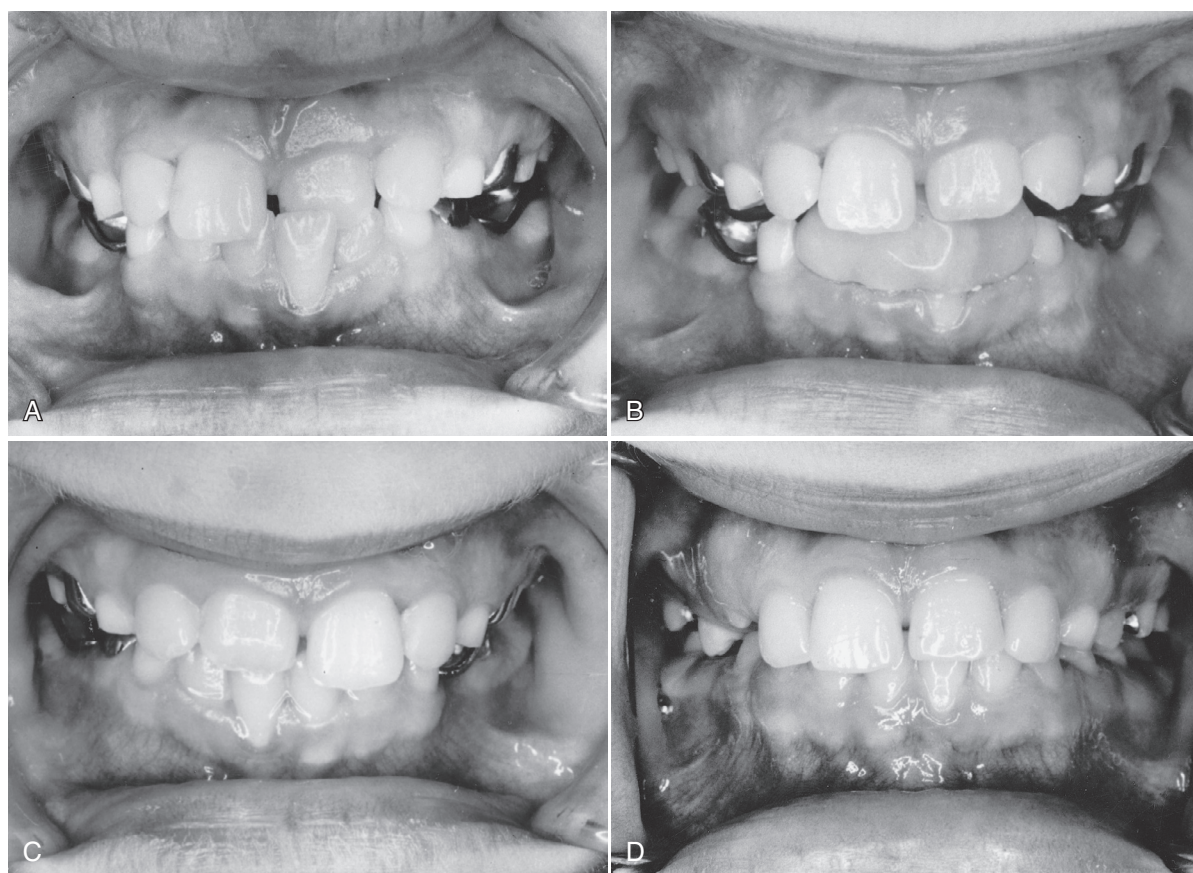


Fig. 23.36 (A) Essentially normal occlusion except for the central incisor crossbite. (B) A lower cemented acrylic bite plane was used to reposition the lingually locked incisor. (C) The tooth has moved into correct position with sufficient overbite to maintain the new relationship. (D) Four years after the correction of the crossbite. Notice improvement in the appearance of the tissue on the labial surface of the lower left central incisor.

plane is positioned in the mouth. In addition, the inclined plane may be dislodged by occlusal stress and require re cementation. Given these disadvantages and the availability of other options that are more predictable and safer, the use of acrylic inclined planes is generally to be avoided except when other options are simply not feasible.

PALATAL SPRING APPLIANCES (REMOVABLE HAWLEY OR FIXED PALATAL WIRE)

A fixed or removable appliance incorporating palatal springs provides the best option for dental anterior crossbites that are not amenable to tongue blade guidance. Properly oriented springs exert targeted, labially directed pressures against the teeth from the palatal side and are not affected by the reverse overjet. The major disadvantages are technical: the finesse needed in engaging the spring to the involved tooth or teeth, adjustments if breakage occurs, modification for retention if overbite is not adequate, and untoward movements. These disadvantages may be readily overcome with proper fabrication and management of the appliance.

A removable Hawley-type retainer modified with auxiliary springs can reduce lingual displacement of maxillary incisors, with correction usually achieved in 6–12 weeks (Fig. 23.37). A conventional Hawley retainer incorporating a labial bow and Adams clasps on the molars provides the base for the spring component. Although usually

not necessary, the use of full posterior occlusal coverage enhances the effectiveness of a removable approach by minimizing any overbite interference to labial movement. Appliance action is enhanced if the appliance is seated when teeth are in occlusion to engage the finger spring more fully in counterbalancing the displacement effects of spring engagement.

With a helical loop finger spring of 0.020- or 0.022-inch stainless-steel wire, activation should represent 2–3 mm of helical loop closing from passive spring positioning that approximates the incisal edge of the contacted tooth. When activated, the spring tends to slide along the sloping lingual surface of the incisor to exaggerate tipping effects. This problem can be overcome by the bonding of a small “button” of flowable composite on the lingual surface to create a retentive undercut for maintaining a cervical orientation of the spring. This optimizes labial movement with less tipping by orienting the force vector closer to the center of rotation of the engaged tooth. The composite should not interfere with vertical closure after the malposed tooth is moved out of crossbite (i.e., not placed too far incisally), while ensuring spring engagement by extending the mesiodistal width of the tooth.

FIXED TRANSPALATAL WIRES WITH SPRINGS

A transpalatal connector wire of 0.036- or 0.040-inch stainless-steel soldered to banded molars that incorporates

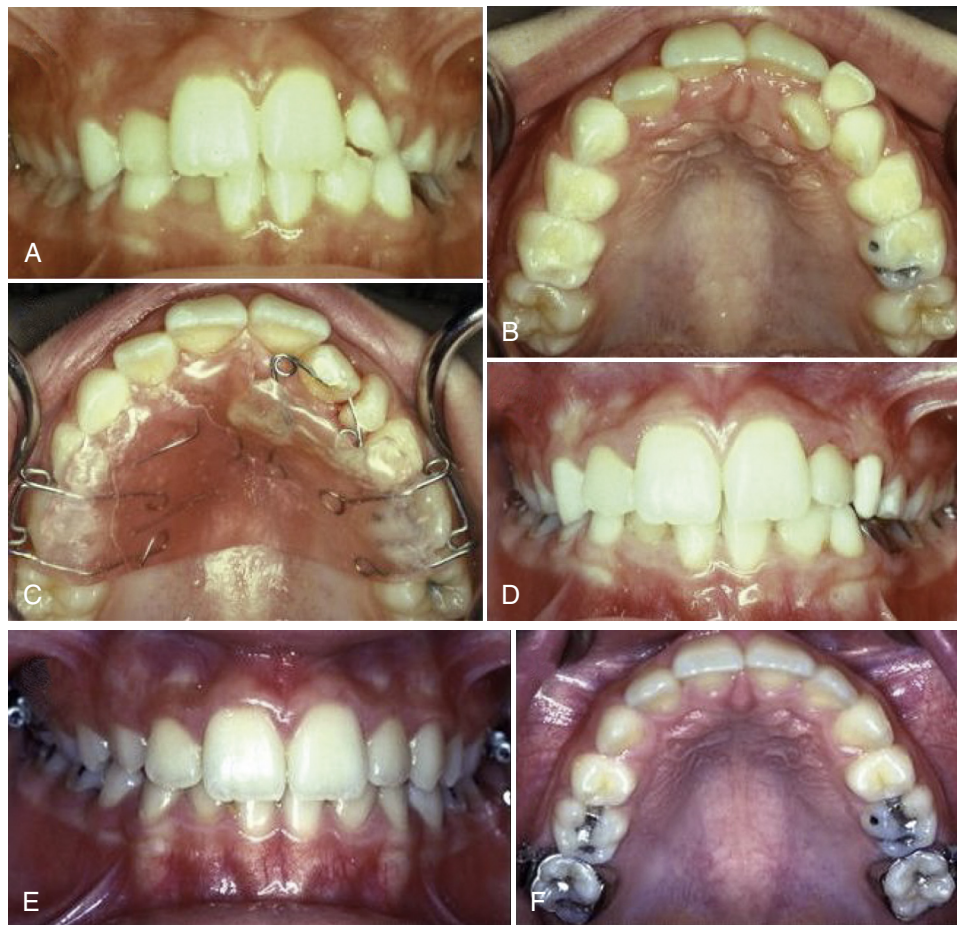


Fig. 23.37 Removable Hawley-type finger spring appliance. (A) and (B) Lingual locked permanent lateral incisor with retained primary lateral incisor and insufficient space for the lateral to move forward. (C) A removable Hawley-type appliance with finger spring designed to correct the condition. Note that the retained primary incisor was extracted and the mesial surface of the primary canine was disked to allow space for tooth movement. Activation of the spring with engagement under the lingual composite “button” resulted in labial movement of the tooth. (D) The corrected occlusion at the time the appliance was discontinued. (E) and (F) Same patient 3 years later without any intervening retention or other treatments. Bands have just been placed in preparation for phase 2 braces.

a helical loop spring of 0.020-inch stainless-steel wire provides a very effective method to labialize maxillary incisors involved in anterior crossbite (Fig. 23.38). The orientation of the spring essentially mirrors the procedures outlined for the removable Hawley appliance. With the lingual composite button used to engage the spring, the increased stability and rigidity of the fixed anchorage system dramatically enhance directed forces toward the center of rotation of the engaged incisors. The fixed approach results in significantly less tooth tipping in offering a more bodily applied tooth movement and provides continuous force application that is not dependent on the child's cooperation. These factors combine to effect correction of dental anterior crossbites by means of a fixed spring approach with average treatment times ranging from 1 to 3 weeks.

Abutment support may be from either second primary molars or first permanent molars depending on developmental and eruptive status, condition of the crown, and clinician choice. After bands are fitted to selected abutments and a working model is prepared, the anchor wire is bent to approximate the palatal arch form about 5 mm lingual to the anterior teeth in crossbite. This positioning provides accurate space for bending a compact double helical loop spring as the active component. The maxillary incisors to

be engaged should be cut off horizontally on the working model at the cingulum level to create a “table” to position the spring horizontally with proper length. Passively, the helical loop extends from the anchor wire to rest on the cut-off incisal table, with the free end of the spring at the labial surface. The original positioning of the palatal anchor wire about 5 mm behind the crossbite teeth provides this distance in a double helical design. Careful soldering of the spring to the palatal wire completes the appliance in preparation for polishing.

Labial Edgewise Brackets and Archwires

Edgewise mechanics are used when multiple incisors are in crossbite, palatal displacement and rotations are severe, and adjacent tooth movements are needed to adjust anterior spacing. While the clinician who wisely applies Edgewise techniques can achieve greater control in tooth positioning, their use presents major disadvantages in the early mixed dentition when most anterior crossbites are corrected. Disadvantages include increased chair time in placement, adjustment, and removal; need for special equipment and supplies; increased soft tissue irritation; decalcification of teeth; risk of injury to developing teeth with excessive biomechanical movements; and the expectations and expenses



Fig. 23.38 Fixed palatal finger spring appliance. (A) Lingual locked permanent central incisor with significant overbite. (B) Fixed palatal appliance at delivery with double helical loop finger spring designed to labialize the single incisor. Initial activation of the spring from a passive position at the labial surface to engage the lingual composite “button” resulted in directed movement of the tooth. (C) The corrected occlusion at 17 days of treatment time. (D) The appearance of the spring at completion with the incisor out of crossbite. The lingual composite had been removed at 10 days of treatment time to eliminate vertical interference with positioning.

associated with “braces.” The discussion of Edgewise archwire techniques falls beyond the concepts of interceptive management and is illustrated in the section Comprehensive Orthodontics (pages 519–528).

Finally, it is worth mentioning that an interesting study by Rosa et al.³⁵ showed 84% spontaneous correction of anterior crossbites in conjunction with rapid palatal expansion treatment in the mixed dentition. This occurred whether or not the patients had an existing posterior crossbite because all 50 patients studied exhibited maxillary crowding, but only 20 had a posterior crossbite.

Posterior Crossbite in Primary and Mixed Dentitions

Before treatment, the type of posterior crossbites in children must be determined—whether the discrepancy is a localized problem in tooth eruption (dental crossbite), a gross basal disharmony between the maxilla and mandible (skeletal crossbite), or a transverse discrepancy in the upper to lower arch width that produces a lateral shift of the mandible on closure (functional crossbite).

Dental posterior crossbites involve atypical eruption and alignment with localized displacement of individual teeth into crossbite configurations. Most often involving isolated permanent maxillary first molars or premolars, dental crossbites are usually corrected in conjunction with comprehensive Edgewise orthodontics. Within an interceptive context, isolated first permanent molar cross-bites can be corrected by the use of cross-arch elastics (Fig. 23.39). A hook or button (either bonded to enamel or welded onto bands) on the lingual and buccal surfaces of the upper and lower molars, respectively, is used to secure elastics. The

elastics should be changed by the child or parent each day until the crossbite has been corrected. Typically, a crossbite involving isolated first molars can be corrected with cross-arch elastics in 4–8 weeks. If either of the opposing molars is in correct alignment before treatment, an anchorage appliance (lower lingual arch or upper Nance/transpalatal bar) may help prevent movement of that tooth. The corrected cuspal interdigitation usually holds the teeth in their new relationship, so there is no need for a retentive appliance.

Skeletal posterior crossbites present as gross discrepancies in basal relationships of the maxilla and mandible, usually presenting a full bilateral crossbite with severe constriction of the maxilla (Fig. 23.40). Midlines are generally coincident to the facial midline in occlusion, with no functional deviations observed on closure. The skeletal dysplasia is often complicated by other factors such as crowding of the maxillary teeth, anterior open bite, and environmental factors that impede normal growth patterns (e.g., severe airway problems, cleft palate). Kurol and Berglund³⁶ found 4 of 86 crossbites in children, a relatively low frequency, presenting as full bilateral crossbite.

Functional posterior crossbites involve a lateral shift of the mandible during closure in response to transverse occlusal interference between the maxillary and mandibular arch widths. The deviation of the mandible presents as a unilateral crossbite in centric occlusion involving multiple posterior teeth on one side, normal buccolingual occlusion of the contralateral side, and a deviation of the lower midline and chin toward the crossbite side (Figs. 23.41 and 23.42). While presenting a unilateral appearance in occlusion, functional posterior crossbites show cusp-to-cusp transverse contacts bilaterally, with a constricted maxillary arch of insufficient width to enclose the lower dentition at initial contact. Factors contributing to constriction in maxillary

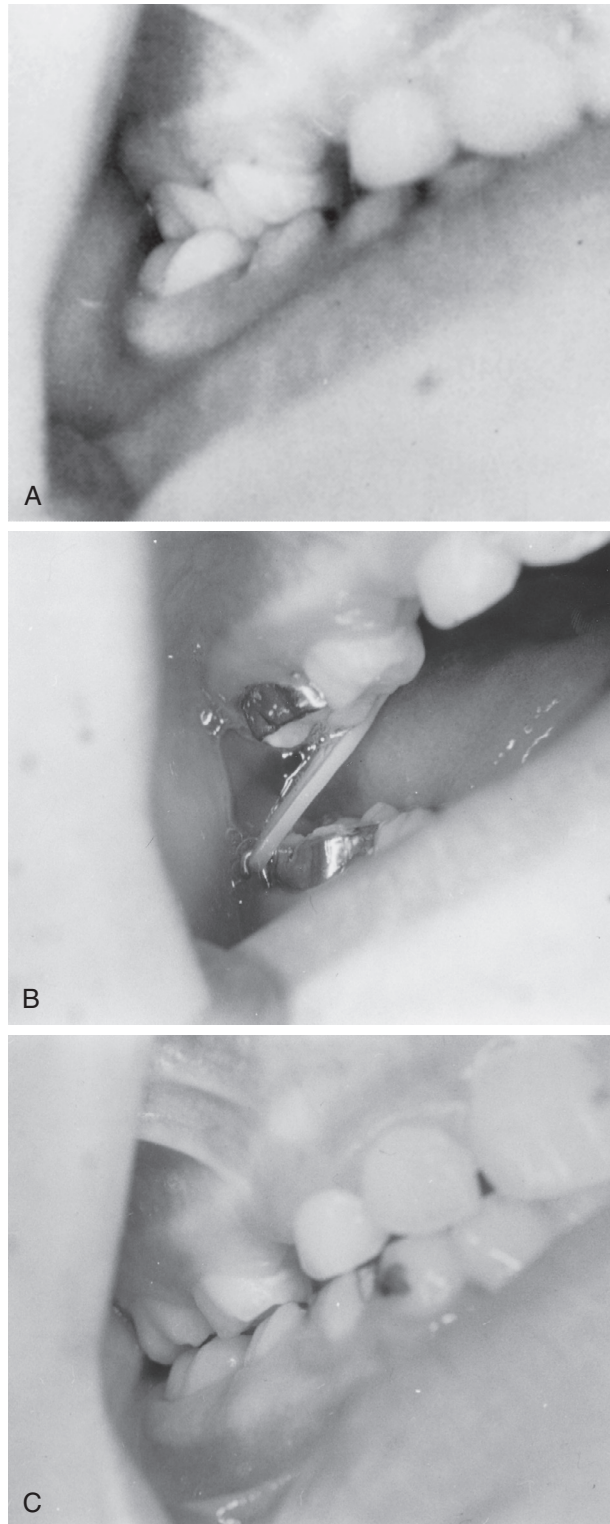


Fig. 23.39 (A) Buccal crossbite limited to the first permanent molars on the right side. (B) Molar bands with hooks and cross-arch elastics from lingual side of upper to buccal side of lower are used to correct the crossbite. (C) The crossbite has been corrected in a 4-week period.

width include upright primary canine interference, thumb- and finger-sucking habits, and mouth breathing/airway problems. Studies demonstrate a direct linear progression between prolonged digit and pacifier habits beyond the age of 4 years and a higher incidence of posterior crossbites.

Functional posterior crossbites are among the more common occlusal problems observed in the primary and mixed dentitions, with an incidence rate of 5%–8% in children. Lindner and Mod  r³⁷ documented patterns in 76 children with primary dentition and reported that three or more teeth (canines back) were involved in 85% of the crossbites, with two-thirds extended to include the primary lateral incisors. A lateral shift of the mandible was seen in 97% of the children, resulting in a lower midline discrepancy of about 2 mm on average. Other studies support the impression that more than 90% of posterior crossbites in children exhibit functional shifting of the mandible on closure as a component of the crossbite pattern. As a result of the functional shift, dental, skeletal, and neuromuscular adjustments likely result in further constriction of the maxillary arch, maldistribution of erupting teeth and alveolar bone, and asymmetric growth of the contralateral sides. In a study of 35 children with posterior crossbite in the primary dentition followed into the mixed dentition, Kutin and Hawes³⁸ reported that 32 of the children showed persistent crossbite of the first permanent molars after their eruption. Other studies have also suggested that posterior crossbites are generally not self-correcting because consistent incidence rates have been shown in children at 3, 6, 8, 10, and 12 years of age. It appears that less than 10% of posterior crossbites present in the primary dentition self-correct into the mixed dentition.

In conjunction with functional posterior crossbites, asymmetric condylar positioning has been demonstrated on tomograms and transcranial radiographs. Hesse et al.³⁹ documented condylar positioning using temporomandibular joint tomograms in 22 patients with functional posterior crossbite corrected with maxillary expansion at a mean age of 8½ years. The condyle on the noncrossbite side was positioned more anteriorly before treatment and moved posteriorly and superiorly after treatment. The condylar position was similar at pretreatment and posttreatment stages on the crossbite side. Importantly, correction of the crossbite with maxillary expansion established symmetry of condylar relationships in all planes of space. On comparing condylar path and mandibular length in 9 children with unilateral posterior crossbite treated with maxillary expansion between the ages of 5 and 8 years with a group of 13 individuals with untreated crossbites into young adulthood, Pirtiniemi et al.⁴⁰ reported that the condylar path evidenced asymmetry in both treated and untreated individuals, with greater steepness and condylar rotation on the crossbite side. The eminence was flatter in both groups on the non-crossbite side, whereas mandibular length was shorter on the crossbite side. The degree of mandibular asymmetric length was twice as great in untreated children as in those with treated posterior crossbites. Other studies confirm that displacement of the mandible in growing children produces asymmetric mandibular length, with the crossbite side shorter than the noncrossbite side. The mandibular rotation also results in a sagittal asymmetry of contralateral sides, with the crossbite side expressing a more distal step–Class II relationship and the noncrossbite side a more Class I to Class III pattern. Even though correction with maxillary expansion improves molar positioning toward Class I positions on the crossbite side and reduces the midline discrepancy, full establishment of symmetric relationships

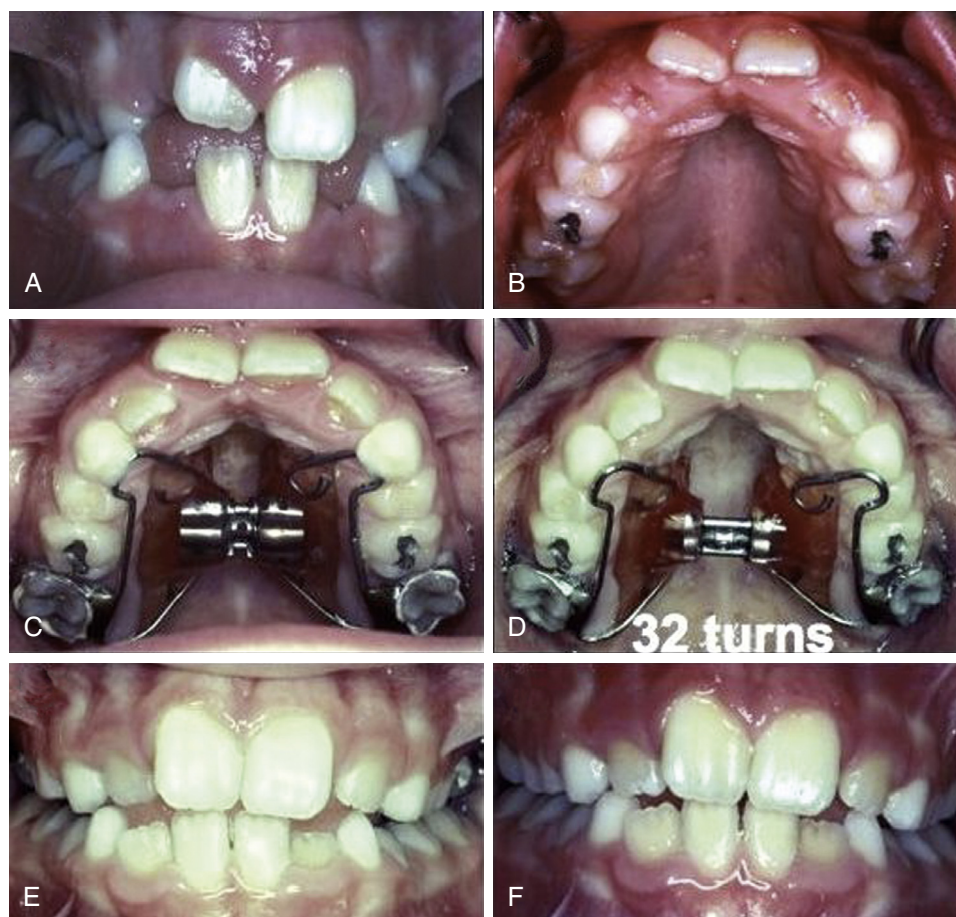


Fig. 23.40 An acrylic jackscrew rapid palatal expander (Haas RPE) in the mixed dentition with bands on the permanent first molars and bonded composite on the primary canines. (A) and (B) The pretreatment bilateral posterior crossbite with constricted and tapering maxillary arch form. (C) and (D) The rapid palatal expansion appliance appearance at cementation and after expansion involving 32 turns on a once-a-day schedule. (E) The occlusion at 3 months with the appliance maintained for retention. (F) The occlusion 1 year after appliance removal.

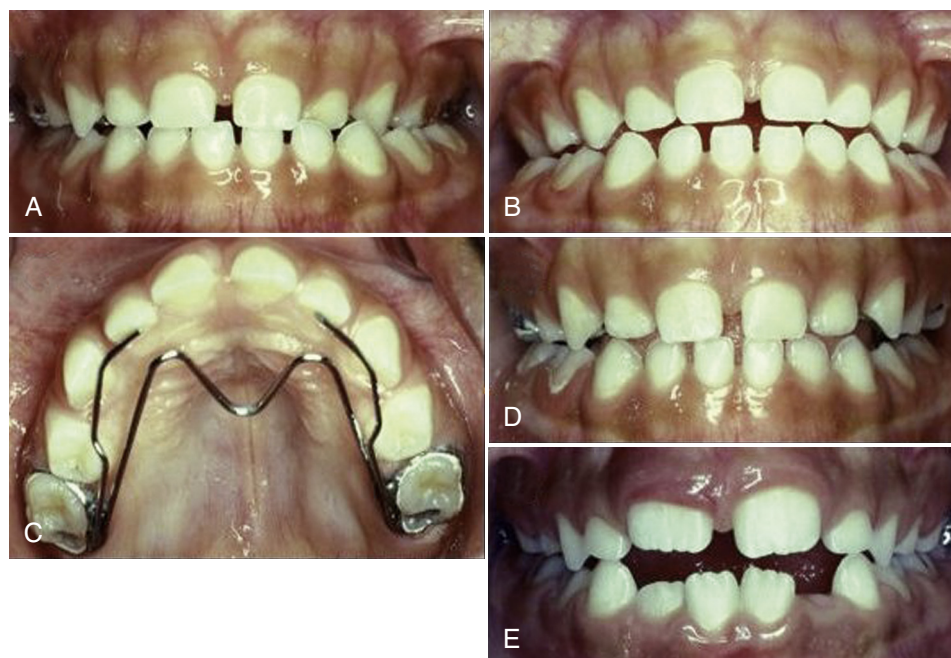


Fig. 23.41 W-arch appliance. (A) Functional posterior crossbite in the primary dentition in maximum intercuspation occlusion. Crossbite extends through buccal segment from the lateral incisor with a 2.5-mm mandibular midline shift to the affected side. (B) In rest to first contact position, the dental midlines are normal with the posterior segments edge-to-edge bilaterally in transverse width. (C) Soldered W-lingual arch appliance at cementation. (D) The crossbite was corrected in 6 weeks with 2- to 3-mm overexpansion; the appliance was left in place for 3 months. Notice that the dental midlines are properly aligned with the functional shift eliminated. (E) Two years posttreatment, the transverse posterior widths are in proper relationship with no mandibular shift evident during closure.

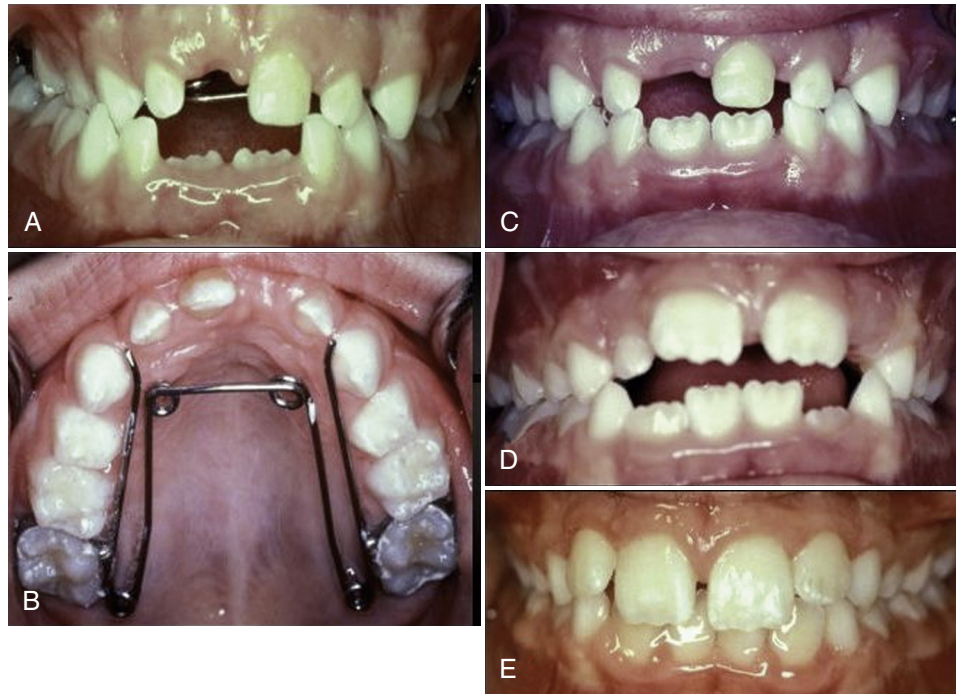


Fig. 23.42 Quad-helix appliance. (A) Functional posterior crossbite in the early transitional dentition in maximum intercuspation occlusion. Crossbite extends through buccal segment with a 1.5-mm mandibular midline shift to the affected side. (B) Soldered quad-helix appliance at cementation. Note the symmetric and horizontal loop design for optimum expansion with minimal buccal tipping of molars. (C) Occlusion 2 weeks after appliance removal. The crossbite was corrected in 4 weeks, and the appliance was left in place for 2 months. Dental midlines are properly aligned with the functional shift eliminated. (D) Six months posttreatment, the transverse posterior widths remain in proper relationship with no mandibular shift evident during closure. (E) Two years after treatment into mid-mixed dentition with proper transverse relationships and no functional shift of mandible noted.

after correction is not a consistent finding. The continuation of some degree of asymmetry after correction suggests that unbalanced growth occurred up to the time of correction, more balanced symmetry of the growth patterns was expressed after correction, and any acquired pretreatment morphological asymmetry remained after correction.

Early correction of functional posterior crossbites has been shown to enhance developmental patterns by redirecting teeth into more normal positions, correcting asymmetries of condylar position, allowing for normal vertical closure without functional deviations, making beneficial dentoskeletal changes during periods of dynamic growth, and eliminating factors detrimental to dentofacial development.⁴¹ Early treatment also allows for simplified approaches that are less complex, less time consuming, and more physiologically tolerable to structural tissues than are treatment demands in older patients. Delaying correction until the permanent dentition requires more complex mechanics to achieve basal arch corrections and may necessitate surgical approaches to achieving maxillary expansion.

SELECTIVE EQUILIBRATION

Selective equilibration of deflective interference, usually the primary canines, may enhance differences between the intercanine widths and offer some potential for functional crossbite correction without appliances. The equilibration involves selective reduction (i.e., slanting) of the lingual aspects of the upper primary canines and labial reduction of the lower primary canines. When the upper-to-lower intercanine width approximates the same width or the lower is

greater, selective grinding is not effective and upper canine expansion is required. In most full primary or mixed dentition cases, equilibration procedures alone are insufficient to eliminate a functional discrepancy associated with a constricted maxillary dentoalveolar width.

MAXILLARY EXPANSION

Appliances used for maxillary expansion in the correction of posterior crossbites include fixed palatal wire designs (e.g., W-arch, quad-helix), fixed jackscrew expanders (e.g., Hyrax, Rapid Palatal Expander [RPE] of Haas), and removable split-acrylic plate appliances (e.g., Schwarz plate). Success rate for treatments during the primary and mixed dentitions have been documented at greater than 90% for the fixed approaches and 70% for removable appliances. Dimensional changes have documented that early expansion techniques to correct posterior crossbites in children require an average final overall increase of about 3–4 mm in intramolar width and 2–3 mm of intracanine width change for successful correction. The clinical reports further indicate that expansion protocols, regardless of the appliance used, should incorporate an overexpansion of about 2–3 mm beyond these final desired increments during the active phase in order to accommodate settling adjustments after treatment.

Transverse expansion of the maxillary arch is directed at a combination of dentoalveolar expansion and orthopedic separation of the midpalatal suture. It is considered desirable to optimize the opening of the midpalatal suture to provide more stable basal arch expansion than

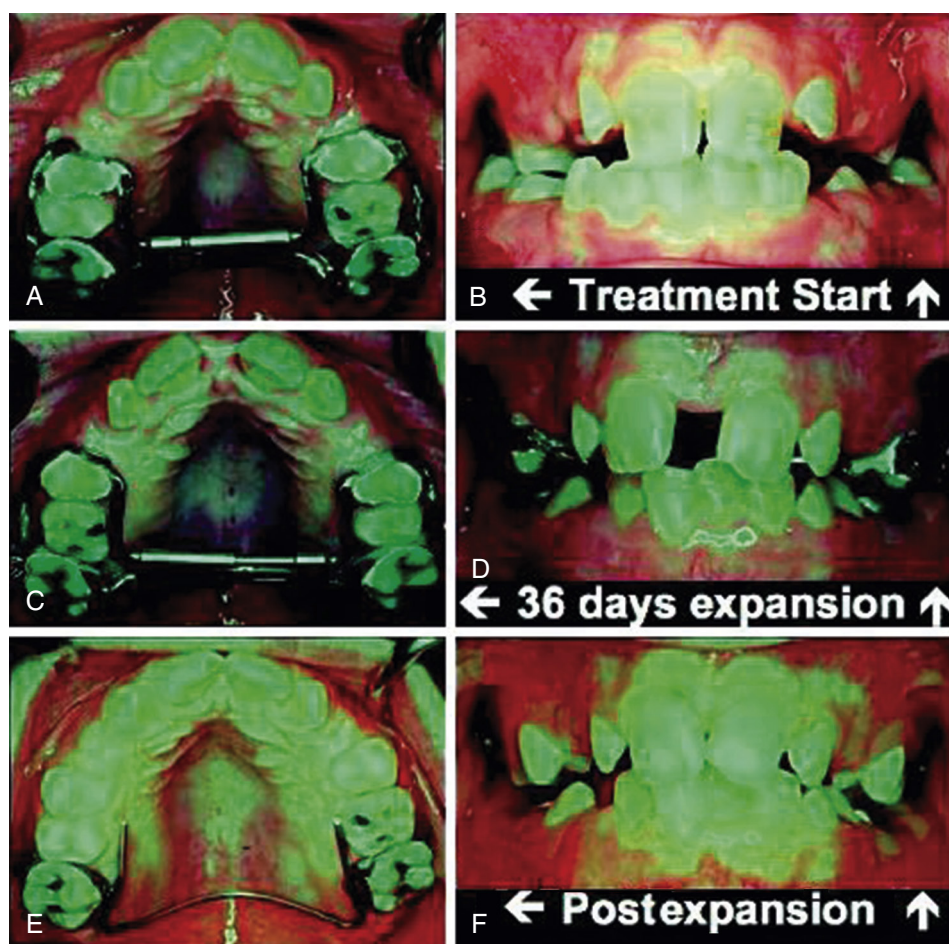


Fig. 23.43 Hyrax appliance in late-transitional dentition with bands on the permanent first molars and first premolars. (A) The Hyrax appliance at cementation. (B) The pretreatment bilateral posterior crossbite with symmetric but constricted maxillary arch form. (C) and (D) Appliance and occlusal appearance after expansion involving 36 turns on a once-a-day schedule. The large midline diastema reflects orthopedic separation of the mid-palatal suture. (E) and (F) The occlusion at 6 months postexpansion. The Hyrax was maintained for 5 months, and then replaced with the fixed transpalatal appliance for retention.

orthodontically oriented lateral expansion. In the consideration of appliance options, the nature of orthodontic and orthopedic movements is closely related to the rate of expansion, the magnitude of force application, and the patient's developmental stage. Fixed palatal jackscrew appliances, such as the RPE of Haas (Fig. 23.40) and the Hyrax (Fig. 23.43), are applied bilaterally to maxillary posterior teeth, with the midline screw generally expanded at a rate of one or two turns per day (one turn equals 0.25 mm of screw widening) during an active treatment time of 1–4 weeks. Single activations of fixed jackscrews produce high magnitude forces in the 3- to 10-pound range that maximize orthopedic separation by overwhelming suture tissues before substantial orthodontic movement can occur. The relative skeletal and dental components produced by rapid palatal expansion have been evaluated with standardized nonanatomic reference points (e.g., implants) and frontal cephalograms. Krebs⁴² reported average arch width increases of 6 mm (range, 0.5–10.3 mm) for 23 individuals aged 8–19 years, with a total dental arch increase twice that of the skeletal segments. Analyzing the Krebs data, Hicks⁴³ estimated that skeletal separation accounted for approximately one-half of increased arch width in 8- to 12-year-olds and about

one-third of the increase in 13- to 19-year-olds. Retention periods of 6 months involving fixed appliances (e.g., expanded appliance, transpalatal bar) are recommended to allow for reorganization and stabilization of rapidly expanded maxillary sutures.

Compared with the jackscrew appliances, fixed palatal wire appliances (e.g., W-arch, quad-helix) accomplish maxillary expansion following “low-force” and “slow-expansion” procedures. Thomas et al.⁴⁴ determined that W-arch (Fig. 23.41) and quad-helix (Fig. 23.42) designs with 6–8 mm of expansion produced lateral forces in the range of 400–600 g (approximating 1 pound) at the molar positions and 200–300 g at the canine level. Some degree of sutural separation has been documented during the primary and mixed dentition stages with forces in these ranges. Using forces of less than 2 pounds to achieve maxillary arch width increases from 3.8 to 8.7 mm during treatment, Hicks⁴³ estimated that skeletal changes represented 24%–30% of the total arch width increase in 10- to 11-year-old children and 16% in 14- to 15-year-olds. Although they did not document the relative ratios of orthopedic versus orthodontic change, Harberson and Myers⁴⁵ reported radiographic evidence of suture opening during the deciduous and early mixed dentition in 8 of 10 posterior crossbites successfully

corrected with a W-arch appliance. Bell and Lecompte⁴⁶ reported suture separation on each of 10 children (mean age, 6 years 9 months) by means of quad-helix appliances with mean increases of maxillary intermolar width of 5.3 mm and maxillary intercanine width of 4.1 mm in successfully correcting functional posterior crossbites. The conceptual model of fixed palatal wire appliances in the primary and mixed dentitions is that favorable orthopedic and orthodontic ratios of expansion are realized with less disruption than with rapidly expanded sutures. Because of the “physiologic” nature of the expansion, the integrity of tissue elements is sustained to allow for enhanced stabilization of the changes, with retention periods of up to 3 months appearing adequate.

The palatal wire W-arch and quad-helix designs offer the advantages of increased molar rotational ability, relative comfort, minimal effect on speech and deglutition, reduced soft tissue irritation, and removal of adjustment responsibility from the patient-parent. Posterior crossbites in the full primary dentition are usually treated with banding of the deciduous second molars at ages 4–5 years. In the mixed dentition period (i.e., 6–11 years of age), the first permanent molars are generally banded for posterior crossbite correction. During the active eruption stage of the first permanent molars, from about 6 months before emergence until opposing occlusion is established, maxillary expansion procedures should usually be delayed. The first permanent molars may not be affected by expansion of the deciduous dentition during this transitional stage and may erupt into crossbite, thus requiring additional treatment. Delaying expansion until the first permanent molars are in occlusion results in no significant technical problems related to treatment. The Hyrax jackscrew appliance becomes the priority choice for maxillary expansion when gross discrepancies in basal relationships present as full bilateral crossbites, when there is pronounced maxillary constriction with severe crowding of the maxillary teeth, and when other factors suggest the use of a rapid palatal expansion to exaggerate orthopedic over orthodontic movements. True bilateral posterior crossbites require twice as much incremental expansion as needed in functional crossbites, bringing into play the greater increments achievable with fixed jackscrew appliances. Given an increasing resistance to sutural separation, older patients with late mixed or young permanent dentition (i.e., 10- to 16-year-olds) require higher force systems of rapid palatal expanders. Additionally, the transitional status of exfoliating primary and erupting permanent teeth in the late mixed dentition may complicate anchorage options in the use of palatal wire appliances. The Hyrax is used until growth is complete (girls, 16–17 years; boys, 18–21 years), with sutural separation anticipated during the earlier stages of this developmental period. After retention, regardless of whether jackscrew or palatal wire-type appliances were used in treatment, the laterally tipped dental elements will upright. This dental relapse must be factored into the active expansion and retention phases.

The soldered W-arch uses a 0.036- or 0.040-inch stainless-steel wire contoured to the arch from bands on the most distal teeth involved in the crossbite. The wire is expanded to the bilateral width of the central fossae of the banded molars before cementation, such that the appliance must be compressed 2–3 mm bilaterally for placement on

the banded teeth. It is reactivated by being removed for additional adjustment every 3 or 4 weeks if necessary until the crossbite has been corrected (Fig. 23.41). The appliance may be used as a retainer for 3–6 months after active treatment. The soldered W-arch is very stable, with its primary use in situations that require 4–5 mm of maxillary buccal expansion such as typically required in functional posterior crossbites. Some palatal expansion may occur with the W-arch.

The quad-helix appliance, by incorporating four helical loops into the W-arch design, provides refined adjustment capability for a longer range of force application (Fig. 23.42). For that reason, quad-helix treatment is emphasized, although the basic W-arch design follows similar protocols. The quad-helix is fabricated from 0.036-inch stainless-steel wire with the loops equal in size to optimize symmetric expansion and the “cosmetic” look of the appliance. The anterior loops should be at the level of the canines and approximate the palatal width to minimize the space between the crossbar and the palatal contour. All loops should be as horizontal as possible, with the anterior loops circling toward the palate at the level of the primary canines and the posterior loops away from the palate. This places the helical loop section and the lateral expansion forces in a more palatal position for enhanced expansion effects. The posterior loops should extend approximately 2–3 mm distal to the molar bands for enhanced molar rotation and expansion.

The progress of expansion is followed as described for the W-arch appliance, with a 2- to 3-week appointments interval. Adjustments are made only when progress between successive appointments is static and the amount of increased arch width is inadequate. Expansion is considered adequate when the occlusal aspect of the maxillary lingual cusps comes into contact with the occlusal slope of the mandibular buccal cusps in representing approximately 2–3 mm of overexpansion to compensate for later uprighting of laterally tipped teeth once appliances are removed. Successful expansion with slight overcorrection is usually achieved in 4–6 weeks. If an adjustment is necessary, the appliance should be removed for activations to ensure appropriate expansion increments in both amount and location. Activations consist of, again, opening with finger “accordion”-type action or incorporating strategic bends along the wire lengths to increase lateral expansion. Bends can be done intraorally but tend to create compensating adjustments such that multiple intraoral activations frequently produce untoward movements. The appliance is left in the expanded position to serve as a retainer with a recommended minimum retention period of at least 3 months, although longer periods are suggested, especially if the patient has a history of oral habits (e.g., thumb sucking, mouth breathing, tongue thrusting) or exhibits continued functional inconsistencies in mandibular closure. While using the appliance as its own retainer is convenient, the possibility of continued expansion into the buccal crossbite must be realized. Thus supervision during “retention” with a monthly monitoring schedule is desirable. Heat annealing of the appliance may also be considered, or the clinician may use a follow-up Hawley-type retainer.

Fixed Hyrax jackscrews are preferred for bilateral posterior crossbites with pronounced maxillary constriction that

require 6–8 mm of expansion to correct the transverse discrepancy, and in older patients in whom sutural integrity requires greater force magnitudes to achieve basal arch changes (Fig. 23.43). Expansion effects with the Hyrax appliance are closely related to the rigidity of the appliance, positioning of the jackscrew relative to the palatal arch form, and resistance of the maxillary complex. Banded designs reinforced with buccal and lingual connector wires between multiple abutments demonstrate the most rigidity in design. If such a design is used in the mixed dentition, the first permanent molars and second primary molars provide excellent anchorage for the appliance. In the adolescent dentition, anchorage usually involves first permanent molars and either first or second premolars. These appliances have been shown to generate the greatest orthopedic response when positioned high in the palatal contour and as far posteriorly toward molar positions as possible. Given the force levels generated, an activation rate of one turn per day is advised to achieve expansion on the order of 6–8 mm (24–32 turns) during an active treatment time approximating 1 month. After sufficient expansion is obtained, the appliance is left in place for 6 months to allow for reorganization of the expanded suture and enhanced stability of the arch width achieved.

Eruption Problems and Eruption “Guidance”

Abnormal eruption patterns with resultant ectopic displacement, asymmetry of alignment, disruption in arch integrity, and crowding are all benchmarks of a tooth size–arch size discrepancy. Furthermore, local factors such as supernumerary teeth, congenital absence or malformation of permanent successors, necrosis or dystrophic calcification of a primary tooth secondary to trauma or caries, and ankylosis of primary molars may present barriers to normal eruption and alignment. The watchword for evaluation should be in monitoring the sequence and symmetry of eruption patterns, with a basic rule that the transition should be about the same for contralateral segments.

ECTOPIC ERUPTION OF FIRST PERMANENT MOLARS

First permanent molars may be positioned too far mesially in their eruption path, with resultant ectopic resorption of the distal root of the second primary molar. Bjerklin and Kurol⁴⁷ distinguished two types of ectopic eruption—reversible and irreversible. In the reversible type, the molar frees itself from the ectopic position and erupts into normal alignment, with the second primary molar remaining in position (Fig. 23.44). Most permanent molars in children with reversible patterns had freed themselves by 7 years of age. In the irreversible type, the maxillary first molar remains unerupted and in contact with the cervical root area of the second primary molar (Fig. 23.45). By the age of 7 and 8 years, any ectopic eruption of a permanent first molar should be considered irreversibly locked. Young⁴⁸ observed that ectopic eruption of first permanent molars occurred 52 times in 1619 children (3%), more frequently in boys (33 times) than in girls (19 times). The ectopic

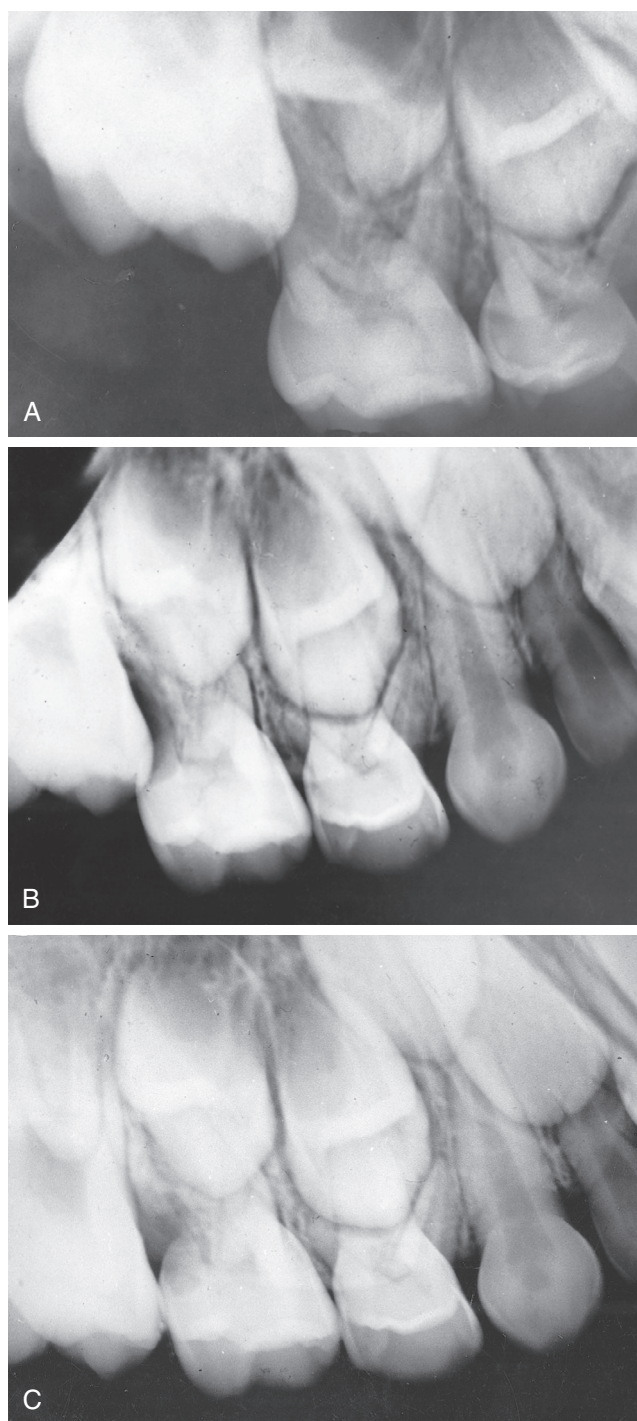


Fig. 23.44 (A) Ectopic eruption of a maxillary first permanent molar with evidence of resorption of the distal buccal tooth of the second primary molar (B) and (C) Subsequent radiographs show continued resorption of the primary molar but “self-corrective” eruptive positioning of the first permanent molar. Approximately two-thirds of ectopic molars are reported to exhibit such a “reversible” pattern.

molar often occurred in more than one quadrant and was most often observed in the maxilla (only two ectopic lower first molars were noted). Young⁴⁸ further observed that two-thirds of ectopic molars erupted into their essentially normal positions without corrective treatment (reversible). Bjerklin and Kurol⁴⁷ also reported that children with irreversible ectopic eruption patterns had significantly larger

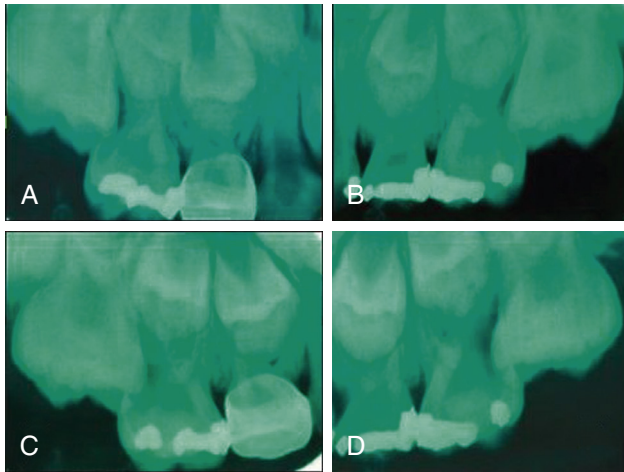


Fig. 23.45 (A) and (B) Periapical radiographs demonstrating bilateral ectopic eruption of maxillary first permanent molars with resorption of the distal aspect of the second primary molars. (C) and (D) Subsequent radiographs obtained at 6-month recall showing “irreversible” pattern of ectopic eruption with continued resorption of the primary molars and greater mesial displacement of the first permanent molars.

permanent first molars, a more pronounced mesial angle path of eruption, and a tendency toward a shorter maxilla in relation to the cranial base. No significant differences in these variables were found between sides with reversible ectopic eruption and sides with normal eruption. Ectopic molars also show a significant familial tendency, with a prevalence of 19.8% in affected siblings versus the overall 2%–3% general occurrence. A frequent occurrence rate of ectopic first permanent molars at 25% in children with cleft lip and cleft palate again implicates maxillary positioning and basal arch size as etiologic factors.

Irreversible ectopic molars that remain locked, if untreated, can lead to premature loss of the primary second molar with a resultant decrease in quadrant arch length, asymmetric shifting of the upper first molar toward Class II positioning, and supraeruption of the opposing molar with distortion of the lower curve of Spee and potential occlusal interference. Early assessment with intraoral or panoramic films approximating the timing of first permanent molar eruption is thus critical to identification of the problem and provides an opportunity to intercept potential sequelae. If the problem is detected at 5–6 years of age, an observation approach of “watchful waiting” with appropriate monitoring may be indicated, given the two-thirds potential for self-correction. With self-correction being unlikely as the child approaches 7 years of age, continued “locking” of the first molar with advanced resorption of the primary second molar usually warrants intervention. Another timing clue is that when the opposing molar reaches the level of the lower occlusal plane, intervention is indicated to establish proper vertical control and prevent supraeruption. Because the anomaly often occurs bilaterally in conjunction with a tooth mass discrepancy, the finding should result in careful examination of other areas for similar conditions.

Interceptive correction involves guidance of the ectopic molar into normal position, retention of a favorable eruption sequence, and maintenance of arch length. Importantly, the resorptive process of the primary molar generally stops once the ectopic positioning is corrected and the tooth remains to stabilize arch integrity. One option is to restore

the second primary molar with pulpotomy and a stainless-steel crown supplemented with band material extending subgingivally to rest mesially to the ectopic molar. Designed to serve as a guide for eruption positioning, the extension must be carefully placed so as not to exaggerate molar entrapment. The technique seems simple but is actually very difficult to perform and should generally be avoided. Several other corrective procedures have been reported, with treatments varied by the extent of blockage, degree of primary tooth resorption, direction of displacement, timing, arch length status, and patient cooperation. Approaches include separators and distalizing appliances.

Orthodontic elastic separators are the first choice if access is sufficient to allow insertion for engagement in the contact areas of entrapment. The first placement is the most difficult and often requires a modified separator and floss engagement. This is done by looping floss through the separator, passing the floss through the contact area, pulling the doubled separator into the cervical area of contact, and then pulling one side of the separator through the contact with the floss. Progressive use of larger separators placed conventionally—from smaller, “stretchier” elastic types to more rigid plastic types—at subsequent visits facilitates this approach. Replacement at 1- to 2-week intervals usually accomplishes correction within 2 months. Separating springs can also be used provided there is sufficient eruption has taken place to allow for their insertion between the contact areas. However, separating springs tend to impinge upon tissues and are easily displaced, raising concerns for swallowing or aspiration. If springs are used, insertion is most easily achieved by the use of Howe or Weingart pliers to grasp the active arm of the spring. Floss looped through the helix serves as a safety device if the spring slips out of the pliers. The head of the spring is placed on the marginal ridge, while the active arm is directed below the contact point of the teeth. The spring may be inserted from the buccal or lingual side (whichever provides the greater access); the buccal approach is usually easier. The spring is left in place until the tooth is freed from contact with the adjacent tooth and is erupting. The patient should be seen every 2–3 weeks for evaluation of eruption progress and reactivation of the spring.

Brass ligature wire threaded between the contact areas of the affected teeth may facilitate distal movement of the permanent molar through periodic tightening of the looped wire as a separating force. The wire should be twisted or a new one placed at approximately 3- to 5-day intervals until the desired separation is achieved. Brass wire usage is uncomfortable and local anesthetic is often required; the brass wire usually has to be replaced one or more times before correction is achieved, relapses easily, and, in essence, is vastly overrated. Treatment with any of the separator techniques requires that only a minimal lock be evidenced and that minimal resorption of the primary second molar has occurred. Of the three, elastic separators are much easier to use and are much less problematic for minimal locks than separating springs or brass wire. Another technique of some value is to reach distal to the second primary molar with a high-speed bur angled back toward the offending “spicule” of enamel on the primary molar and slicing this “spicule” off. While technically a bit difficult, it can be worth the attempt, especially if it prevents use of the more involved and expensive techniques mentioned next.

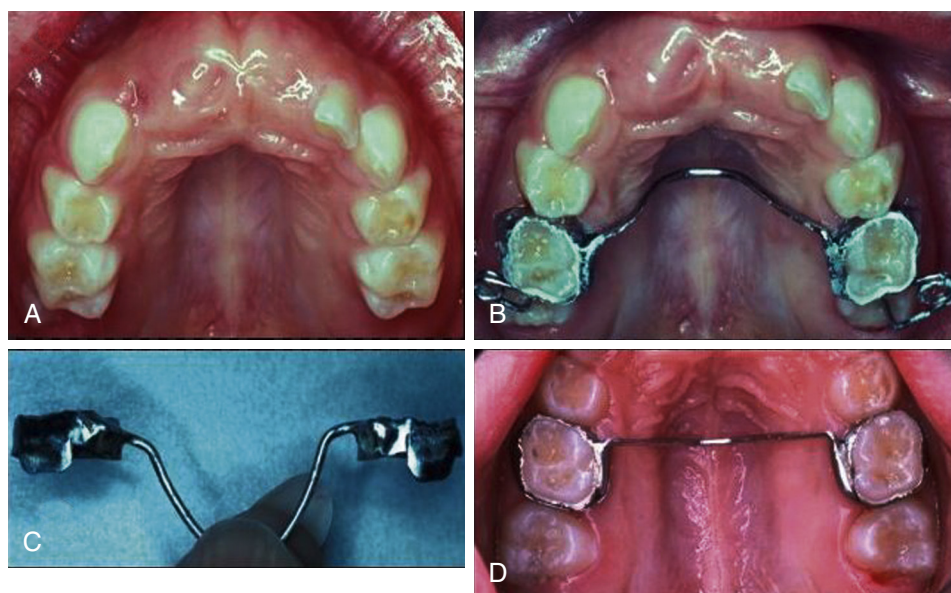


Fig. 23.46 Distalizing spring (Humphrey) appliance. (A) Bilateral ectopic eruption of the maxillary first permanent molars. (B) A Humphrey-type banded appliance with distalizing springs has been fabricated to reposition the ectopic first permanent molar. The ectopic molars were uncovered at the time of band fitting. At placement, composite ridges were bonded to the occlusal surfaces for spring engagement. (C) and (D) After distal repositioning of the first permanent molar was achieved, the appliance was removed, springs were cut off, and band material was tack welded to provide extensions to maintain first permanent molar eruption into favorable positions.

Irreversible ectopic eruptions may require the use of distally directed forces from the second primary molars to disengage and allow eruption of the first permanent molar. The Humphrey appliance uses a distally directed S-shaped loop that is actively engaged on the occlusal surface of the ectopically erupting permanent molar (Fig. 23.46). In original usage, it was often necessary to remove the appliance for activations of the loop, and a restoration was required in the first molar after correction. The advantages were stability and ability for severe locks of the 6-year molar to be corrected. Subsequent modifications to the original Humphrey design include the use of helical springs (0.018- to 0.022-inch wire) to provide more continual force and easier reactivations, added stability by the anchoring of banded molars bilaterally with a palatal wire, using springs from buccal and lingual aspects to minimize rotations of the permanent molar, and using bonded composite resins to engage the distalizing springs. Disadvantages include problems in activation and adjustment of the spring, possible occlusal interference distorting the wire, need for access to the occlusal surface of the first permanent molar, and possible reciprocal movement of primary molars. Once distalized, the spring needs to be removed to allow for vertical eruption of the molar to ensure correction. To prevent relapse of the molar into the undermined area, band extensions are tack welded to the distal aspect of the band and the appliance is recemented.

The Halterman appliance uses elastomeric chains rather than springs as the distalizing force (Fig. 23.47). With a rigid 0.036-inch stainless-steel wire “hook” extended distally from the lingual aspect of bands on the second primary molars, stretching of elastomeric chains from bonded buttons on the ectopic molar essentially “slingshots” the molar distally. Extending the wire from the lingual side of the primary molar avoids wire impingement with the anterior border of the ramus during opening. The wire should

approximate the palatal contour with the hook positioned horizontally to approximate the buccolingual midpoint of the desired molar location and about 5 mm beyond the distal marginal ridge of the involved permanent molar. This position provides adequate stretch of the elastic forces in a vertical and parallel orientation to normal arch alignment. An occlusal button, cleat, or bracket is bonded to the central fossae area of the ectopic first molar as far mesially as accessible. Clinician-preferred (i.e., self- or light-cured) resin bonding is used with success depending on avoidance of moisture contamination. Hybrid glass-ionomer cements that allow moisture exposure and do not require acid etching are an alternative if isolation is compromised. In placement, the elastomeric chain should already be secured to the button during the bonding process to ensure that composite material does not extend into undercut areas and block elastic engagement. After the button is bonded, the appliance is cemented and the elastomeric chain is stretched to the distal hook. A closed-loop chain is recommended for enhanced force application. Being relatively simple to apply as well as predictable and effective, the Halterman distalizing technique is currently the preferred method when elastic separators are not applicable.

ERUPTION GUIDANCE IN THE LOWER INCISOR SEGMENT

Developmental patterns often find permanent lower incisors erupting into a lingual position behind the primary incisors as a “double row” of teeth. The majority of these cases self-correct via eventual exfoliation; however, if the problem does not self-correct by 8 years of age, extraction of the primary incisors may be necessary (see Chapter 20). The tongue usually positions the permanent incisor forward into normal alignment. In conjunction with eruption of lower lateral incisors, there is a normative increase

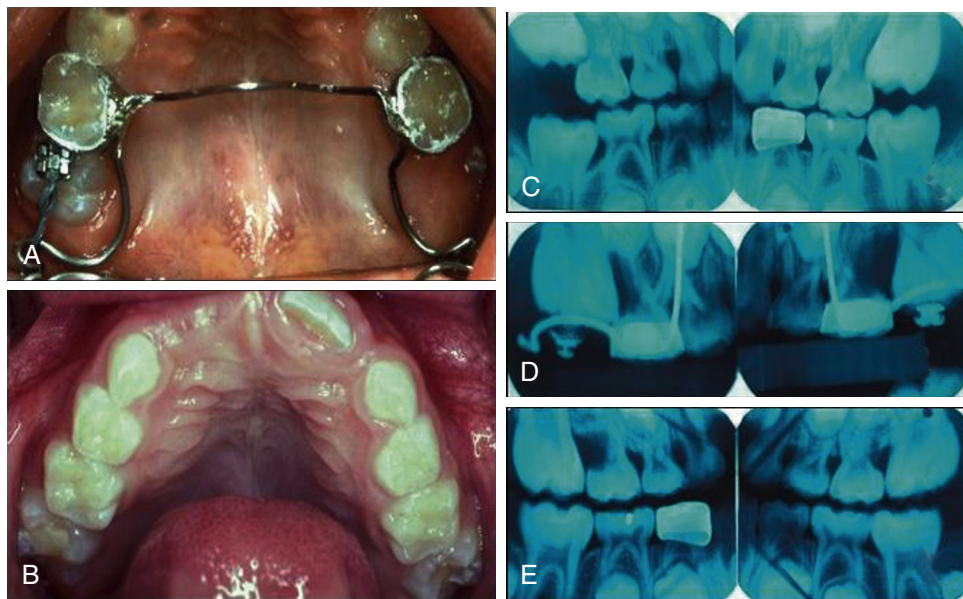


Fig. 23.47 Fixed maxillary Halterman appliance. (A) Bands on second primary molars with distal engagement arms for engaging elastomeric chains to bonded attachments on bilateral ectopic first permanent molars. (B) The first permanent molar has erupted into a favorable position after 6 weeks' treatment time. Radiographs showing distal repositioning of the first permanent molar from (C) pretreatment, (D) at 2 weeks of treatment, (E) to 1 year posttreatment.

in the lower intercanine width of 2–3 mm (range, 0–5 mm). This “growth” in lower anterior space helps compensate for the inherent tooth mass liability. After the lower permanent incisor transition is complete by 7–8 years of age, the “normative” finding presents almost 2 mm of incisor crowding. Studies document that no future increase in the lower intercanine width for relief of crowding will occur after this stage of incisor eruption is complete. However, extra space is available within the overall arch, as represented by the size difference between the primary canines and primary molars versus the permanent canines and premolars. This “leeway space” represents a +1.7 mm, on average, in each lower quadrant and provides potential for the relief of lower incisor crowding. Gianelly,¹¹ reporting on 100 consecutive mixed dentition children presenting for orthodontic needs, found that 85 of them had lower incisor crowding, with an average crowding discrepancy of –4.4 mm, a discrepancy significantly greater than population averages of approximately 2 mm. When leeway space was calculated into a space analysis, adequate room to accommodate an aligned dentition was indicated in 72% of the individuals with crowding. Given this potential, if an overall space analysis indicates that a child's arch perimeter is adequate to accommodate or be within 2–3 mm of relieving any incisor malalignment, the clinician should consider options to facilitate adjustments through guidance of eruption and timely use of the available leeway space.

The first option when incisor crowding is less than 3–4 mm involves “disking” the primary canines on their mesiolingual surfaces. Timely disking provides a “sluiceway” for lingual displaced incisors to slide forward toward the anterior arch form under the muscular pressure of the tongue (Fig. 23.48). Bilateral disking can provide up to 2–3 mm of space for “unraveling” of lingually displaced incisors. With proper slicing of the mesiolingual corner

at the gingival contact area, there is actually no measurable encroachment on overall leeway space in the individual quadrant. Movement of the incisors under tongue pressure potentially increases the midline arch length and overall arch circumference as the arch is rounded out in a forward direction. In the case of labial malpositioned incisors, while disking may provide additional room for alignment, the lips are a more significant factor in the balance between muscular forces. The result is lingual flattening of the anterior segment and a decrease in overall arch space. Disking must involve slicing the canine subgingivally to completely free the contact area. Disking just the crown is not enough. The use of a tapered bur of a size to allow access without injury to adjacent permanent teeth is required (#699 or #169). Local anesthesia or nitrous oxide support is frequently required because dentin exposure and periodontal insult are necessary to disk primary canines adequately. Placement of a wedge is sometimes necessary to protect the lateral incisor. Timing is critical to allow for optimal tooth positioning and ease of access. Given that the normative intercanine width increases 2–3 mm during lateral incisor eruption, disking should be delayed until eruptive “wedging” effects of the incisors are realized. If indicated, disking of lower primary canines is therefore recommended at around 7–8 years of age, near completion of lateral incisor eruption.

While excessive incisor liability may result in ectopic loss of lower primary canines (reviewed earlier in this chapter), more often the primary canines remain and the permanent incisors erupt significantly malpositioned. If disking of the canines is not an option due to the level of crowding or positioning of the incisors, elective extraction of the primary canines to maintain arch symmetry, coincident midlines, and incisor integrity may be considered (Fig. 23.49). Such intervention becomes more viable when the



Fig. 23.48 Incisor guidance with disking of lower primary canines. (A) and (B) Presentation of approximately 4.5 mm of lower incisor crowding with lingual malpositioning of lateral incisors, retained lower left primary lateral, and 80% overbite. Given significant overbite and positioning of incisors, the decision was made to disk the lower primary canines bilaterally in conjunction with restorative appointments. (C) Same patient at 6-month recall appointment after disking. Slight additional disking of canines was done at recall. (D) Same patient at 1 year from start of first disking. Arch form is established as tongue pressure positioned the lingually displaced incisors forward into the spaces created by disking.



Fig. 23.49 Elective extraction of lower primary canines. (A) Significant lower incisor crowding and malpositioning evidenced by advanced lower right primary canine resorption with ectopic positioning of adjacent lateral incisor, lower dental shifting toward right, and retained lower left primary lateral. Due to imminent loss of the lower right canine and malpositioning, a decision was made to extract the primary canines bilaterally. (B) Same patient 1 year later with symmetry and integrity of lower incisor alignment. Patient is on course for either serial extraction protocol or setup for arch development, depending upon other variables.

incisor liability and crowding are greater than 4 mm in the anterior segment. However, the clinician must remember that early loss of lower primary canines will likely result in significant lower arch collapse. Therefore the extraction of primary canines should not be undertaken without parental understanding of the consequences and, ideally, orthodontic consultation. Given the long-term implications, such intervention goes beyond the first step in guidance of eruption and actually represents the start of either a phased early treatment program or a serial extraction program. On a final note, some clinicians advocate primary canine extraction to aid in alignment of the lower permanent incisors for fear of increased caries risk secondary to the incisor malalignment. However, Alsulaiman et al.⁴⁹ found no association with maxillary and mandibular incisor irregularity, although it is well known that there is associated plaque retention.

ERUPTION GUIDANCE IN THE MANDIBULAR CANINE AND PREMOLAR SEGMENT

For a child between 10 and 12 years of age, radiographic evaluation of the buccal segments provides particular consideration in eruption guidance relative to primary resorption patterns, eruption sequencing, molar adjustments to achieve Class I relationships, and usage of leeway space. Because the lower canine and first premolar often erupt nearly concurrently and are larger than their primary predecessors, they often take a mesial eruption path, with the canine overlapping the lateral incisors. To minimize such malpositioning, their timely transition along with concurrent disking of the mesial surface of the second primary molar may provide up to 2–3 mm of space for their distal positioning (Fig. 23.50). The second premolars usually erupt about 1 year later, frequently taking a path of

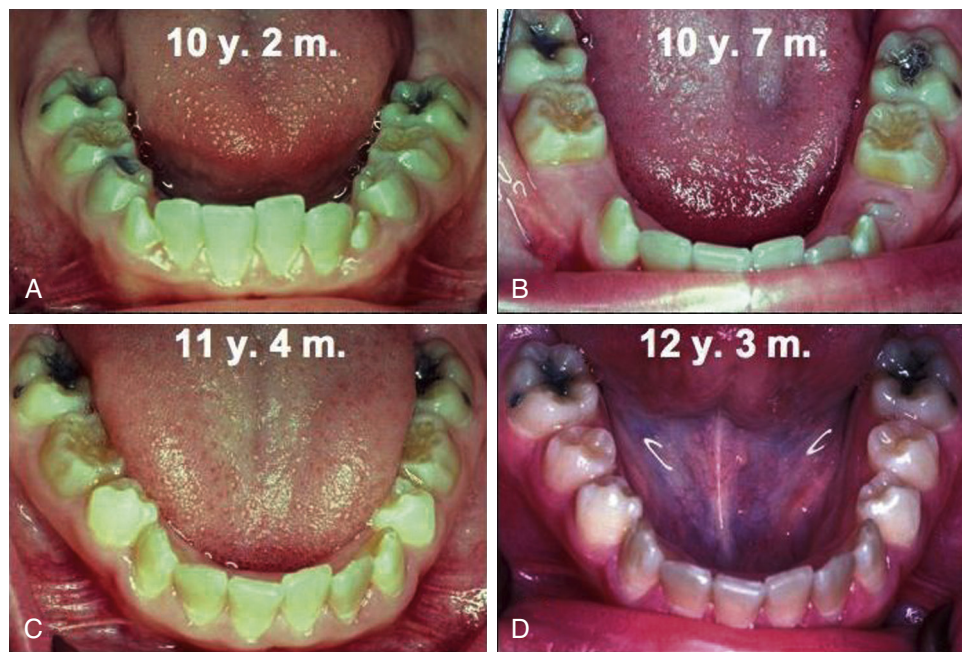


Fig. 23.50 Eruption guidance with sequential disking and selective extraction of primary teeth. (A) Pretreatment alignment with mesial eruption path of permanent canines to overlap incisors. (B) Alignment at 5 months after elective extraction of primary first molars and disking of the mesial surfaces of the second primary molars. (C) Permanent canines and first premolars have erupted in distal orientation with reduction in anterior crowding. (D) After eruption of second premolars, good arch form is established, with overall adequate space and easily correctible minor rotations.

eruption along the distal root of the second primary molar. Extraction of the second primary molar is sometimes indicated to allow for normal eruption of the second premolar, if such an atypical pattern is noted. In addition to assessing eruption of the second premolars, the clinician should consider placement of a lingual holding arch concurrent with removal or exfoliation of the second primary molars (Fig. 23.18). If the available buccal segment space is tight, the optimal use of leeway space for crowding is desirable, and/or the second permanent molars are erupting before the second premolars, the lingual arch may be a critical element in controlling overall arch dimensions.

Treatment-based articles have documented positive alignment effects in the use of passive lingual holding arches for control of leeway space when used in the late mixed dentition. Dugoni et al.⁵⁰ published findings in 25 mixed dentition patients with reductions in lower incisor crowding of greater than 3 mm after placement of passive lingual arches and selected primary molar extractions. After an average postretention period of 10 years, 19 of the 25 patients continued to show clinically satisfactory lower anterior alignment. When compared with 10-year follow-up studies of orthodontically aligned patients, these results suggest that stability of the alignment with lingual arch therapy was greater than or at least equal to that of active orthodontic treatments. Using cephalograms, study models, and tomograms of the mandibular body, Rebello et al.⁵¹ reported dimensional changes in 14 mixed dentition patients with incisor crowding of 3 mm or more who were treated with passive lingual arches in comparison with 16 untreated control individuals. In lingual arch patients, the arch length did not measurably change through eruption of the succedaneous teeth compared with an average arch length decrease of 2.5 mm per side in the untreated

control individuals. Arch length changes were related to first molars moving forward +1.7 mm in the control group compared with only +0.3 mm in the lingual arch group. Concurrently, incisors tipped forward slightly in the lingual arch group (+0.4 mm), whereas uprighting of incisors in the controls reduced the arch length to 0.65 mm. In brief, the lingual arch reduced the mesial molar migration and incisor lingual movement in controlling arch length, with concurrent relief of 3–4 mm of lower incisor crowding in the treatment population. Brennan and Gianelly⁵² quantified dimensional changes in 107 consecutive mixed dentition patients treated with passive lingual arches through eruption of all succedaneous teeth, with occasional extraction of second primary molars being the only other intervention. Arch length decreased an average of 0.4 mm, whereas width increased slightly in lingual arch patients. The resultant average +4.4 mm of total available leeway space produced an average decrease in lower incisor crowding from a pretreatment of –4.8 mm to +0.2 mm of space after treatment. The space adjustments were enough to resolve incisor crowding completely in 65 individuals (roughly 60%). An additional 16 individuals (1 in 6) had a final discrepancy of less than 1 mm, and 13 (1 in 10) had a final discrepancy of less than 2 mm. Only 14 patients (13%) had crowding greater than 2 mm after full buccal segment eruption was complete. Of note, the majority of patients with higher levels of postlingual arch crowding presented with initial ectopic loss of the lower primary canines. In sum, a passive lingual arch with selected removal of primary teeth provided adequate space and eruption guidance to relieve significant lower incisor crowding in 105 of the 107 individuals.

These studies consistently confirmed that arch length remains relatively constant or decreases minimally in

patients treated with a passive lingual arch by reducing forward movement of molars and lingual movement of lower incisors. Timely treatment not only maintains arch length but also allows for distal eruptive positioning of canines and premolars as a positive influence on relief of mixed dentition crowding in the 2- to 4-mm range, enough to relieve lower crowding in about two-thirds to three-fourths of patients.

ERUPTION GUIDANCE IN THE MAXILLARY CANINE AND PREMOLAR SEGMENT

In the 7- to 8-year-old child, maxillary permanent canine positioning approximates the distal aspect of the root of the lateral incisor. This is associated with a normative distal tipping of the lateral incisor crowns under the fulcrum pressure of the canine at the lateral root area. The maxillary canine then normally deflects with a more vertical positioning toward the primary canine root area as eruption continues, with a concurrent more labial orientation of the canine. This labial orientation can be noted clinically by bulging in the vestibular aspect of the alveolar process. As resorption of the primary canine proceeds in normal patterns, the adjacent maxillary lateral incisor crown should tip mesially as vertical eruption of the permanent canine continues down the primary canine root length. With exfoliation of the primary canine, the maxillary permanent canines typically emerge with a slight labial orientation that tends to lingualize into the arch form as eruption proceeds under the balancing forces of the perioral tissues.

Given this tortuous and long journey, permanent maxillary canine eruption disturbances resulting in severe displacement and/or impaction are reported in 2% of the population, with females affected three times more frequently than males. As the final succedaneous tooth to erupt in the maxilla, mesiolabial displacement of the permanent canine is usually due to an arch length deficiency as the canine assumes whatever space is left over in the quadrant. In contrast to labial displacement, arch length deficiency appears to be less of a factor in palatal impactions because 85% demonstrate adequate arch length in the involved quadrant. An etiologic factor in true palatal impactions may actually be excessive space in the canine area rather than a lack of arch length. When maxillary lateral incisors are absent, peg-shaped, or smaller than the lower incisors, palatally displaced maxillary canines are noted in approximately 40%–45% of patients. When the ectopic permanent canine is close to the root of the lateral incisor, notable displacement of the incisor and idiopathic root resorption of the incisor may occur. The resorption is often difficult to diagnose because most of the lesions are located palatally toward the middle and apical thirds of the incisor, with the overlapping canine crown concealing radiographic visualization of the resorptive process. It has been reported that up to 12.5% of ectopic palatally positioned canines cause resorption of the adjacent incisors. In about half of the cases analyzed, the resorption extends into the pulp of the involved teeth, with the degree of resorption ranging from loss of one-fourth of the root to almost complete loss of root structure. The actual percentage of resorption occurrence may be much higher than reported due to inherent limitations of the two-dimensional radiographs used by most clinicians.



Fig. 23.51 Example of bilateral impaction of the maxillary permanent canines corrected by bilateral extraction of the primary canines and first molars; before and after extractions. (Giulio AB, Serena IP, Matteo Z, et al. Double vs single primary teeth extraction approach as prevention of permanent maxillary canines ectopic eruption, *Pediatr Dent*. 2010;32(5):407–412.)

Screening for potential displacement and impaction of maxillary canines should start at 10–11 years of age with clinical and radiographic examinations to include evaluation of eruption trajectory, symmetry of positioning, status of root development, and orientation to the adjacent lateral incisor and primary canine. In cases of mesially displaced maxillary canines with overlap of adjacent permanent lateral incisor roots beyond 10 years of age, timely removal of the adjacent primary canines, and often simultaneously the first primary molars, greatly enhances the possibility for more distal and vertical eruptive directions (Fig. 23.51). This timing coincides with when eruptive forces are optimal, as the permanent canine attains approximately two-thirds root development. Once the apices of the canine are three-fourths or more formed, the eruptive force is reduced and the tooth will more likely have to be actively moved into the mouth. The clinical examination should involve palpation of the buccal aspect of the alveolar bone in the canine region slightly above the primary canine. A canine bulge should be evident, indicating the presence of the canine in a normal path of eruption at this stage of development. Although the presence of the buccal bulge does not necessarily preclude

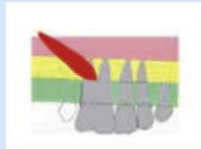
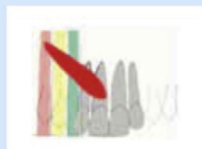
Category	Good Prognosis	Average	Poor
Overlap of incisor	No horizontal overlap 	Up to half root width 	Complete overlap 
Vertical height	CEJ – halfway up root 	>half <full root length 	>full root length 
Angulation	0–15° 	16–30° 	>30° 
Position of apex	Above canine position 	Above 1st premolar 	Above 2nd premolar 

Table 1. Prognosis for realignment depending on assessment in various categories. Key – Green: good prognosis; Yellow: average prognosis; poor prognosis

Fig. 23.52 Prognosis for realignment, depending on assessment in various categories. Green: good; Yellow: average; Pink: poor. (Guidelines for the assessment of the impacted maxillary canine, Kate Counihan, Ebrahim A. Al-Awadhi, Jonathan A. Butler Dental update 2013;40(9):770–772, 775–777.)

the possibility of impaction, the absence of such a clinical indicator by 10–11 years of age should warrant exploration. A major clinical clue to significant canine malpositioning involves excessive distal and labiolingual tipping of the lateral incisor crown. This suggests that the erupting canine is placing fulcrum-type pressure on the lateral root, “pushing” the root mesially to tip the crown in a distal direction. If the lateral crown is tipping labially, the permanent canine is probably displaced in front of the lateral root. If the lateral crown is tipping in a lingual direction, the canine crown is more likely to be displaced behind the lateral root. Other clinical signs include delayed eruption of the canine beyond 13–14 years of age, with prolonged retention of primary canines, and soft tissue bulging either too high in the vestibule or palatally.

Radiographic evaluation of the maxillary canine area should be particularly emphasized when lateral incisor inclinations are pronounced (as noted before), when small maxillary (pegged) lateral incisors are present, when primary canines are not appropriately mobile, and when the eruptive bulging of the canines is atypical. Although excessive mesial inclination resulting in overlap of the canine crown with the lateral incisor roots, as observed on radiographs, may suggest potential impaction, this prognostic

sign can be applied reliably only if the overlapping is present after root development of the lateral incisors is almost complete and the canine has attained approximately two-thirds root development (i.e., around 10–11 years of age). At that point, the degree of overlap of the canine crown with the lateral incisor root and the resorption pattern of the primary canine and first primary molars are key indicators for potential canine impaction and for the prognosis of successful interceptive guidance. Localization of the labial or lingual positioning of the tooth by special radiographic techniques is essential. (Procedure with specifically positioned periapicals or cone beam computed tomography described in [Chapter 2](#) help in this localization.) Studies indicate that if the displaced permanent canine overlap of the adjacent permanent lateral incisor is not beyond the midline long axis of the lateral (still toward the “distal” half of the root), the chances for the canine repositioning and erupting into normal position after primary canine extraction show roughly 85%–90% success. If the canine overlap is beyond the lateral incisor’s long axis (toward the mesial half of the root or beyond), successful repositioning drops to approximately 60% of cases, with extraction of the primary canine ([Fig. 23.52](#); Reprinted from: Counihan et al. 2013).

Follow-up at 1 year after the primary canine extraction should find significant improvement in canine positioning. If not improved, the canine is probably positioned toward the palate and will require complicated treatment options, including surgical exposure with removal of obstructing structures to allow “hoped-for” passive eruption, surgical exposure with active orthodontic traction to move the tooth into position, autotransplantation of the impacted canine into the proper position, or extraction of the impacted canine and substitution by the first premolars. Surgical exposure that allows for natural eruption is dependent on the displaced tooth having a reasonable axial inclination and incomplete root development to achieve eruptive potential. When conditions for “passive” eruption are not met, an active approach involving surgical exposure followed by active orthodontic traction applied to the tooth may be necessary. Orthodontic traction involves complex biomechanical force parameters of direction, duration, amount, and method of activation in positioning the tooth, which are beyond the scope of our discussion.

Maxillary Anterior Diastemas

Parents are often concerned about anterior spacing that presents during eruption of the maxillary dentition. Unless there is a valid reason to intervene early, active treatment should be postponed until the complete eruption of the permanent canines because anterior spaces often close spontaneously as the lateral incisors and particularly the permanent canines erupt. After the canines erupt, the condition can be reevaluated and appropriate treatment taken as needed. Fig. 23.53 shows a patient whose parent wanted the diastema closed and was concerned about the high position of the canines. No treatment was begun. The 24-month follow-up image shows that diastema closed, with the canines in reasonably good alignment.

Valid reasons for early closure of excess maxillary spaces may be in consideration of atypical or asymmetric eruption patterns. Lateral incisors may be erupting lingually without sufficient space to be aligned labially into the arch. The maxillary incisors may be excessively flared and “splayed,” with lip interpositioning that puts the teeth at risk for traumatic injury. Adjusting the symmetry of alignment, consolidating spaces, and retracting excessively proclined incisors may be indicated to facilitate long-term development. An extremely heavy labial frenum may prevent natural closure of a diastema. If orthodontic closure is advocated, it should occur before the frenectomy to reduce the chance of scar tissue impeding tooth movement. If there is sufficient arch space for the eruption of incisors and canines, it is best to delay frenum surgery until these teeth have fully erupted.

Supernumerary Teeth

Supernumerary teeth can be associated with delayed eruption of permanent teeth, overretention of primary teeth, deflection of roots with unusual inclinations, displacement of teeth, diastemas, abnormal root resorption, and formation of follicular or dentigerous cysts (Fig. 23.54). Occurring approximately eight times more frequently in the maxilla than in the mandible, supernumerary permanent teeth have been reported in up to 3.6% of children. The occurrence of supernumerary teeth in several members of the same family has been observed, indicating a familial

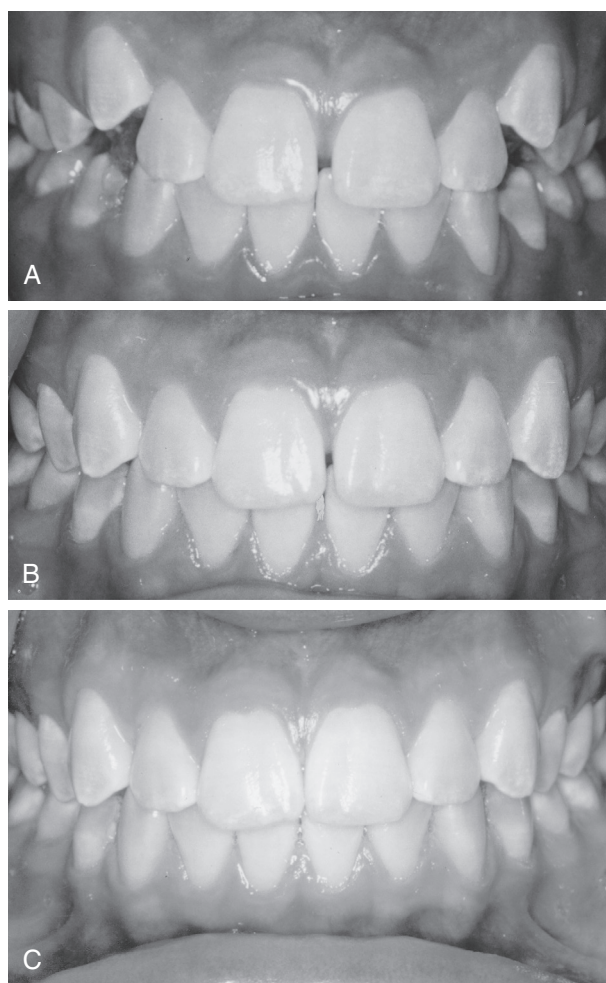


Fig. 23.53 (A) Patient with midline diastema and highly positioned canines. No treatment was instituted. (B) After 24 months, the diastema has closed significantly and the canines are erupting into a more favorable position. (C) After 36 months, the diastema has closed completely, and the canines have assumed a near-ideal position.

pattern. The most frequent site is the maxillary anterior segment where atypically shaped accessory teeth of a conical tuberculated form, known as *mesiodens*, occur between the maxillary central incisors (Fig. 23.55). Reported in boys twice as often as in girls, 80% of mesiodens have a single occurrence, whereas 20% have two or more supernumerary teeth. The mesiodens usually presents a peg- or cone-shaped crown with a single root. More than 90% are palatally positioned. Approximately three of four mesiodens remain unerupted and commonly need surgical removal at some point during treatment because they often prevent eruption of adjacent permanent teeth or cause their ectopic eruption. Supernumerary primary teeth (Fig. 23.56) are apparently less common than supernumerary permanent teeth.

If a supernumerary tooth is identified through radiographic techniques (see Chapter 2), the decision whether to intervene surgically or keep the tooth under observation must be made. If the supernumerary tooth is not interfering with the symmetric development of adjacent teeth and there is no evidence of cyst formation, the correct decision may be to observe the tooth until the child is old enough to better tolerate the surgical procedure. Watchful waiting

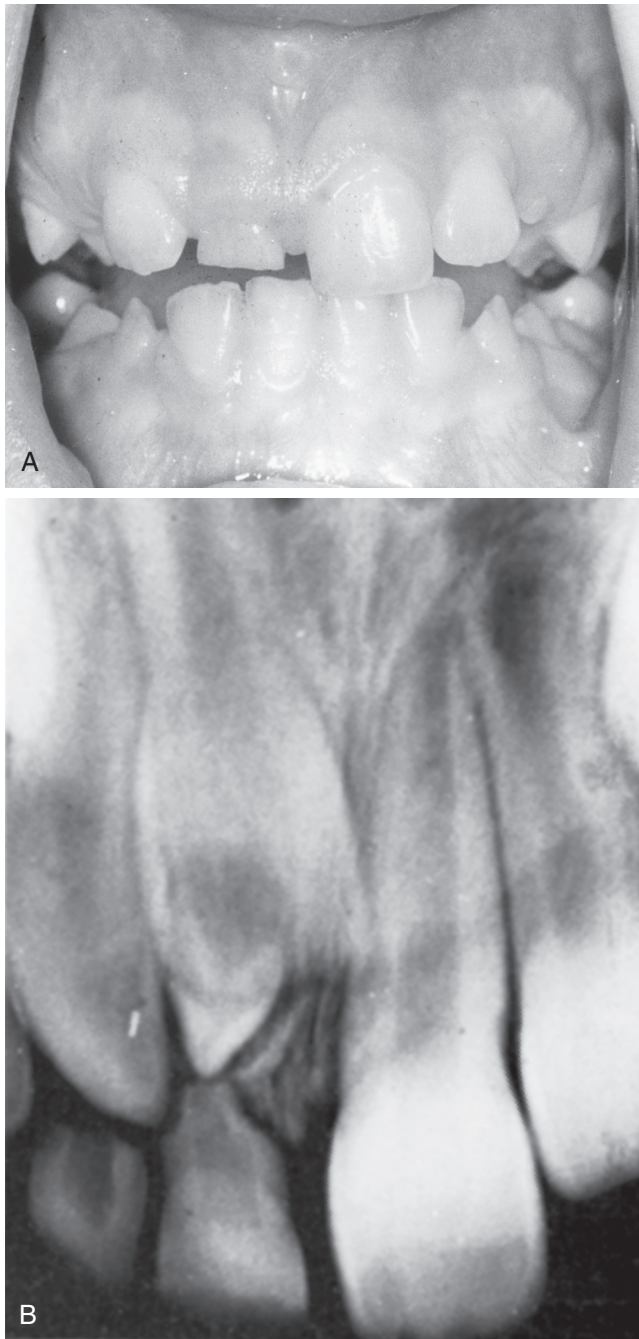


Fig. 23.54 (A) Patient with an unerupted maxillary permanent central incisor and retained primary central incisor. Permanent laterals are erupting. (B) Radiograph shows a supernumerary tooth (mesiodens), which has delayed the eruption of the permanent incisor.

until the development of the permanent incisors reaches approximately two-thirds to three-quarters root formation allows for less risk to the incisor development in the surgical procedures. Possible eruption of the supernumerary tooth and avoidance of surgical exposure are also potential benefits in delaying intervention. However, in the case of severe exfoliation and eruption irregularities, earlier removal of a supernumerary tooth and the over retained primary teeth may be desirable to lessen potential sequelae. The clinician must still consider the status of the adjacent permanent

teeth and may prefer to wait until root development is preferably two-thirds established before surgically removing the supernumerary tooth.

When surgical removal is accomplished, exposure of the unerupted permanent tooth or teeth with provision of an eruption channel is recommended (Fig. 23.57). Reports suggest that up to 80% of permanent maxillary teeth will spontaneously erupt after the supernumerary is removed. During surgery, the bone and soft tissue should be removed from the incisal third of the tooth or teeth that are delayed in their eruption. If the permanent teeth are positioned extremely high, a prolonged period of watchful waiting may be necessary until they have migrated within the bone to a position that would allow for surgical intervention. An open pathway should be maintained, if possible, to hasten the eruption of the delayed tooth. A thin covering of dense scar tissue can delay eruption indefinitely. Ultimately, orthodontic treatment is often necessary to make adequate room for the unerupted tooth and to position it properly in the arch. Because of these considerations and the frequency with which supernumerary teeth are observed, radiographic surveys that include maxillary anterior views are essential for children at 5–7 years of age to allow for early detection and planning.

Congenitally Missing Teeth

Studies have reported that congenitally missing permanent teeth (excluding third molars) occur in 2.3%–9.6% of the population, with no significant gender differences. Oligodontia affects two or more teeth in about one-half of cases, frequently in a symmetric pattern involving antimeres. The most frequently missing permanent teeth are third molars (one to four wisdom teeth are absent in up to one-third of the population), mandibular second premolars, maxillary lateral incisors, and maxillary second premolars. Morphologic changes such as cone-shaped teeth are characteristically seen in association with missing permanent teeth—agenesis and peg-shaped maxillary lateral incisors approximate a 1:1 ratio. The congenital absence of primary teeth has a much lower prevalence than that of permanent teeth. The prevalence of missing primary teeth ranges between 0.1% and 0.7%, with absence usually located in the maxillary or mandibular incisor areas. When several primary teeth fail to develop, other ectodermal deficiencies are usually evident (e.g., ectodermal dysplasia). If the absence is localized to only one or two primary teeth, no specific treatment is generally needed. However, the long-term implications are significant because the analog of the permanent tooth is derived from the primary tooth bud. Therefore a missing primary tooth almost always means that the associated permanent tooth will be missing, with attendant occlusal factors.

The management of congenitally missing permanent teeth requires a thorough evaluation of arch length, occlusion, and facial growth patterns, given the long-term consequences to aesthetic and functional arch alignment in terms of which specific tooth is missing, adjacent teeth drifting into the space, the distribution of the space, and supraeruption of opposing teeth. Early consultation with the orthodontist and prosthodontist is important in determining appropriate care. If one or both of the permanent maxillary lateral incisors are missing, the dentist must

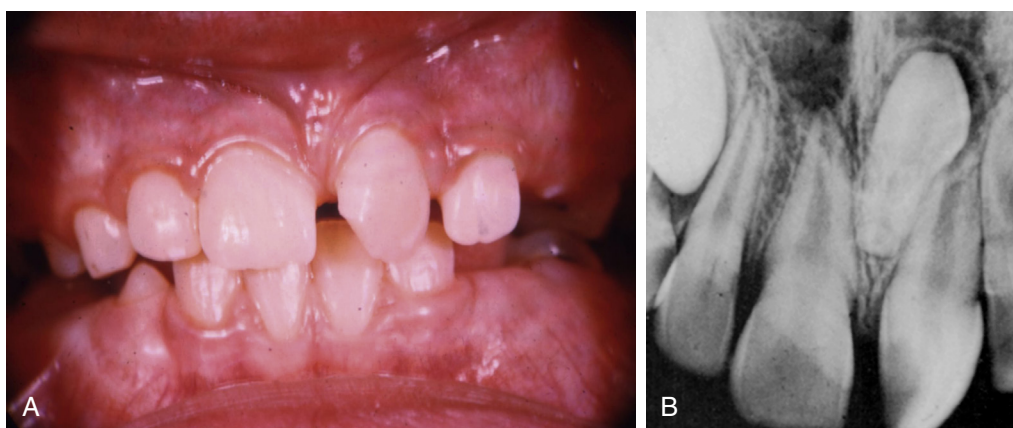


Fig. 23.55 (A) Rotation and labioversion of a maxillary central incisor with midline diastema. (B) Radiographic assessment revealed a well-developed midline supernumerary tooth (mesiodens) with an inverted eruption path. Surgical removal of the tooth is indicated.



Fig. 23.56 Supernumerary maxillary right primary lateral incisor positioned distal to the lateral incisor. There may be corresponding supernumerary permanent teeth. The teeth should be counted at the time of the clinical examination so that erupted supernumerary teeth will not be overlooked.

decide whether to hold space for prosthetic replacements or to encourage the permanent canine to erupt mesially into the lateral incisor position. In the latter instance, the mesial eruption path of the adjacent permanent canines may erupt fully forward into the lateral space and naturally compensate for the missing lateral incisors. This pattern of “canine replacement” is particularly beneficial when the patient presents with excessive maxillary overjet and dental protrusion or a significant tooth size discrepancy that would benefit from an extraction protocol. Consolidation of the maxillary arch form with canine “replacement” leads to reduction of the protrusive overjet and compensation for a tooth mass discrepancy. Orthodontic treatment is generally needed to place the canine in the correct axial inclination before the crown is reshaped to resemble the lateral. In some instances, the shape of the canine may not be favorable to use as a lateral, even with extensive recontouring. In contrast, a patient with Class I or Class III relationships and more normal alignment spacing usually benefits from having the canines in their normal A-P positions and restoration of the missing lateral incisors with prosthodontic treatment (Fig. 23.58). If the canines are erupting too far

forward from their normal positions in this case, timely removal of the primary canines may enhance a more distal eruption path toward normal canine positions. However, with the advent of implants for replacement of lateral incisors, that recommendation has changed. According to Kokich,⁵³ the ideal situation is to encourage the canine to erupt adjacent to the permanent central incisor. After it has erupted, it can be moved distally into its normal position. By distal movement of the tooth, the bone is maintained in forming an alveolar ridge with adequate buccal lingual width to facilitate proper implant placement.

When one or more permanent premolars, usually the second premolars, are congenitally missing, should the space be maintained for fixed prostheses later or should it be closed? Many factors influence the decision whether to retain or extract the overlying second primary molar, including the degree of arch length deficiency, facial and skeletal patterns, molar relationships, vertical aspects of the malocclusion, anteroposterior incisor positioning, and stage of transitional dentition. For example, if just one premolar is absent and the rest of the occlusion is aesthetically and functionally sound, long-term retention of the primary molar is usually encouraged until growth is complete and prosthodontics can be used to replace the missing premolar. However, the larger mesiodistal width of the primary molar may cause incorrect occlusal relationships with the permanent teeth. Slicing the mesial and/or distal surfaces of the primary molar may allow for improved interdigitation, but often the bulbous, divergent roots of the primary molar prevent mesial movement of the permanent molar. Also, the roots of the primary molar may be resorbed, and the tooth may be lost eventually. To summarize, if the primary molar is maintaining vertical occlusion and arch length stability, then it should be retained for alveolar bone integrity and to allow for future implant prosthetics. An exception would be in a child with a significant tooth size–arch size discrepancy where a serial extraction protocol would provide successful aesthetic and functional outcomes. Early extraction would provide positive alignment factors without compromising long-term results because later orthodontic tooth movements will bring alveolar bone support.

The general concept of the primary molar being maintained when the underlying premolar is missing applies except when the retained primary molar exhibits significant



Fig. 23.57 Surgical removal of supernumerary incisors with uncovering of blocked permanent incisors allows for normative eruption positioning of the involved incisors. (A) Radiograph showing two mesiodens associated with retained primary central incisors and delayed eruption of permanent central incisors at age 9 years and 6 months. The primary incisors were extracted at this time. (B) and (C) Same patient at age 11 years and 10 months. (D), (E), and (F) Surgical removal of two mesiodens with uncovering of unerupted incisor. (G) One week after surgery. (H) and (I) Same patient at age 13 years and 1 month. One year after surgical uncovering, no orthodontic appliances.

ankylosis. Restorative coverage (i.e., composite buildups, stainless-steel crowns) of the ankylosed primary molar may help maintain occlusal harmony if the vertical discrepancy is not extreme. In most cases, however, early extraction of the affected primary molar may enhance occlusal outcomes by avoiding excess vertical collapse and the loss of alveolar bone height that occurs secondary to early ankylosis. Even in cases of ankylosed second primary molars over missing premolars where future prosthetic replacement is planned, early extraction of the primary molar may be advisable. The consequence of leaving severely displaced ankylosed primary molars when the premolars are absent will likely result in vertically compromised alveolar heights of adjacent teeth because there is no erupting premolar to maintain alveolar ridge integrity. For these reasons, the early extraction of ankylosed second primary molars when the second premolars are congenitally absent should be an early treatment planning decision and is usually desirable. If such teeth are extracted early, the majority of alveolar ridge reduction secondary to the extraction will occur in the first year after removal, will represent about an overall one-third loss in width, and is not progressive. Adjacent tooth movements usually maintain adequate alveolar width for subsequent implant placement and establish better arch length adjustments for proper occlusion. Planning must

also consider whether to hold the space for future prosthetic replacement or allow “driftodontics” to start closing the space of the missing premolar. Early extraction is particularly indicated if the case can be handled long-term with a premolar extraction protocol and where multiple premolars are absent symmetrically. Given the long-term considerations, the treatment options available, and the multiple disciplines potentially involved, the clinician must take the lead role in coordinating treatment and utilizing the expertise of specialists.

Obstructive Sleep Apnea and Orthodontics

An evolving area of interest to dentistry is the management of OSA in children. While the etiology for OSA is multifactorial, it seems clear that moderate to severe mandibular retrognathia may play a considerable role for some patients. While orthodontic interventions are not mentioned in the 2012 American Academy of Pediatrics Guidelines for Diagnosis and Management of Childhood Obstructive Sleep Apnea Syndrome, they are considered by some sleep medicine experts to be an alternative treatment option and are cautiously recommended in the 2016 American Academy

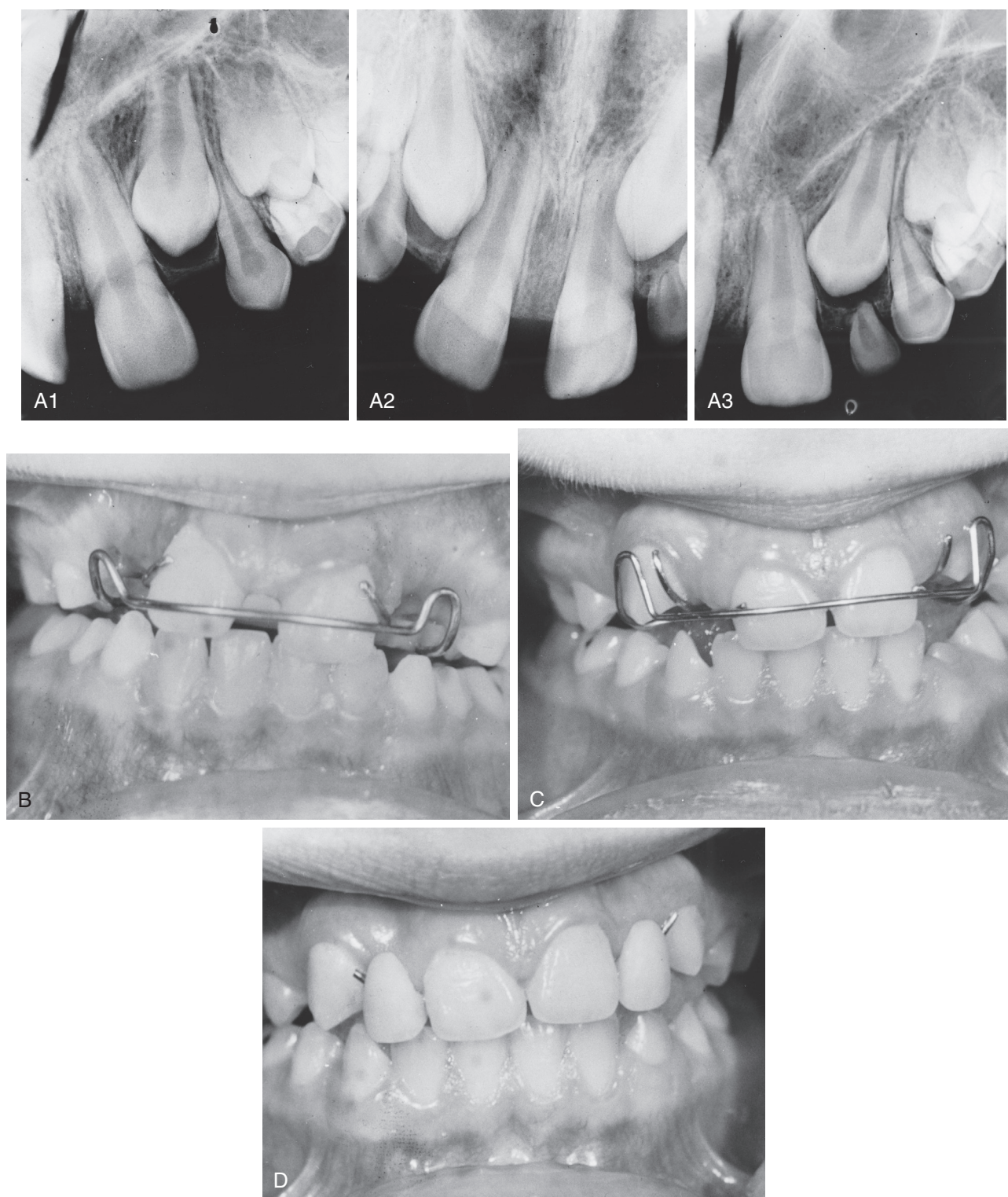


Fig. 23.58 (A) Congenital absence of permanent lateral incisors shown on periapical radiographs. (B) The primary canines were extracted to encourage a more distal eruption path of the permanent canines. A Hawley-type appliance with springs was constructed to close the diastema between the central incisors. (C) Auxiliary wires were added to the appliance to guide the permanent canines into a more favorable position. (D) Space has been regained for eventual fixed prostheses to replace the lateral incisors. Meanwhile, the removable retainer with lateral pontics is worn.

of Pediatric Dentistry Policy on Obstructive Sleep Apnea (AAPD 2016 Policy on Obstructive Sleep Apnea).⁵⁴

As discussed by Canto et al.,⁵⁵ sleep-disordered breathing is of significant relevance to practicing dentists because it has been associated with a variety of oral and craniofacial

problems including chin retrusion, Class II malocclusion, vertical growth direction, and sleep bruxism. While it seems clear that dentistry has an opportunity to contribute in this significant problem area for children, comprehensive diagnosis and management are beyond just the placement

of mandibular advancement appliances, such as those described in the following section. Therefore it seems reasonable that the team approach—involving a pediatrician, dental practitioners, sleep disorder centers that can provide definitive diagnostic techniques such as a polysomnogram, and others—is important to ensure that the problem is diagnosed and managed appropriately. Clearly, pediatric dentists can play a significant role in diagnosing breathing-related sleep disorders through evaluation of the skeletal factors such as small maxillas and small and/or retropositioned mandibles.⁵⁶ Finally, the 2019 AAO White Paper on Obstructive Sleep Apnea and Orthodontics⁵⁶ (AAO eBulletin, February 25, 2019: <https://www.aaoinfo.org/system/files/media/documents/sleep%20apnea%20white%20paper%20FINAL%202019.pdf>, accessed June 27, 2019) makes several significant statements:

1. Only a physician can definitively diagnose OSA.
2. Regardless of the presence of OSA, it is recommended that the orthodontist uses expansion devices only when there is an appropriate underlying skeletal condition. There is no indication in the literature that prophylactic application of maxillary expansion prevents the future development of OSA.
3. There is no clear indication in the literature that prophylactic use of mandibular anterior repositioning appliances prevents later development of OSA.
4. No guarantees of OSA resolution can be implied or stated emphatically by the treating orthodontist.

Comprehensive Orthodontics for the Developing Occlusion

Comprehensive orthodontics can be defined as an in-depth evaluation of a patient's entire orofacial complex and the corrective treatments necessary to achieve optimal dental aesthetics, facial aesthetics, skeletal balance, and functional harmony. Comprehensive orthodontic treatment recognizes more broadly based malocclusion factors than those cited in interceptive orthodontics and guidance of eruption. Diplomates of the American Board of Orthodontics (ABO) listed the correction of skeletal Class II and Class III malocclusions, excess vertical development, and severe tooth size–arch size discrepancies presenting displaced permanent teeth as complex problems indicated for comprehensive levels of early treatment intervention.⁵⁷ The achievement of functional and aesthetic harmony requires the coordination of a multitude of factors, from the fine details of tooth positioning to the relationships of the maxilla and mandible.⁵⁸ Since “normality” encompasses a variable range, the fundamental goals of comprehensive orthodontic management of the occlusion may be delineated as the possession of:

1. *Dental aesthetics*: The tooth alignment and arch form are generally consistent with orthognathic Class I molar positioning, normal anterior overbite and overjet, integrity of dentitional alignment, and symmetric arches positioned over the basal bone. The details of these dental aesthetic descriptors are best defined in the context of the “six keys of occlusion,” as delineated by Andrews,⁵⁸ to include proper molar relationship, proper crown
2. *Facial aesthetics*: Balanced facial profile and frontal symmetry with harmonious relationships among the jaws, teeth, and soft tissues are realized within the context of normal facial developmental patterns relative to patient age, ethnic/racial differences, and growth patterns.
3. *Optimally functional occlusion*: The interplay of gnathologic factors allows for comfortable and efficient actions of the orofacial components in a harmonious neuromuscular environment without deleterious stress on the teeth, periodontal structures, and temporomandibular joints.
4. *Stability of occlusion*: When applied to postorthodontic treatment, the interrelationships of the teeth, jaws, and soft tissues should not only meet the aesthetic and functional goals of treatment but also be sustained with long-lasting stability and retention of achieved goals.

Comprehensive orthodontic treatment usually requires complete fixed Edgewise appliances to achieve final positioning of all or nearly all of the permanent teeth into optimal aesthetic and functional harmony within the alveolar basal bone. If a practitioner decides to initiate comprehensive levels of orthodontic care, it is important that he or she accepts responsibility to provide the treatment to full completion standards. It is not appropriate to provide only one phase of treatment with the intention of referring the patient for the final and definitive phases of care unless the separate treatments were predetermined between consulting providers. If the practitioner recognizes the need for, but is unwilling or unable to provide, comprehensive care, it is appropriate to refer the patient to a practitioner able to address all of the orthodontic needs.

The interventions necessary to achieve comprehensive goals may be accomplished in one single phase or in specifically planned phases of treatment. To determine the approach in most patients, the preferred time for evaluating comprehensive orthodontic needs and implementing treatment is from the transitional mixed dentition into the young permanent (adolescent) dentition. The ABO Diplomates have stated that there are numerous advantages for both the patient and the practitioner in terms of early orthodontic treatment and, importantly, that the final results of early treatment tend to be better. The basis for these statements lies in the fact that the clinician has the ability, with mixed dentition timing, to control arch length adjustments in terms of leeway space and late mesial molar shifts for the relief of most levels of crowding, to utilize space gaining and arch expansion procedures in reducing extraction needs, to control incisor and buccal segment eruption patterns for adjustments in overbite, open bite, and leveling of the curve of Spee, to control deleterious habits and functional deviations in occlusion, and to use growth modification with dentofacial orthopedics for skeletal discrepancies. Most of the January 1998 and June 2002 issues of the *American Journal of Orthodontics and Dentofacial Orthopedics* are dedicated to a broad range of topics related to the rationale for common procedures used in early orthodontic treatment. These issues serve as excellent reference sources for review.

A convenient way to look at comprehensive orthodontics in the context of “early” treatment is to relate it in terms of

the developmental stage of the dentition. The dental stages in which comprehensive treatments are considered for growing patients involve the full primary to the mid-mixed dentition through transitional eruption of the first molars and incisors (4–10 years of age), the mid- to late mixed dentition overlapping the transition of the buccal segments (10–12 years of age), and the early permanent dentition (12–16 years of age). The general scope of interceptive orthodontic interventions in these stages is outlined earlier in this chapter. They serve as a focus for the presentation of case examples that illustrate the more comprehensive treatments necessary to address more complex needs in growing patients.

PRIMARY TO MID-MIXED DENTITION (AGES 4–10 YEARS)

If not corrected early, abnormal dental, skeletal, and functional relationships that are notable in the primary dentition may have profound effects on the orofacial growth patterns. They can become increasingly difficult to correct as the child transitions toward the permanent dentition. Some of the more significant problems that can be treated effectively in the primary dentition involve functional and bilateral posterior crossbites along with deleterious oral habits. As illustrated in earlier sections, significant orthodontic and orthopedic changes can be affected with various “interceptive” appliances in this period. A further example of primary dentition intervention that potentially extends into more comprehensive concepts is shown in [Fig. 23.59](#) with correction of a pseudo-Class III malocclusion. Without such early treatment, the functional aspects of the malocclusion could carry over into much more complex skeletal problems, as growth continues to compensate for the deviations. It is not necessarily the intent of an early phased treatment to prevent the need for full Edgewise appliances in the permanent dentition. The goal is to establish normal vertical, transverse, and sagittal relationships of the dentition with functional perioral balance. However, as illustrated in this interceptive case, it is possible to establish such a harmonious relationship of the dental units that further treatment is unnecessary. Such an outcome is also illustrated in [Fig. 23.60](#), where more involved early treatment mechanics were used. Each of these cases supports the idea that the real goal of such treatment in developmental stages should be to minimize or eliminate the amount of orthodontic treatment needed in the permanent dentition, with more ideal outcomes. The remaining cases presented involve just such comprehensive treatments where Edgewise appliances were used to finish the treated occlusion toward optimal functional and aesthetic outcomes.

Correction of Class II skeletal relationships in the primary and early mixed dentition stages with functional appliances and extraoral headgear has been reported in the literature. In contemporary practice, however, Class II malocclusions are generally managed from the mid- to the late mixed dentition, extending on into the young permanent dentition, with positive outcomes. This later timing coincides with the pubertal growth period for enhanced dentofacial orthopedics and the transition of the buccal dentition to optimally affect sagittal dentoalveolar corrective changes.

In addition, later timing simplifies retention considerations of any achieved correction by reducing the time between the early treatment phase, the full Edgewise phase, and the completion of growth. In contrast, skeletal Class III relationships can be addressed in the primary and incisor transition periods to establish normative overbite and overjet relationships into the mixed and permanent dentitions. Class III corrections in this time frame with reverse-pull headgear have been consistently shown to present efficient and effective treatment outcomes compared with later treatment timing. This particularly applies if the Class III pattern involves a retruded maxillary complex as the causative factor or if the anteroposterior discrepancy is the result of a functional anterior displacement of the mandible (pseudo-Class III). If the major component of the Class III pattern is a severe skeletal overgrowth of the mandible, attempts at correction are more variable and often require retreatment as the lower jaw outgrows the correction. This is especially true if there is a strong genetic/familial component to the mandibular prognathia.

Vertical growth abnormalities can also be successfully managed in this early transitional period. Patients with deep overbites and a horizontal growth pattern (low mandibular plane angle) may benefit from a removable anterior bite plane to allow for supraeruption of the posterior dentition.

Because the permanent incisors and first molars have erupted by ages 8–9 years in both arches, fixed Edgewise appliances can be placed in a segmental fashion to accomplish specific dental orthodontic movements. Molar-to-incisor bracketing treatments (2×4 setup) generally last 6–12 months and are designed to correct severe and detrimental displacements in establishing normative overbite and overjet of the incisor segments. After the 2×4 mechanics, the patient is typically placed in a resting retention phase until full eruption of the permanent dentition is established around ages 12–13 years. A first-phase approach involving a 2×4 setup with a transpalatal bar for anchorage to help correct a Class II division 2 deep-bite malocclusion at age 9 years and 4 months is presented in [Fig. 23.61](#). Lower arch development was enhanced with a mandibular lip bumper during the upper retention phase. Full Edgewise appliances followed in the permanent dentition to finalize alignments (age 12 years and 10 months).

MID- TO LATE MIXED DENTITION (AGES 10–12 YEARS)

Given that the majority of patients present with Class I skeletal relationships and that any malocclusion requiring treatment most likely involves crowding, the incorporation of space supervision concepts with the control of leeway space is a major component of treatment in the late mixed dentition. Addressed in a sequential consideration of guidance in an earlier section of this chapter, [Fig. 23.62](#) illustrates the value of a mandibular lingual holding arch in the relief of lower anterior crowding at 11 years and 8 months of age in controlling leeway space. Class I molar relationships were maintained with the lingual arch and selective primary extractions over 18 months of space supervision. Seventeen months of full Edgewise appliances completed the alignment (15 years and 5 months).

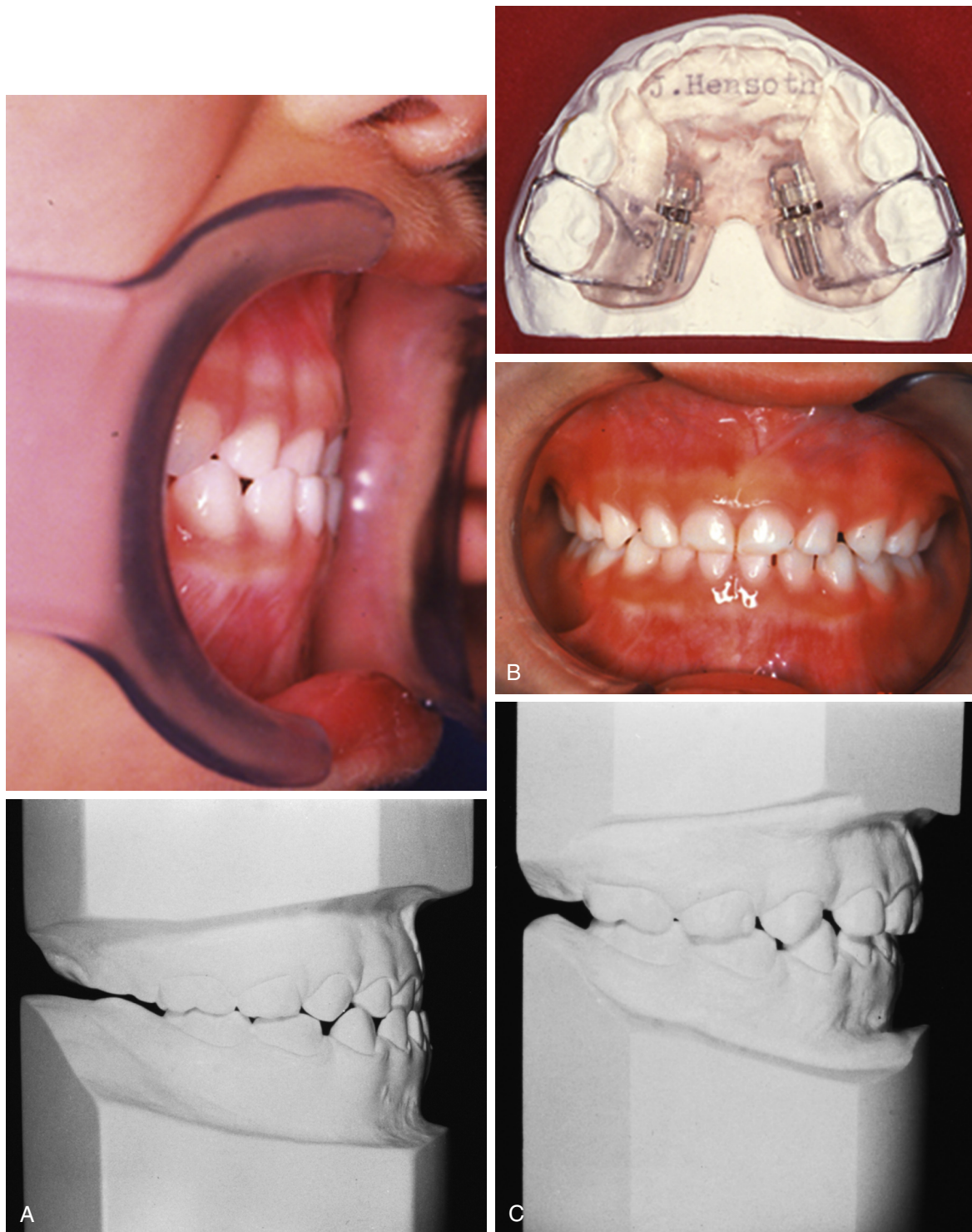


Fig. 23.59 Primary dentition anterior crossbite with functional shift of mandible. (A) Pretreatment clinical and model view of occlusion. (B) Anterior sagittal appliance designed to labialize the primary incisors. (C) Posttreatment clinical and model view of occlusion.

Patients who present with skeletal Class II malocclusions often benefit from dentofacial orthopedics involving directed extraoral headgear mechanics and/or mandibular advancement (functional) appliances during the late mixed dentition period. The growth modification appliances, timed with pubertal growth, enhance maxillary to mandibular skeletal and dental relationships in preparation for full Edgewise appliances to finish and detail final alignment.

Mid- to late dentition treatments in managing the occlusion, with full Edgewise appliances to follow in the permanent dentition, typically involve:

Space supervision: To hold lower leeway space (lingual holding arch), hold upper leeway space, and derotate permanent first molars (transpalatal bar).

Expansion appliances: Transpalatal arch bars, Hyrax, lip bumpers.

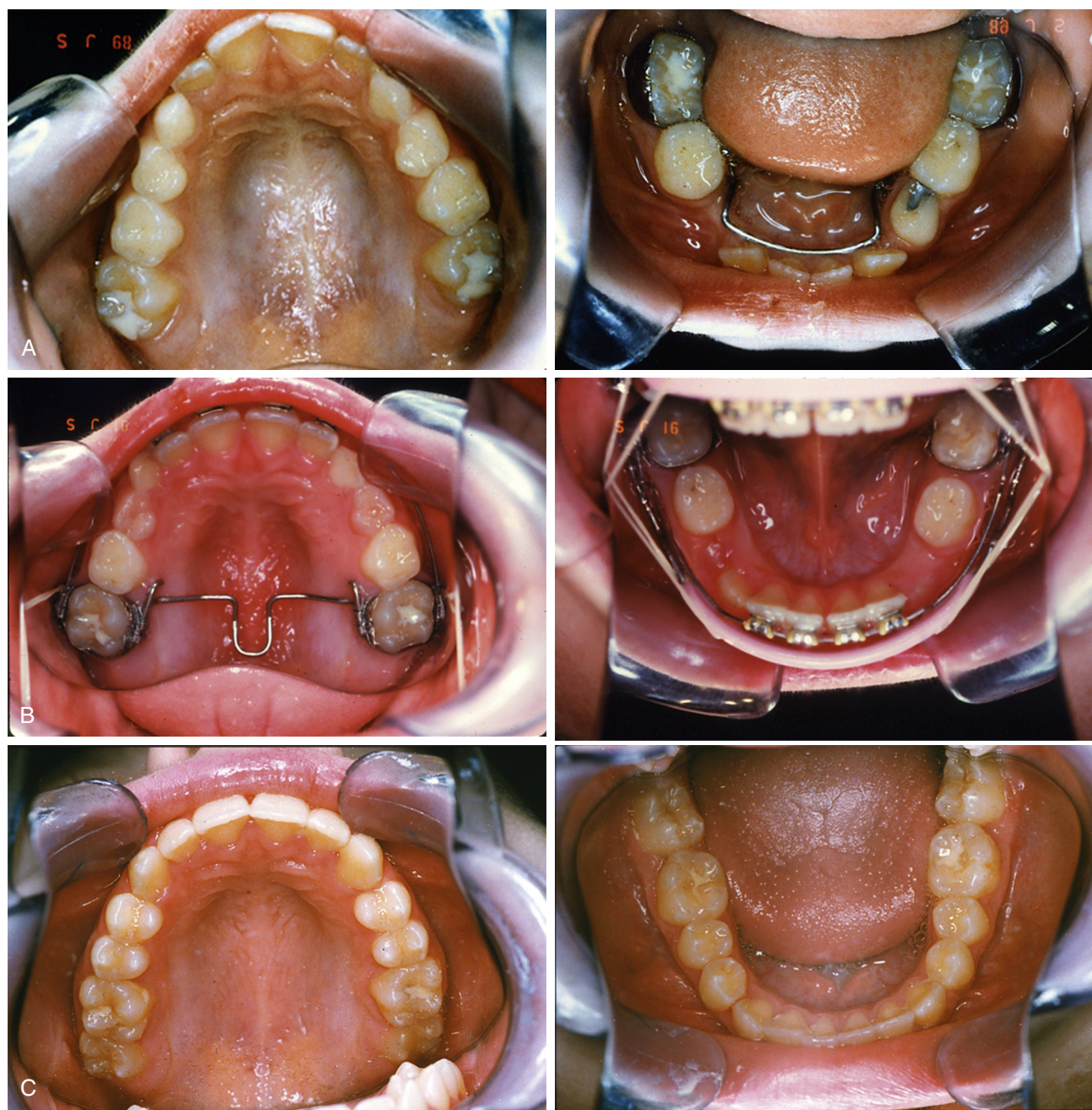


Fig. 23.60 Patient treated with phase I orthodontics only. (A) Pretreatment occlusal views; note tapered maxillary arch and arch length insufficiency in the mandibular arch. (B) Phase I treatment with fixed 2 × 4 Edgewise appliances, maxillary transpalatal bar, and mandibular lip bumper. Note arch length development, particularly in the lower arch. (C) Posttreatment occlusal views in permanent dentition without additional full Edgewise bracketing.

Fixed Edgewise appliances and archwires: Banded molars and bracketed incisors for 2 × 4 mechanics. Allows for molar derotation and uprighting, incisor leveling, incisor alignment, and incisor protraction or retraction.

Extraoral headgear: Directed cervical-pull, high-pull, or protraction reverse-pull headgear applications, with selection dependent on the vertical and sagittal facial growth patterns as well as the stage of development. Often used with anterior bite planes.

Functional appliances: Removable (e.g., Bionator) and fixed (e.g., Herbst) mandibular advancement appliances serve as examples of many options for Class II problems. Reverse-pull

facemasks and maxillary and mandibular miniplates with orthopedic traction are examples for Class III problems. The type of functional appliance and its design vary significantly depending on the facial growth pattern.

Selected extractions: Timely removal of both primary teeth and selected permanent teeth in guidance and serial extraction protocols optimizes the use of available space. The patient's diagnosis influences which "early" treatment modalities would be appropriate. One pervasive philosophy in early orthodontic treatment is that the simplest biomechanics necessary to achieve the desired treatment outcome is the best.

EARLY PERMANENT DENTITION (AGES 12–16 YEARS)

Comprehensive orthodontic care in the adolescent permanent dentition again includes both orthopedic and orthodontic components. Orthopedic components might involve continued applications of palatal expanders, headgear, and

functional appliances. Fig. 23.63 illustrates the correction of a Class II malocclusion with a functional appliance in the permanent dentition. An activator for mandibular advancement worn in combination with a high-pull headgear for restraint of maxillary growth addressed the skeletal Class II problem. The orthodontic component included full fixed Edgewise appliances to establish occlusal relationships as near to “ideal” as

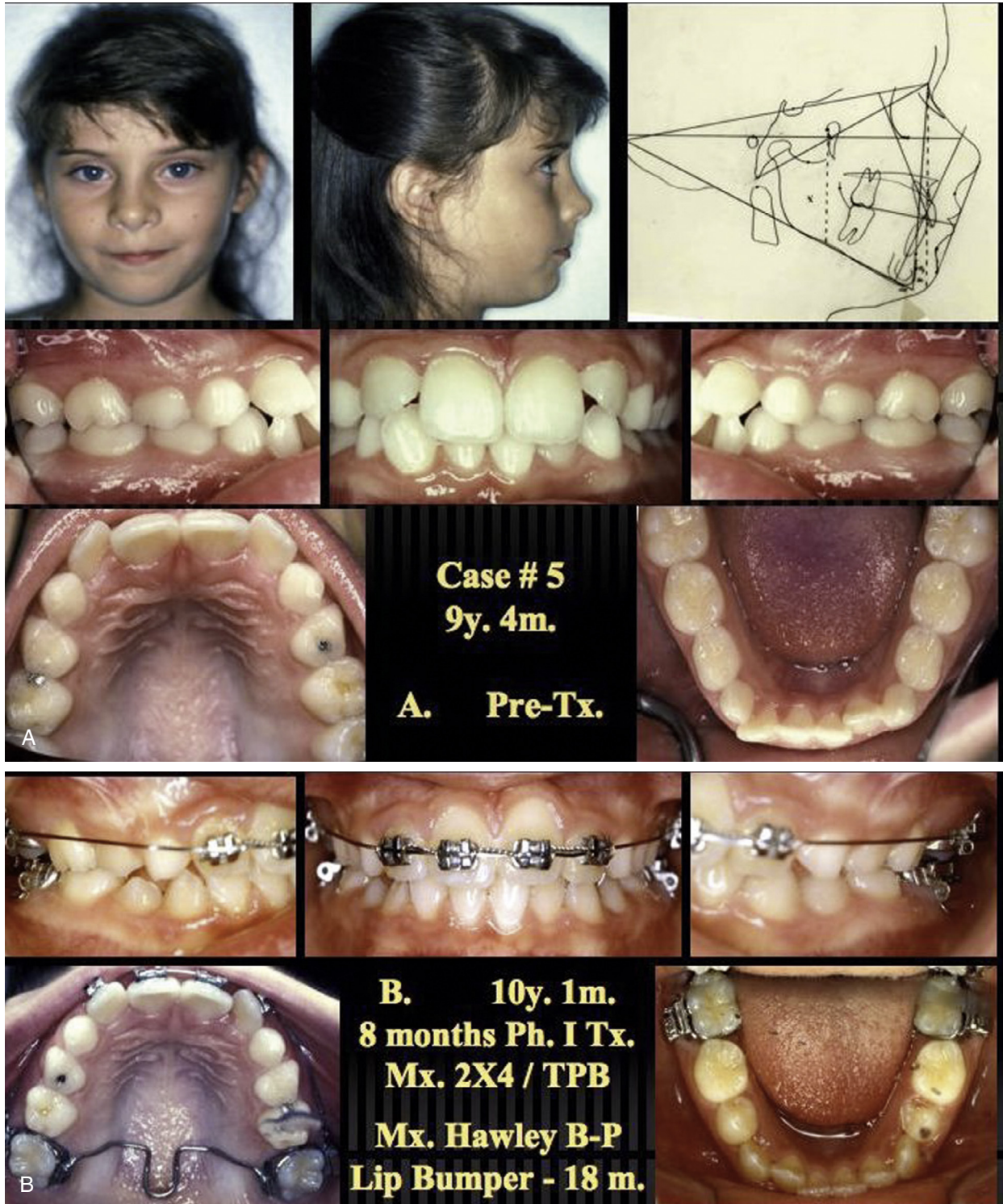


Fig. 23.61 (A) Class II division 2 deep-bite malocclusion in a child aged 9 years and 4 months with mesofacial growth pattern, retrognathic mandible, ANB = +6 degrees, moderate incisor crowding. (B) A maxillary 2 × 4 with a transpalatal bar was used along with a mandibular lip bumper for 8 months of phase I treatment. The upper was retained with a Hawley bite plane; the lip bumper was continued for an additional 18 months.

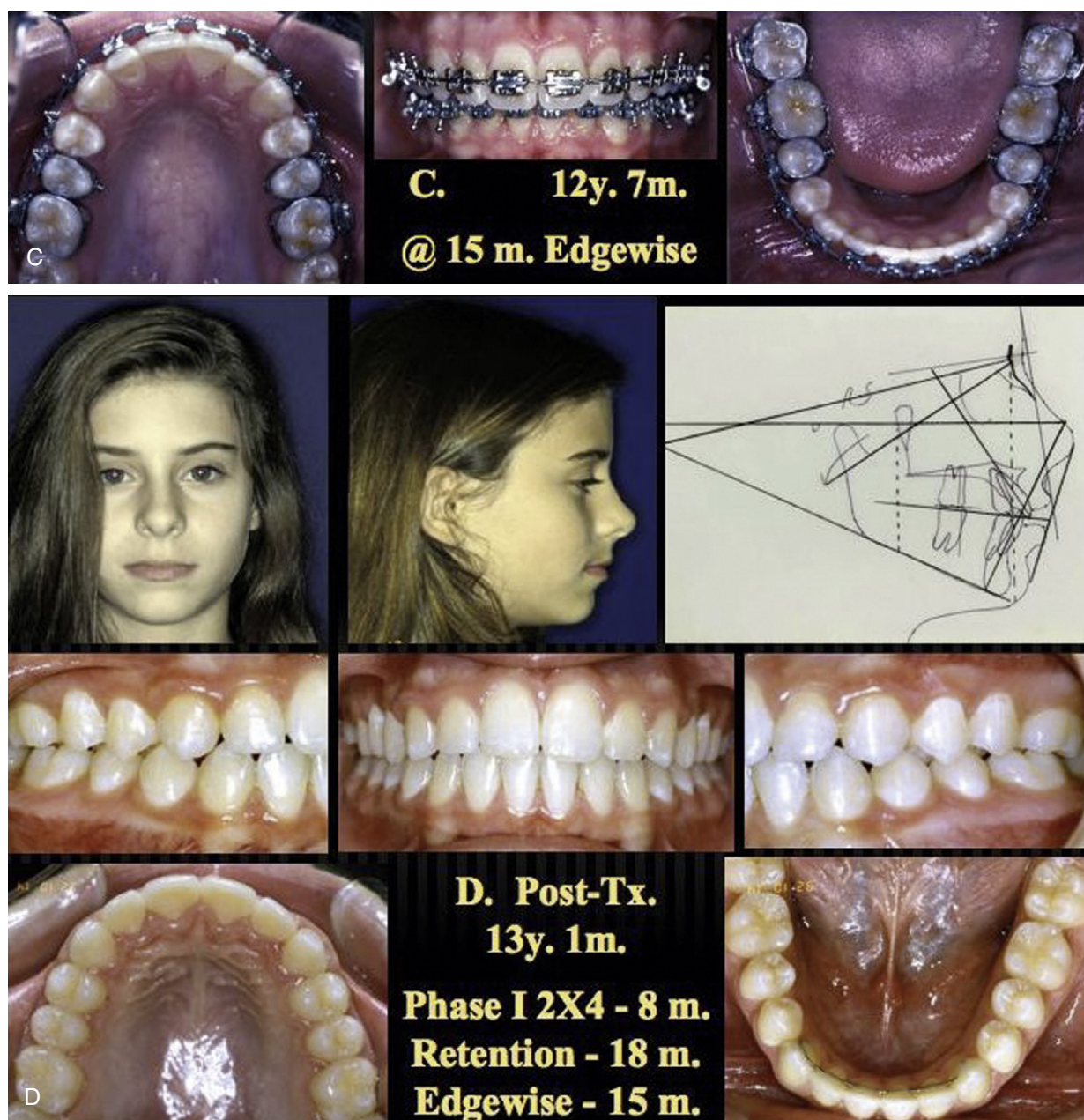


Fig. 23.61 cont'd (C) Patient started second Edgewise phase that continued for a total of 15 months until age 12 years and 7 months. (D) Final records obtained 3 months after removal of Edgewise appliances at age 12 years and 10 months.

possible. Extraction of a single maxillary first premolar was used in the full Edgewise phase to camouflage the midline asymmetry in finishing with a good buccal occlusion.

Localized tooth displacements such as maxillary canine impactions and significant genetic tooth size–arch size discrepancies not manageable with space supervision procedures are also commonly addressed in this period. The removal of selected permanent teeth in cases of significant tooth size–arch size discrepancies with severe tooth displacements or to camouflage Class II or Class III dental malocclusions often offers good options as part of a comprehensive treatment plan.

If a patient has undergone an earlier phase of treatment successfully, the Edgewise phase of treatment might take

as little as 12–18 months and, it is hoped, will involve few, if any, orthopedic needs. However, if this is the start of comprehensive care, more treatment time will likely be needed. Treatment with full Edgewise appliances includes leveling and alignment of the dentition, space consolidation, transverse coordination of upper to lower arch forms, sagittal arch coordination (Class II or III elastic wear), establishment of root parallelism over basal bone, finishing and detailing of intra- and interarch positioning (i.e., first-, second-, and third-order archwire bends), and buccal or anterior segmental finishing procedures to establish maximum interdigitation between arches. In selected patients, the Edgewise treatment may be more limited, unnecessary as determined by the dental practitioner, or unwanted as

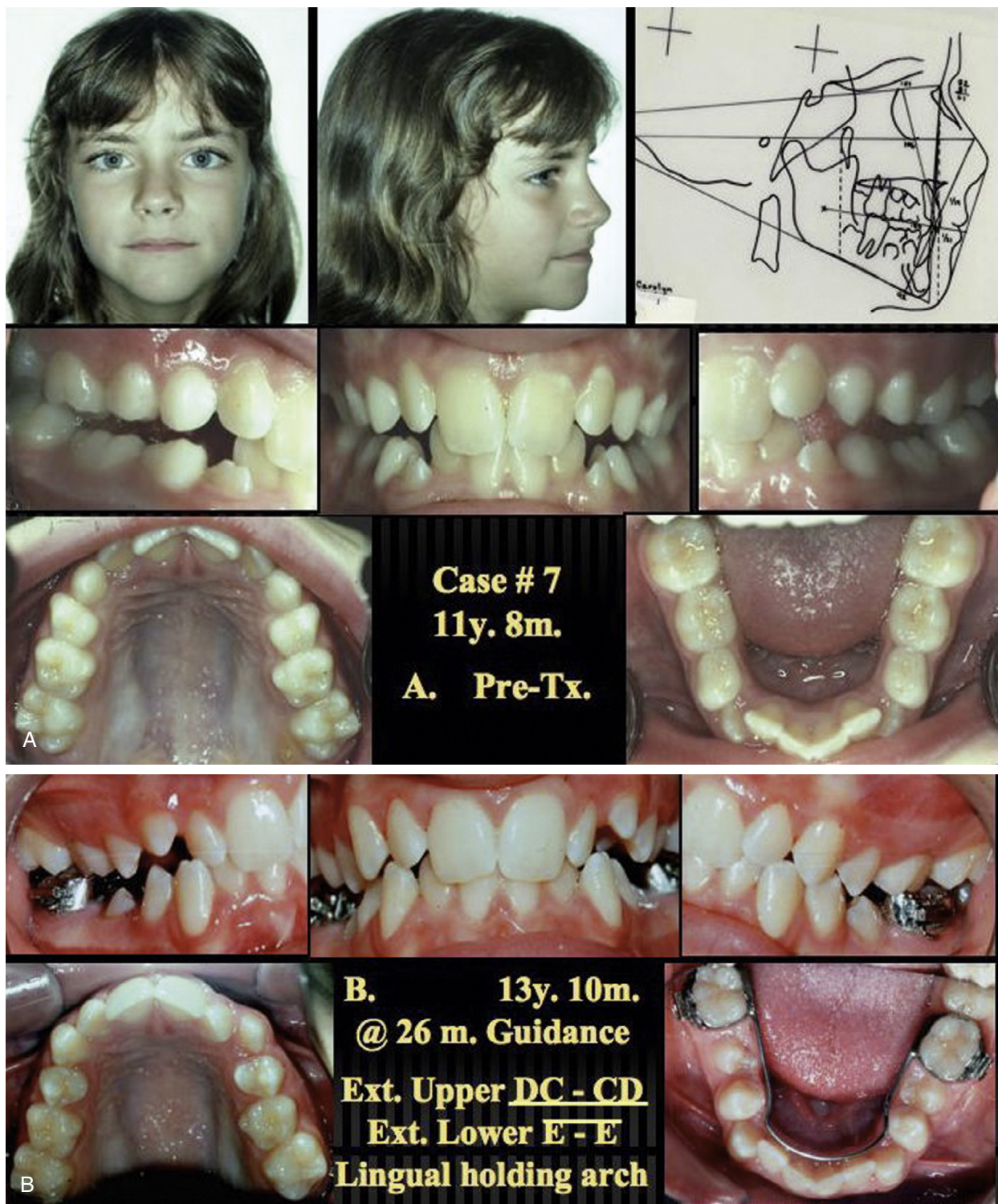


Fig. 23.62 (A) Class I mixed dentition in a patient aged 11 years and 8 months with notable anterior crowding, delayed dental developmental timing, mesofacial growth pattern, and bilateral ankylosed lower primary molars. (B) Patient at age 13 years and 10 months after 26 months' guidance with selective extraction of upper primary canines and first molars, lower first and second primary molars, and passive lingual holding arch.

determined by the patient and/or parent. Limited treatment can involve segmented arch therapy in which only the teeth or arch needing attention is addressed. Occasionally the practitioner may be so satisfied with the result after an earlier phase that no further treatment is recommended. However, this is fairly uncommon. A more likely

occurrence is that the patient and/or parents decide that they are satisfied with the result, even though some finishing details are needed. It is critical to stress to parents before initiating early treatments that most children will benefit from a final period of full orthodontic appliances (phase II) to optimize aesthetic and functional outcomes. It

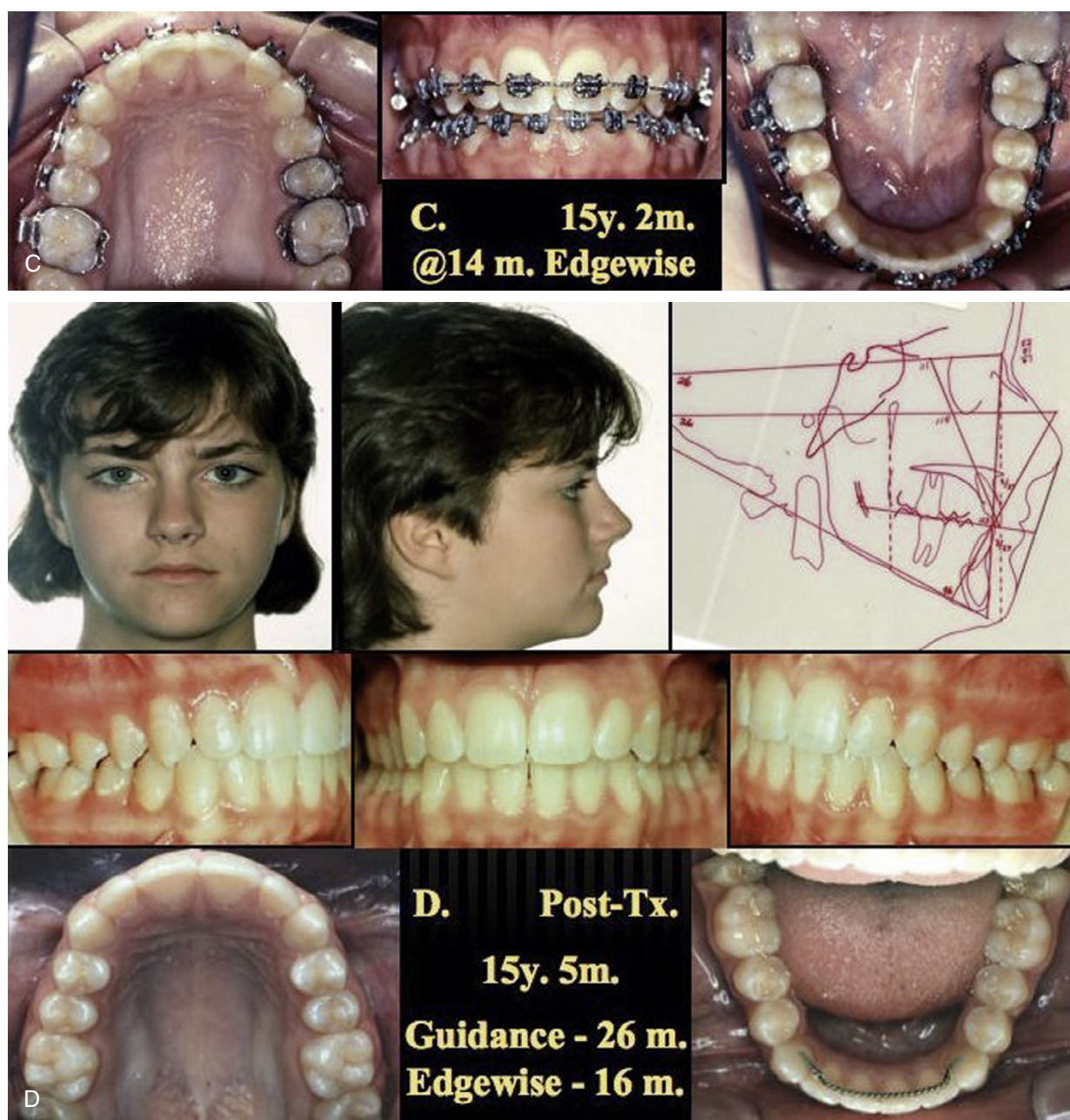


Fig. 23.62 cont'd (C) Full upper and lower Edgewise appliances were used for a total of 15 months. (D) Final records obtained after removal of Edgewise appliances at age 15 years and 5 months.

is particularly important to allow for final tooth positioning of the permanent second molars.

Retention following the definitive stage of comprehensive Edgewise treatment should involve the philosophy of “retention for a lifetime.” There are many different types of retention schemes. Although no perfect retention scheme has been developed and periodic observation is warranted for all, the following retention schedule seems to provide for stable results:

1. Maxillary and mandibular Hawley retainers to be worn 24 hours a day for 4–6 months, followed by worn at night only for 6–8 months.
2. After 1 year, reassess if wear can be reduced to 1 or 2 nights per week with the patient increasing wear as

needed if the retainers become tight from tooth movement.

3. Continue wear as above for “retention for a lifetime” or, at an absolute minimum, until 21 years of age, at which time the craniofacial growth rate has been reduced to that of an adult.

The use of a backup set of thin acrylic overlay retainers is a useful way of inexpensively giving the patient an emergency set of retainers if the Hawley retainers are lost or damaged. As an added benefit, they can be used for home bleaching of the teeth for those patients who are interested. Fixed retention may be necessary in special circumstances. A lower canine-to-canine fixed bonded wire can be helpful for severe rotations, and an upper lateral-to-lateral fixed

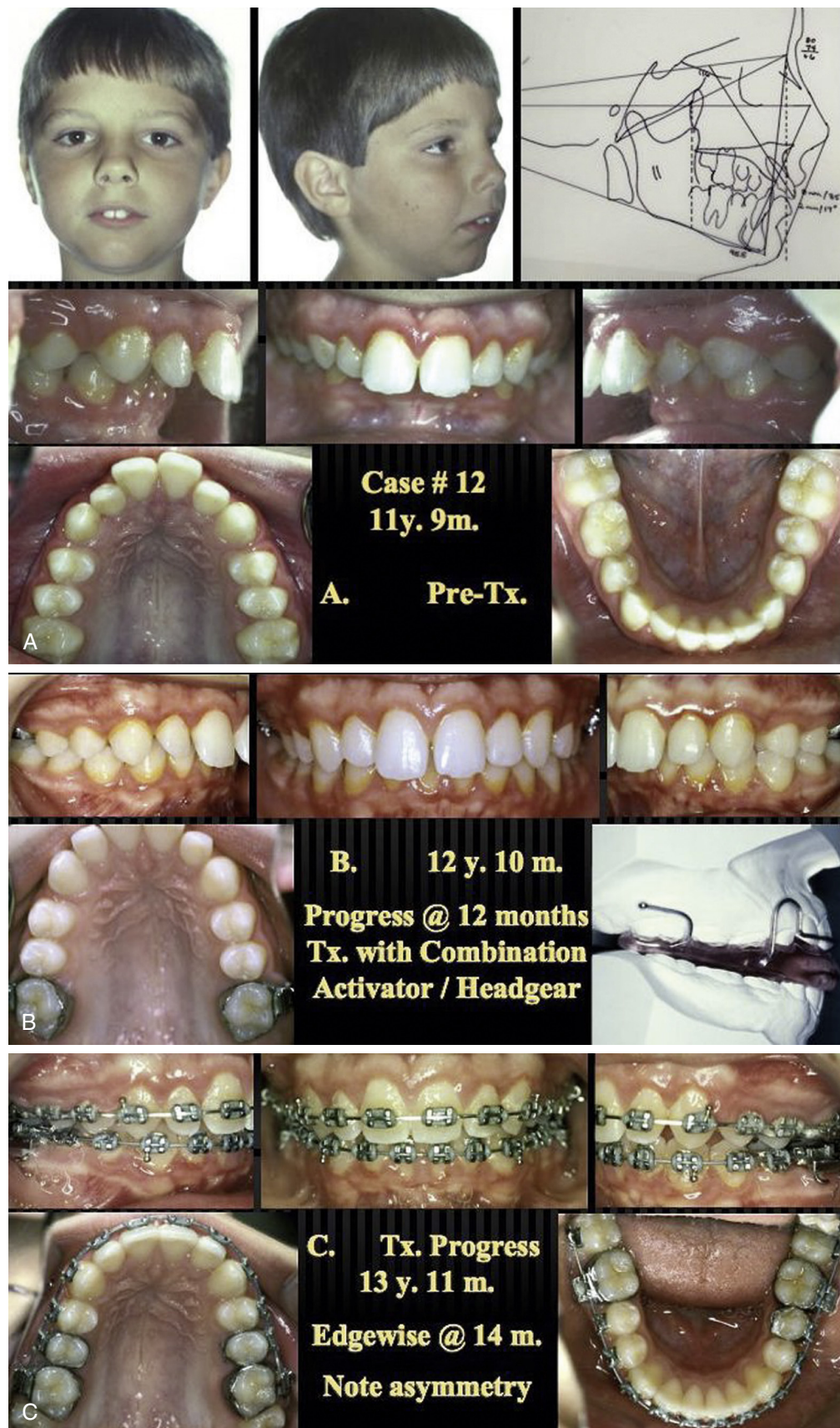


Fig. 23.63 (A) Class II division 1 mixed dentition with convex profile, lip interpositioning, mesofacial growth patterns, ANB = +10 degrees, mandibular retrognathia, and maxillary dental protrusion in a patient aged 11 years and 9 months. (B) Patient after 12 months of wearing a mandibular functional advancement appliance (i.e., Activator) and cervical-pull headgear in combination with following a regimen of 12 to 14 hours of wear per day. (C) Patient started full Edgewise phase at age 12 years and 10 months. The treatment progress at 14 months of Edgewise use illustrates midline asymmetry with Class I right and Class II left buccal occlusion.

bonded wire is useful to prevent space opening for patients with initial diastemas.

One final thought that seems of particular interest to parents regards the effect of extraction of third molars on late lower incisor crowding. Although more studies will be necessary to corroborate the results, a nicely done prospective

randomized controlled clinical trial of orthodontic patients who had early extraction of third molars versus those who showed no clinically significant difference in incisor crowding between the two. The authors concluded that removal of third molars to reduce or prevent incisor crowding was not justified.⁵⁹

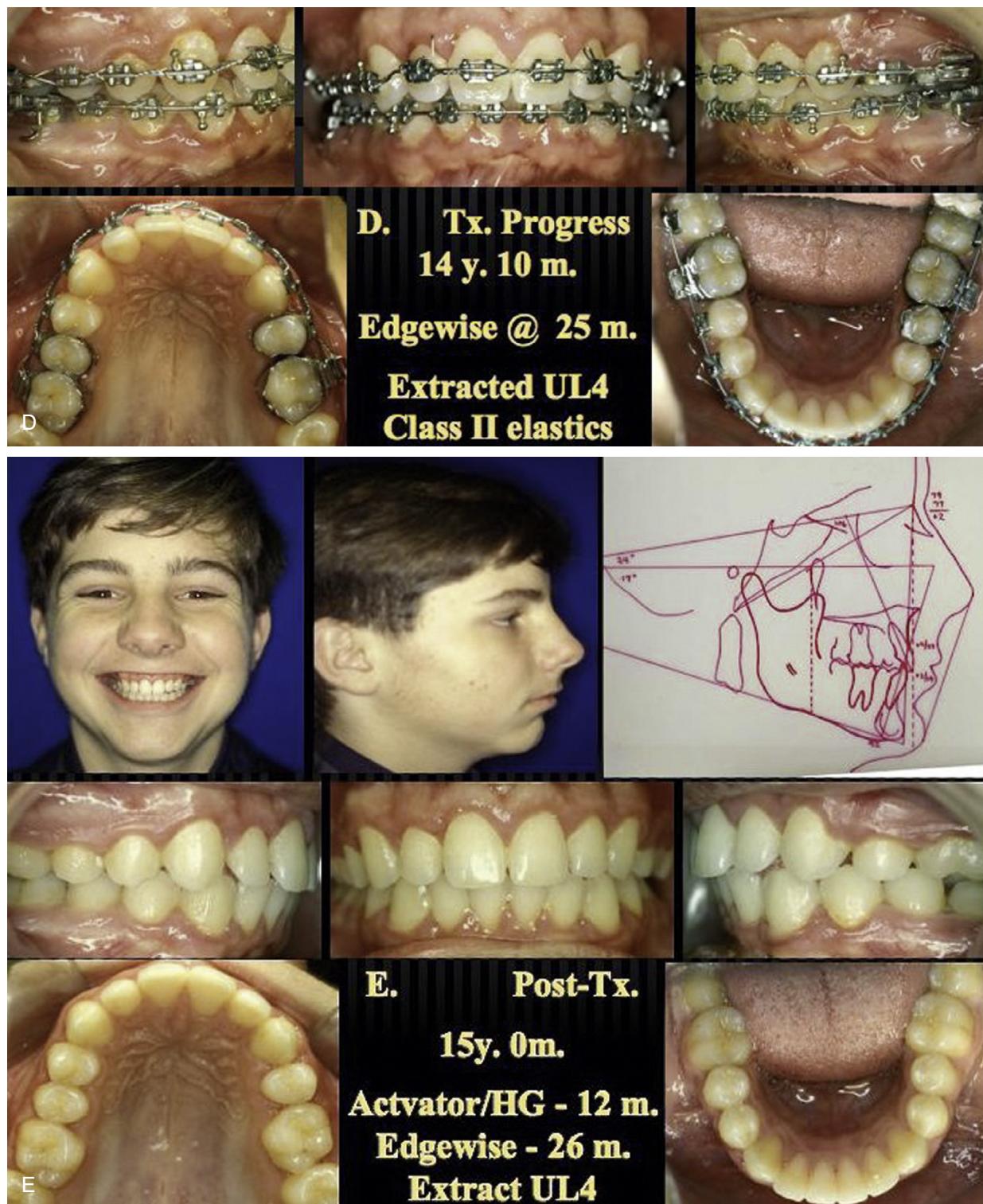


Fig. 23.63 cont'd (D) Treatment progress at 25 months of Edgewise treatment illustrates midline symmetry attained in conjunction with selective extraction of the upper left first premolar. (E) Final records obtained at age 15 years and 0 months after 12 months of growth modification and 26 months of Edgewise appliances.

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