Orthodontic treatment in adolescents with cleft lip and palate

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The orthodontic treatment of adolescents with cleft lip and palate is complex and highly individualized. For such patients, there is a great need for thorough and comprehensive diagnosis as well as attention to multidisciplinary aspects of orthodontic care. A framework for categorizing patients with varying forms and degrees cleft lip and palate into three levels of skeletal discrepancy from least to most severe is presented, and the specific treatment objectives of phase II orthodontic treatment for each of the three categories is then outlined. Moreover, due to specific challenges of a cleft-related dentition, the various aspects of the management of missing teeth are reviewed. Finally, the importance and most pertinent methods of retention are emphasized. (Semin Orthod 2017; 23:295–304.)

Introduction

Numerous treatment-planning challenges are faced in the orthodontic management of adolescents with varying forms and severities of cleft lip and palate. Some of these challenges are due to the deficiency of hard tissues (i.e., bone and teeth), soft tissues[1] and the growth challenges arising from prior surgical interventions. As a result of the challenging presentation and unpredictable course of growth, orthodontic treatment plans require re-assessment and modification over time, and "therapeutic diagnosis" may be necessary.[2] This article will focus on the "phase II" orthodontic diagnosis and treatment planning of patients with cleft lip and palate; pre-surgical orthodontic preparation will be discussed in a subsequent article.

Patients will typically present for phase II orthodontics between the ages of 10 and 15 years. In conventional orthodontic treatment, phase II is often postponed until all primary teeth have exfoliated and the permanent teeth have erupted. In patients with cleft lip and palate, phase II treatment may be initiated earlier. Considerations for early initiation of phase II treatment in this population include intervention for multiple missing or supernumerary teeth with ectopic positions and patterns of eruption.[3] Premature or delayed dental eruption due to premature exfoliation of primary teeth is common in patients with clefts.[4–6] Additional considerations in the early initiation of phase II orthodontics in this patient population include psychosocial concerns related to the malocclusion or appearance of the dentition, as well as the severity of skeletal discrepancy. Treatment goals will vary depending on the above considerations,[7] with complete records being critical to the diagnostic decision-making process.

Diagnostic records

Accurate diagnostic records are of critical importance in planning the complex treatment of patients with cleft lip and palate. A complete record set should include the following:

1. A detailed history of past surgeries, other medical conditions, medications and allergies.
2. A photographic series where standard extra-oral and intra-oral photos are supplemented with additional views to better appreciate facial asymmetry. The additions consist of contralateral lateral and three-quarter views, top-down view, worm's eye view, and frontal view with the patient's posterior teeth occluding on a bite stick to demonstrate occlusal cant.

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3. A set of standard dental casts and a record of articulation, both of which may be digital or analog.
4. Radiographs, including 3D imaging. This may consist of a single full-volume facial CBCT, which captures the anterior cranial base structures. Alternatively, a traditional lateral cephalogram and panoramic radiograph, with an optional postero-anterior cephalogram, as well as a partial-volume CBCT that captures the cleft site may be utilized. The inclusion of 3D imaging of the cleft site is of importance in assessing bone quality and quantity in this region. Because of the complexity of the cleft alveolus, conventional 2D imaging may not be sufficient to fully diagnose the shape, size, and location of bony deficiency and unerrupted teeth, particularly when assessing the results of alveolar bone grafting. Finally, one may also choose to perform a hand-wrist radiograph, which would provide some information regarding growth.
5. A thorough clinical exam to assess: form and function of the tempero-mandibular joints, centric relation occlusion and presence of functional shift to intercuspal position, facial midline, maxillary and mandibular dental midlines, incisal and gingival display at rest and when smiling, and lip posture and competence. Growth assessment questions regarding menarche, shoe size and height changes can be combined with radiographic indicators for a more thorough assessment of growth potential.

Supplemental records beyond those outlined above are indicated in specific clinical situations. These may include, but are not limited to:

1. *Airway assessment*: Obtructive sleep apnea is both more common and more severe in children with cleft lip and palate.[8,9] Due to the hypoplastic and retrusive nature of the maxilla in patients with clefts, part of the upper airway may be obstructed. Furthermore, muscular dysfunction in the soft palate can also contribute to obstruction. If a patient reports snoring with difficulty breathing or sleeping at night, an airway assessment is indicated. Although a CBCT may be used to evaluate the volume and minimal cross-sectional area of the airway space, the static nature of the evaluation is not ideal. Similarly, clinical features and screening questionnaires may assist in identifying patients at risk for sleep disordered breathing, but are of limited use in determining severity.[10] An observed sleep study (polysomnogram) remains the gold-standard for diagnosing sleep apnea.[11] ENT referral may also recommend evaluating the tonsils and adenoids, which may be contributing to airway problems. However, interventions such as adenotonsillectomy may introduce problems with hypernasality, thus a speech evaluation is recommended. Various treatment options for obstructive sleep apnea exist, but their discussion exceeds the scope of this article.
2. *Referral for speech evaluation*: Patients with cleft lip and palate often experience speech anomalies in both resonance and articulation.[12] With respect to orthodontic treatment, articulatory errors may result from aberrant tooth and jaw positions. Though many children are able to compensate for such speech errors, certain speech habits are acquired that may not be corrected once the tooth and jaw relationships are corrected. Such patients benefit greatly from speech therapy.[12,13] If a patient or parent would like to know if speech errors will be corrected with orthodontic treatment, it is best to have them evaluated by a speech pathologist, preferably one with craniofacial training. As mentioned above, certain interventions may introduce physiologic challenges to speech production. At times, an alternate or additional surgical procedure to assist in a type of speech production may be recommended by the speech pathologist and the surgeon.
   If an orthodontic treatment plan includes an orthognathic intervention, such as midface skeletal advancement, the patient should be evaluated by a cleft trained speech therapist to asses the risk that the patient may become hyponasal, as a possible consequence midface skeletal advancement.
3. *Soft tissue evaluation*: In many instances, particulary when a patient is anticipated to pursue soft tissue surgery in the future, facial soft tissue evaluation is best assessed by a craniofacial plastic surgeon. Since cleft lip and

palate also affects nasal esthetics and function, through alteration of the nasal tip position and septal deviation,[14] rhinoplasty is often indicated. Various types of nose and lip revisions may be suggested to refine the outcome of past surgery. Rhinoplasty is often recommended once maxillary growth has ceased. In most cases, it is recommended to postpone such surgical treatment until orthodontic treatment is complete. However, it is very important to discuss with the patient and their surgeon if a lip lengthening or other lip procedure is anticipated, as this may alter orthodontic treatment goals regarding the esthetic positioning of maxillary anterior teeth. When orthognathic surgery is employed to correct occlusion and facial esthetics, it is best to delay definitive surgical interventions to the lip and nose until after 6 months of healing, once swelling has decreased.

Evaluation of maxillomandibular skeletal discrepancy

Skeletal discrepancies may be categorized as *no skeletal discrepancy*, *mild*, *moderate* or *severe*. Consideration should be given not only to sagittal discrepancy, but to discrepancies in the vertical and transverse dimensions as well.[7]

An absence of skeletal discrepancy is diagnosed when no sagittal, vertical, or transverse skeletal discrepancy is observed. Patients present with a Class I skeletal relationship, a mandibular plane angle within normal limits, and adequate buccal dental overjet in the posterior regions without significant dental compensation. Due to the frequency of maxillary growth disruption and inhibition in patients with cleft lip and palate, a Class II skeletal relationship may also be considered part of this category (Fig. 1). In patients with no skeletal discrepancy, the soft tissue profile appears slightly convex or straight and is well-balanced. Patients born with mild clefts, particularly those not involving the hard palate are the most likely to exhibit no skeletal discrepancy.[1]

A *mild* sagittal skeletal discrepancy is characterized by a mild Class III skeletal relationship. Vertically, there may be a mandibular plane angle that is two to three standard deviations above normal (Fig. 2A). Transversally, the posterior buccal overjet may be reduced to an edge-to-edge cusp relationship bilaterally or with approximately 2–3 mm of skeletal transverse discrepancy. The soft tissue profile may be straight and the lower anterior face height typically appears slightly long. The lower lip is frequently everted.

The sagittal discrepancy is classified as *moderate to severe* when the Class III skeletal relationship is significant, frequently presenting as a negative anterior overjet and a concave profile. Transversely, a complete posterior crossbite is often observed unilaterally or bilaterally, unless significant dental compensations have occurred (Fig. 3). Patients may have depressed infraorbital and malar skeletal anatomy on the cleft side. Vertically, the mandibular plane angle may be more than three standard deviations above normal. The lower anterior face height may be long with lip incompetence and apparent lip strain on closure.

Assessment of sagittal skeletal discrepancies may be evaluated by conventional cephalometric measures such as the Steiner analysis (SNA, SNB, and ANB), Wits, and McNamara (maxillary and mandibular lengths and distance from N-perpendicular), as well as by clinical photographs. However, in order to more accurately evaluate maxillary and mandibular position and morphology in individual patients, the Individual Scaled Cephalometric Analysis* is recommended. The comparison to cephalometric norms is scaled to the patient's cranial base, which results in a more customized and accurate assement then which occurs when comparison is made to standard non-scaled cephalometric norms. Additionally, the description of patients' skeletal discrepancies must take into account the growth pattern as well as future growth potential. Lateral cephalometric superimposition is used to identify changes in sagittal and vertical skeletal growth. It is important to determine if skeletal discrepancies are stable or worsening over the passage of time, as this may affect treatment plan objectives.

*An analysis developed at NYU Institute of Reconstructive Plastic Surgery with consideration for cleft and craniofacial patients and in use for > 20 years, available through Dolphin imaging Cephalometric Analyses "ISCA").

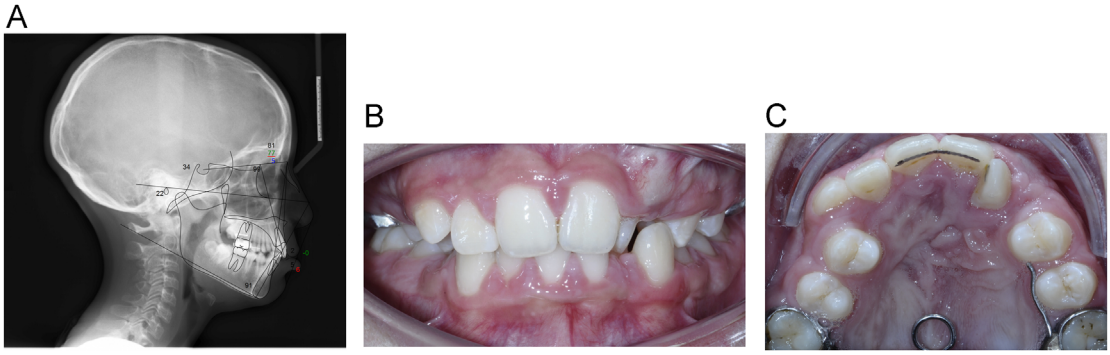

Figure 1. Patient who presents for phase II evaluation at 12 years of age. (A) Lateral cephalogram illustrating Class II skeletal discrepancy (SNA 81° and SNB 77°). (B) Initial positive overbite and overjet. (C) Initial maxillary occlusal showing space loss and crowding.

Phase II othodontic treatment objectives

Orthodontic treatment objectives for patients without skeletal discrepancy

As mentioned previously, individuals born with mild oral clefts may present with minimal or no skeletal discrepancy. Treatment goals for such patients whose malocclusions are only characterized by a dental rather than a skeletal component should be consistent with the treatment goals for patients without cleft lip and palate. Phase II orthodontics consists of full fixed appliances (or aligners if appropriate) in both maxillary and mandibular dental arches. Maxillary and mandibular dental arches should be well coordinated and occlusion should be normalized, with molar and canine classification depending on the number of missing teeth. In the case of substitutions for missing teeth, additional care should be taken to assess and eliminate occlusal interferences in centric and normal occlusal excursions. As will be discussed in the subsequent section on the management of missing teeth, patients without any skeletal discrepancy are more likely to have mild dental anomalies with no or few missing teeth. The question to perform canine substitution or to maintain space for replacement of the lateral incisor is common and the decision should be determined according to the patient's needs and specific clinical presentation as in non-cleft patients.[15]

Orthodontic treatment objectives for patients with mild skeletal discrepancy

The treatment goals for a mild Class III skeletal discrepancy due to a hypoplastic maxilla often consist of acceptable dental compensations or "dental camouflage." In some cases, attempts to

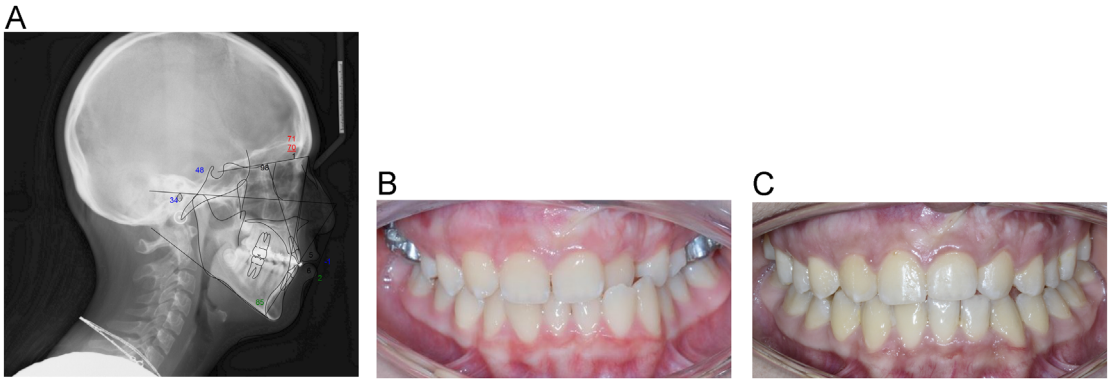

Figure 2. Patient with mild skeletal discrepancy. (A) Lateral cephalogram during phase II showing high mandibular place angle at 15 and a half years of age (FMA 34° and SN-MP 48°). (B) Phase II initial malocclusion. (C) Phase II final occlusion following extraction of a mandibular incisor as a form of camouflage treatment.

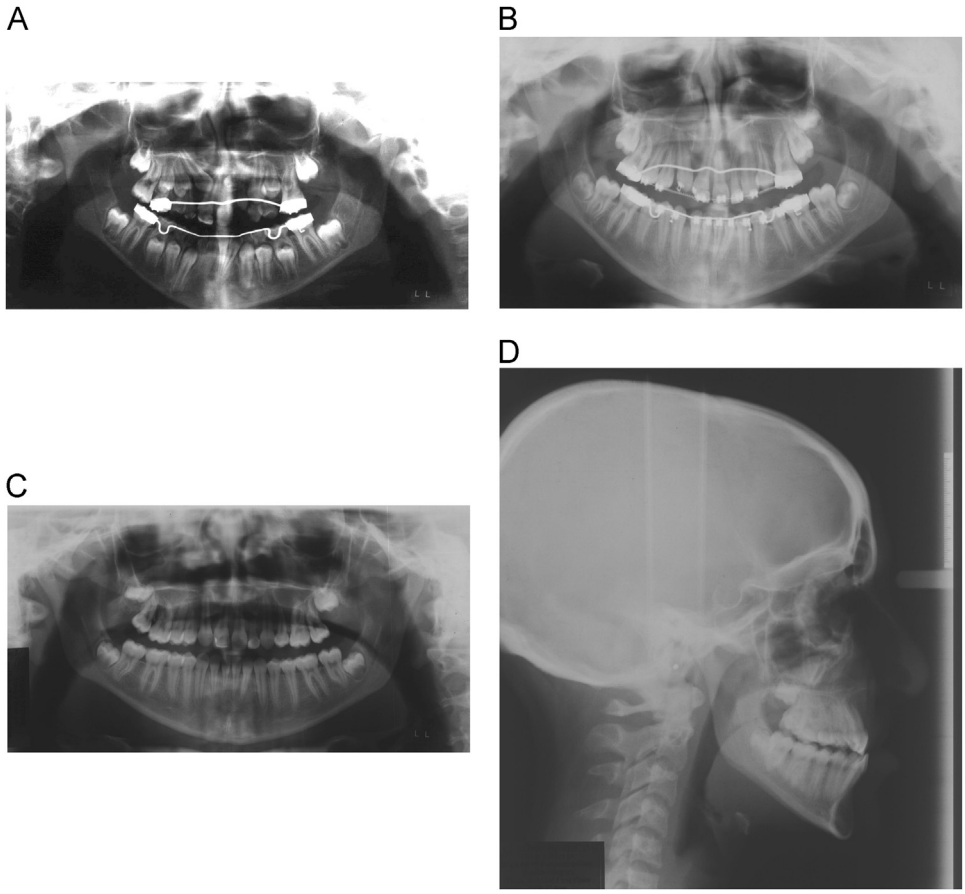

Figure 3. Patient with moderate skeletal discrepancy. (A) Pre-treatment panaromic radiograph show impacted right maxillary canine, peg shaped left lateral incior and maxillary crowding. (B) Phase II progress panoramic radiograph. (C) Panoramic radiograph after completion of Phase II and correction of interarch malocclsuion. (D) Lateral cephalogram showing no dental compensation during phase and maintainence of anterior crossbite to be corrrected at skeletal maturity with orthognathic surgery.

minimize dental compensation and to improve the skeletal discrepancy may be attempted with skeletal anchorage.[16] However, it is important to keep in mind that genetically inherited growth patterns, degree and location of scar tissue from previous surgical repairs, and other environmental factors all contribute to the unpredictability of future growth in patients with cleft lip and palate. Thus, even patients with mild skeletal discrepancy may possess unpredictable growth during and after treatment.

During phase II treatment, maxillary and mandibular arches are bonded and Class III interarch elastics are used to achieve acceptable overjet. Non-extraction or extraction treatment may be indicated. This includes Class III extraction pattern of maxillary second premolars and mandibular first premolars. Alternative extraction patterns include finishing with a Class III molar occlusion by extraction of mandibular first premolars, or extraction of a mandibular incisor (Fig. 2B and C). For patients presenting with agenesis of one or more maxillary teeth, mandibular premolar extractions combined with dental substitution in the maxillary arch may be indicated. Additionally, autotransplantation of extracted mandibular teeth to the maxillary arch in patients missing multiple maxillary teeth may be considered, and can be successfully performed by skilled clinicians in patients with cleft lip and palate.[17–20]

When transverse discrepancy is mild, arch form may be corrected with archwires or through use of transpalatal arches, maxillary expansion appliances, or interarch elastics. Maxillary expansion may be peformed rapidly or slowly,

however, rapid expansion is thought to be more likely to open an existing occult palatal fistula, and 1–2 turns per week is usually sufficient to attain mild expansion objectives. Patients should be provided with retainers that maintain any palatal expansion that was previously performed. An expansion screw may be added to a Hawley retainer to allow correction of mild amounts of transverse relapse.

Despite the mild skeletal discrepancy, if the patient still possesses skeletal growth potential, prior to initiating treatment it is important to address the risks of later developing an anterior crossbite with the patient and parents. In many cases, it is favorable to maintain an excess positive overjet at the end of Phase II treatment as a form of overcorrection, to compensate for later growth.

Orthodontic treatment objectives for patients with moderate-to-severe skeletal discrepancy

Patients with moderate-to-severe skeletal discrepancy possess the least favorable growth pattern. For this reason, treatment goals in this group are limited to alignment and leveling of the maxillary, and occasionally the mandibular dentition followed by monitoring of the maxillomandibular discrepancy until skeletal growth cessation. It is of upmost importance to emphasize the likelihood of further unfavorable growth and future recommendation for orthognathic surgery at skeletal maturity for best esthetic and functional outcome.

The main objective of phase II treatment in patients with severe skeletal discrepancy is to manage orthodontic issues that require interceptive treatment to prevent damage, and to reduce the duration of pre-surgical orthodontics in late adolescence or early adulthood. Treatment should be limited to 12–18 months, as patients undergoing multiple phases of orthodontic treatment are at risk of "burn out" and decreased compliance.[21]

Phase II treatment in this group typically consists of fixed appliances in the maxillary arch to manage and consolidate space, and to correct significant dental rotations and ectopically positioned teeth. In cases of mild mandibular crowding, patients may request alignment and leveling of the lower dentition. If one plans to maintain a compensated inclination of the lower dentition inclination or to correct an anterior crossbite at this time, the mandibular arch may be bonded to maintain curve of Spee. However, bonding and aligning the lower dentition is typically not recommended during this phase as a greater anterior crossbite is likely to develop and may result in patient dissatisfaction. Similarly, it is best to defer the treatment of borderline-mandibular extraction cases to the time of patient re-evaluation, following the completion of growth. On the other hand, severe crowding in the mandibular arch may be treated at this time with extractions to achieve leveling and aligning without sagittal bite correction.

Orthodontic treatment objectives to avoid

While planning the orthodontic treatment of patients with severe skeletal discrepancies, it is important to identify orthodontic goals that should *not* be achieved during phase II therapy. Most importantly, dental compensations should not be performed during phase II in patients who are anticipating orthognathic surgery at the conclusion of growth.

Additionally, patients with a history of unilateral cleft lip and palate may have significant maxillary dental midline deviation from the midsagittal plane towards the affected side. A unilateral maxillary hypoplasia of the cleft side may be present. If maxillary orthognathic surgery is planned, the maxillary dental midline may undergo a yaw (vertical axis) rotation during surgery to correct the dental midline as well as to provide differential midface advancement on the depressed cleft side. This will, however, require special consideration during the pre-surgical orthodontic planning and treatment. Furthermore, in patients with severe skeletal discrepancy characterized by maxillary and mandibular asymmetry, occlusal cant correction should be avoided during phase II orthodontic treatment. Severe occlusal cant should be corrected during maxillary-mandibular surgery (Fig. 4).

Management of missing teeth

The most common finding in patients with cleft lip and palate is a missing maxillary lateral incisor on the cleft side, with reported frequencies ranging from 50% to above 90%.[3,26,27]

Figure 4. Patient with unilateral CLP following phase II treatment completion. (A) CBCT illustrates significant asymmetry. (B) Post-surgical CBCT illustrates correction of the maxillary dental midline and skeletal cant at the skeletal maturity with orthognathic surgery.

A supernumerary tooth in the cleft region is the second most common dental anomaly in this group of patients.[22–26] Agenesis of ipsilateral premolars and other anterior teeth is common; furthermore, missing teeth are observed on the non-cleft side in 15–50% of unilaterally affected patients.[3] Literature shows that patients with non-syndromic unilateral cleft lip and palate and multiple missing maxillary teeth have more severe skeletal discrepancy, characterized by maxillary underdevelopment and the need for maxillary advancement surgery.[28]

Canine substitution

If only one or both maxillary lateral incisors are missing, one option is to close the space and substitute the maxillary canine as the lateral incisor. In this case the first premolar is advanced and substitutes as the cuspid. Canine substitution is a favorable option in cases of single or bilateral missing maxillary laterals when the maxillary canines erupt in a more mesially oriented position, just distal to the maxillary centrals into adequate bone, which is possible following successful alveolar bone graft or after a successful gingivoperiosteoplasty. Canine substitution is most esthetic when bracket position is modified to improve the appearance of the gingival height relative to the central incisor. Enameloplasty, composite build-ups or veneers, in combination with gingivectomy of the primary bicuspid substituting as the canine, are important to consider in order to maximize esthetics with the contralateral side.[15]

Prosthetic replacement

A second option for the missing lateral incisor/s, is to maintain the space for future prosthetic replacement, such as an implant, a bridge (conventional or Maryland), or a pontic on a removable appliance (i.e., "flipper").[29–31] Tooth replacement is often preferable to substitution in cases where multiple teeth are missing in the buccal segments Maintaining or creating space for future prosthetic restoration of the maxillary lateral incisor may benefit patients who have multiple missing teeth due to a hypoplastic maxilla and to obviate the need for orthodontic mesial migration of large numbers of posterior teeth. Doing so may also be the preferred choice in cases of mild skeletal discrepancy where the incisor position and occlusal relationship (i.e., the canine in a Class I position) are favorable and the maxillary dental midline is deviated toward the cleft side, making canine substitution less suitable. Such treatment requires careful retention to maintain the site of the missing tooth, particularly if eventual implant placement is planned. A removable Hawley retainer with pontics is not ideal if the root position should be

maintained for a future implant, as the tooth roots may drift into the site during retention. In these cases, it may be preferable to use a bonded lingual retainer with a lateral pontic, though debond failures are common. Alternatively, fixed lingual retainers on either side of the edentulous space may be combined with a pontic-Hawley to improve retention of the edentulous space and root position of the adjacent teeth.

Implants should not be placed during adolescence due to the remaining vertical growth of the alveolus, which causes the implant to appear submerged over time. On average, females have been shown to cease growing at around 17 years of age and males at 21 years of age. An individualized growth assessment, should be made for each patient, ideally by the superimposition of lateral cephalograms taken 1 year apart to ensure the cessation of growth.[29] Research has also demonstrated that some patients may exhibit implant infraocclusion or grey show through over time, despite apparent growth completion[32–34]; this risk should be considered when assessing treatment options.

Primary tooth retention without permanent successors

In cases of primary tooth retention without permanent successors, it is recommended to maintain the primary tooth for as long as possible to maintain the alveolar bone level. Additionally, non-carious or minimally restored primary molars may be maintained well into adulthood in the absence of ankylosis or significant root resorption.[35,36] If extraction of the primary tooth is required, every effort should be made to maintain as much bone as possible and to preserve the buccal cortical plate around the site of the cleft defect. Alternatively, the tooth may be extruded orthodontically to bring the bone level further occlusally prior to extraction. Future bone grafting may be required in the site of the missing tooth prior to future restoration in adulthood, particularly if the area has been edentulous for a prolonged period.

If a primary tooth is ankylosed, the decision to maintain or extract the tooth depends on the degree of submergence and current bone level of the adjacent teeth. If the patient has already surpassed their peak skeletal growth rate and minimal growth remains, an ankylosed tooth may be kept if the periodontal status of the adjacent teeth is acceptable.[36] A boy who has not yet undergone his pubertal growth spurt; however, is likely to undergo much vertical change in the height of the alveolus and further submergence of the ankylosed tooth is expected; extraction of the ankylosed tooth is recommended in such situations to prevent the development of periodontal defects and tipping of adjacent teeth over the anyklosed primary tooth.[36,37]

Ectopic and impacted teeth

There is an increased frequency of canine impaction in patients with clefts compared to the general population, with 20% of patients with UCLP exhibiting canine impaction.[38] Possible contributory factors include missing lateral incisors, the hypoplastic maxilla resulting in less space and bone deficiency, and ectopic dental positions.[38] Extraction of the primary cuspid and adjacent teeth and increasing the arch dimension may help in preventing canine impaction; however, surgically exposure and orthodontic bonding of the canine may be necessary to prevent root resorption of adjacent permanent teeth.

Despite the presence of missing teeth in patients with cleft lip and palate, maxillary hypoplasia may lead to severe crowding and associated impaction or ectopic eruption, particularly of second premolars and lateral incisors, if present. In such cases, distalization of the maxillary dentition may be indicated to relieve crowding and to align the ectopic teeth. Alternatively, palatally positioned permanent teeth may be maintained in their ectopic positions rather than being extracted. The reason for this suggestion is that such teeth may serve as "orthodontic real-estate" in the case that another tooth has a poor prognosis and requires replacement. The preserved tooth may substitute in lieu of a dental implant or assist in bone preservation until the time of implant placement (Fig. 5).

Retention

Maxillary and mandibular retention during the growth-observation period following phase II, is extremely important. While patients with normal skeletal relationships or with mild skeletal discrepancies are provided with standard retainers, pontics and palatal coverage, it is recommended to provide patients with moderate-to-severe skeletal discrepancies with a retainer bonded on the lingual of the maxillary anteriors, as the lack of

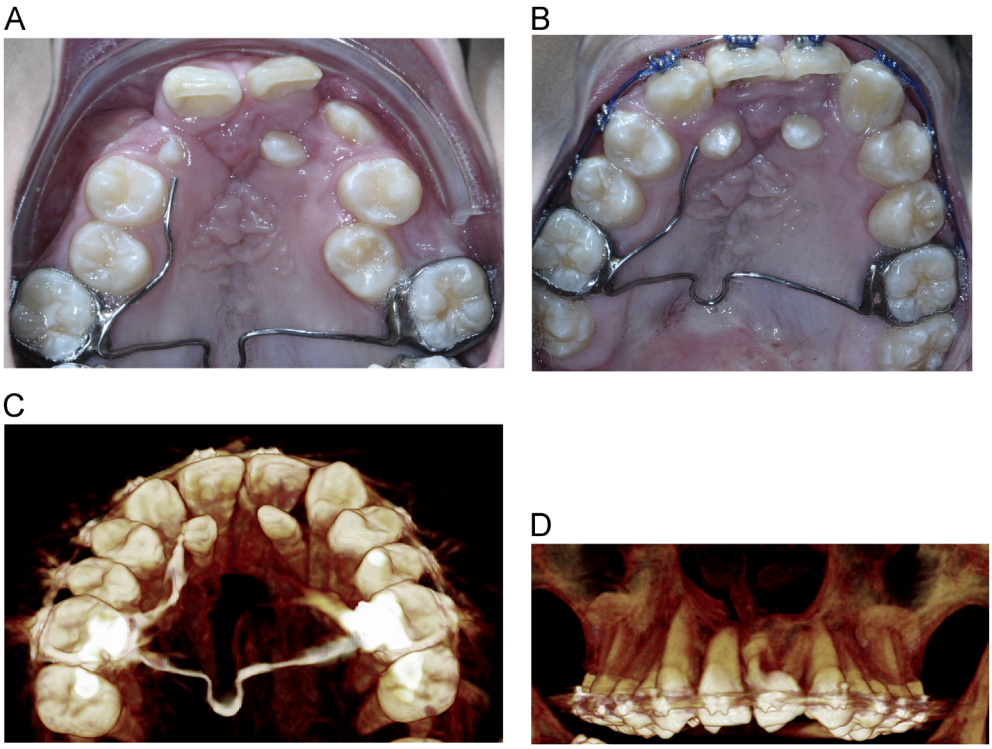

Figure 5. (A) The CBCT of a patient with severe external root resorption of the UL1. (B) Palatal view illustrates the root position of the UL2 which contributed to the decision to extract the UL1 and substitute the UL2 in the position of the UL1.

positive overjet results in rapid malalignment of the maxillary incisors. For this reason, removable maxillary retainers are less then ideal. Even if the mandibular arch was untreated, it is advised to use an essix-type retainer or to place a passive lower lingual holding arch that rests on the cingulum of the mandibular incisors to reduce incisor eruption. Overeruption of the mandibular incisors is commonly seen in patients with negative overjet due to the lack of incisal stop. The result is an accentuated Curve of Spee, which may require extended time to level prior to surgical correction.

Skeletal growth should be monitored by measurements of change in height and serial cephalometric films at 12 month intervals. This is performed as the patient completes skeletal growth. Every patient with cleft lip and or palate is different and requires individualized treatment planning and interdisciplinary evaluation. While most patients will have definititive orthognathic surgical intervention delayed until growth completion, certain patients may, for critical psychosocial reasons, undergo early surgery to benefit from improved esthetic appearance.

Conclusion

Orthodontic treatment for patients with cleft lip and palate is complex, due to an increased frequency and severity of dental anomalies such as missing or impacted teeth. In addition, growth, timing of bone grafts and orthognathic surgery must be factored into the already complicated orthodontic treatment plan. Appropriate treatment of the adolescent patient requires careful observation and diagnosis in an effort to predict eventual surgical needs, and provide efficient and effective orthodontic intervention that is tailored to the patient's specific needs.

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