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THE EFFECTS OF ORTHOGNATHIC SURGERY ON GROWTH OF THE MAXILLA IN PATIENTS WITH VERTICAL MAXILLARY EXCESS

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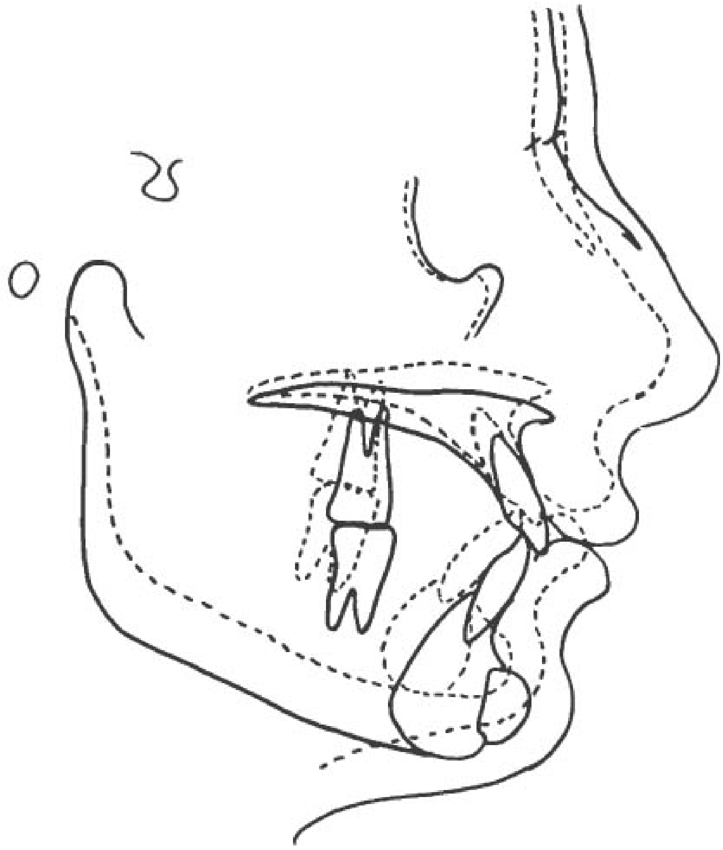

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Orthognathic surgery has become a useful and acceptable treatment modality for many patients with skeletal discrepancies in addition to orthodontic problems. In the nongrowing patient, postsurgical changes can usually be attributed to instability at the osteotomy site or to temporomandibular joint (TMJ) problems, such as joint edema, hemarthrosis, condylar malposition, or condylar resorption. Postsurgical change is of greater concern in the growing patient, for whom further growth — or lack of growth — could adversely affect the treatment result. The functional, esthetic, and psychological benefits to the patient when surgery is done during growth must be weighed against the patient's sometimes unpredictable growth potential and the unknown effects of surgery on the growing craniofacial skeleton. The inability to predict growth subsequent to surgery is especially significant for the maxillary complex. Because surgical trauma could affect growth and the long-term surgical-orthodontic outcome for these young patients, practitioners may select a nonsurgical treatment plan with a compromised result.

If most of the anteroposterior maxillary growth is complete by puberty,[44,53] then only minimal effects of maxillary surgery on growth of the maxilla during adolescence should be expected, especially if the cartilage of the nasal septum is considered inactive at this time.[50]

Conversely, it is possible that maxillary growth in normal, untreated patients continues well into adulthood. Behrents,[6] surveying data from 113 young adults followed 25 to 35 years into adulthood, found significant increases in many craniofacial dimensions. Lewis and Roche,[29] in an attempt to estimate ages at which growth ceased, recently found that growth of the cranial base and mandible continues into the second and third decades, albeit at a much reduced rate. Nevertheless, the majority of facial growth is complete following puberty. Approximately 98 to 100 per cent of maxillary growth of 22-year-old males and females is complete by 15.5 years of age.[12]

One important reason for performing early orthognathic surgery relates to the psychological well-being of the patient. Facial appearance is fundamental in determining interpersonal relationships.[30,31] Patients with severe skeletal deformities are likely to be less attractive than their peers when they are entering the teen dating years, and differences in behavior toward attractive versus unattractive individuals are well documented.[1,2] Waiting to do orthognathic surgery until growth is complete or choosing a nonsurgical treatment plan merely to provide teeth that mesh while compromising overall facial esthetics could be detrimental to the patient's self-image during the impressionable teen years. Graber[23] noted that treatment regimens that improve facial appearance appear to produce concomitant improvements in esthetic self-satisfaction and body image. While much work is still required in the evaluation of post-treatment patients, it can be stated that, for the most part, treatment-induced improvements in facial functional and esthetics result in associated improvements in self-esteem.

A dentofacial skeletal discrepancy recognized in adolescence and left untreated until adulthood can also cause or aggravate problems in occlusion, masticatory function, TMJ function and morphology, speech, airway, and esthetics.[37] A major concern when operating on young patients is the presence of unerupted permanent teeth, including the cuspids, bicuspids, and molars, that could be damaged during surgery. These teeth usually are erupted and can be aligned orthodontically by the ages of 12 to 13 years.

CONTROL OF MAXILLARY GROWTH

Normal growth of the maxilla must be carefully considered when attempting to evaluate the effects of maxillary surgery. Unfortunately, the mechanisms of normal growth are not well understood. Beginning with Fick in the 19th century,[20] many researchers have studied the role of the nasal cartilage in attempting to define the mechanism of normal growth.[52]

Scott's theories on the role of the nasal septum as a pacemaker for midfacial growth are perhaps the best known. Scott[47] defined two distinct phases of midfacial growth. During the first 7 years of life, growth of the brain and the eye increases the size of the cranial base and orbits; nasal cartilage forces the maxillary complex away from the sphenoid bone. After 7 years of age, corresponding to closure of the sphenoethmoidal suture, growth of the cranial base and orbits is minimal, and the nasal cartilage ceases to grow. Subsequent maxillary growth is attributed primarily to apposition of bone, with vertical growth predominating and with limited horizontal growth and width changes. Scott[48] concluded that the horizontal component in the growth of the cartilage of the nasal septum can be estimated by the length of the hard palate.

Sarnat and Wexler[41] found that extensive resection of nasal cartilage in young growing rabbits resulted in a marked lack of midfacial growth. Kvinnsland[26] and Gange and Johnston[22] showed similar growth changes in studies involving partial resection of the nasal cartilage in rats.

By contrast, Moss et al subordinated the role of the nasal septum to that of a passive or compensatory response associated with orofacial function.[36] According to the "functional matrix" theory, the nasal cartilage had no direct "morphogenetic" role in the growth of the maxilla. Proponents of the theory believe that it is simply the collapse of the roof of the nasal cavity which leads to growth retardation in surgical patients.

Babula's group[3] concluded that while the cartilaginous nasal septum was significantly shorter in mice fetuses with bilateral clefts of the lip and palate, this finding alone did *not* support the view that the nasal septum acts as a growth center. In a study involving young guinea pigs, Stenstrom and Thilander[55] concluded that the nasal septal cartilage is not a primary growth center for the midfacial skeleton; rather, its main function is related to mechanical support.

Searching for an alternative mechanism, Latham and Scott[28] suggested that the septo-premaxillary ligament pulls the maxilla downward and forward. Latham[27] subsequently proposed that osteogenesis at the posterior and superior maxillary surfaces exerts forces against the circummaxillary pad of fatty tissue to induce sutural adjustment of the maxilla. The roles of sutures and periosteum in maxillary growth have also been examined.[16,34] In general, growth of the maxilla has been attributed to numerous factors, including growth at synchondroses such as the nasal septum, growth at the sutures, remodeling, and the influence of the soft tissue and environmental factors.

THE DIRECTION OF MAXILLARY GROWTH

Björk[9,10] concluded that the increase in height of the maxilla takes place by "growth at its processes; suturally toward the frontal and zygomatic bones and appositionally on the lower aspect of the alveolar process in association with the eruption of teeth." The maxilla tends to rotate forward during growth, but differential remodeling maintains the relationship of the nasal floor to the anterior cranial base. Growth in the length of the maxilla occurs "suturally towards the palatine bones and by apposition on the maxillary tuberosities."

Scott[49] and Enlow[15] note that maxillary growth in both higher primates and humans tends to be oriented more vertically than horizontally. Melsen,[33] evaluating 132 human skulls from India, found that during development, the maxillary complex as a whole moves downward and forward from the time of fully erupted deciduous teeth until the permanent canines and premolars are fully erupted. The direction of growth changes to become mainly downward during the last part of the growth period.

Singh and Savara[44,53] studied the size and rates of maxillary growth for boys and girls 3 to 16 years of age. They found that in girls, height and length of the maxilla grow at approximately the same rates from 3 to 6 years. After a slight lag period, maxillary height grows faster than length from 8 to 16 years of age. An adolescent spurt in maxillary growth was found between 10 and 12 years of age in girls. Growth of the maxilla was similar for boys, who experienced their adolescent spurt 1 to 3 years later than girls.

ABNORMAL MAXILLARY GROWTH

An understanding of the mechanisms and direction of normal growth is important when variations in normal maxillary growth are considered. Sassouni and Nanda[42] analyzed longitudinal cephalograms taken from birth to adulthood of eight individuals with Class II skeletal open bite and eight with Class II skeletal deep bite. The open-bite patients were found to have a greater maxillary dental height at both the incisor and molar levels, as well as unfavorable (clockwise) rotation of the mandible. Schendel and coworkers[45] characterized the open-bite morphology as the "long face syndrome," characterized by excessive lower facial height, extreme clockwise rotation of the mandible, adenoid facies, idiopathic long face, total maxillary alveolar hyperplasia, and vertical maxillary excess (VME). Excessive vertical maxillary growth is described as the "common denominator" for these patients. They generally show an inordinate amount of the maxillary teeth and gingiva upon smiling. Anterior open bites may or may not be present.

When patients with maxillary hyperplasia present for orthodontic treatment as adolescents, the treatment plan of choice for the best functional and esthetic result often calls for orthognathic surgery in conjunction with orthodontics. Surgery commonly involves a Le Fort I osteotomy with superior repositioning of the maxilla.[17,59]

The effects of maxillary surgery on growth of the maxillary complex are poorly understood. Epker and Wolford[17] described the use of Le Fort I osteotomy with complete mobilization of the osteotomized segments and their overcorrection due to relapse. Fixation at that time involved only the use of suspension wires and intermaxillary fixation. They reported some success in treating patients 8 to 12 years old but did not have data regarding their subsequent growth.

While noting that the faces of baboons grow in a much more horizontal direction than those of humans, Siegel[52] found that nasal septal cartilage resection in baboons had an effect on growth of the maxilla; however, if the surgery was done at a later age, more growth had been attained and the effect was less noticeable. They conclude that "what [growth] is lost as a result of surgery is lost forever."

Freihofer,[21] in examining the effects of various surgical procedures on growth in adolescents, found that maxillary advancements performed "too early" would experience "pseudorelapse" because of continued growth of the mandible without apparent maxillary growth. However, 19 of the 20 cases were cleft palate patients, for whom maxillary retrusion is well established. Freihofer was not able to determine whether further growth of the maxilla occurred following surgery.

The problems of maxillary surgery during growth may be compounded when maxillary growth is already deficient, as in patients requiring Le Fort I anterior and inferior repositioning of the maxilla[51] or in craniofacial syndrome patients requiring Le Fort III advancement surgery.[4,32] In patients exhibiting maxillary hypoplasia, a second surgery after completion of facial growth may be indicated.[4]

ANIMAL STUDIES

Conclusions drawn from animal studies assessing the effects of maxillary surgery on growth have also been variable. Kokich and Shapiro,[25] studying six juvenile (27 to 33 months) *Macaca nemestrina* monkeys, found that maxillary Le Fort I advancement osteotomies adversely affected anteroposterior maxillary growth. They suggest that anteriorly directed postsurgical extraoral forces be applied when Le Fort I advancement osteotomy is performed in patients who already have severe hypoplasia due to lack of growth prior to surgery. Nanda and Topazian[37] studied seven experimental and eight control *Macaca fascicularis* monkeys, 30 to 40 months of age. It was found that in the experimental monkeys, who had Le Fort I osteotomies with impaction, the vertical component of growth was "most aberrant" following surgery. The vertical displacement was primarily in a superior direction in four monkeys and in an inferior direction in three monkeys. However, anteroposteriorly the maxilla and mandible were found to grow in a "harmonious fashion" after total maxillary osteotomy; the mandible of each experimental animal showed significantly less growth than did those of the controls, although it was subjected to no surgical intervention. Growth during the first 6 months after surgery was relatively less than in controls, but long-term follow-up showed a "significant increase in growth."

Nanda et al.[38] studied 14 *Macaca fascicularis* monkeys 30 to 41 months old; three received Le Fort I osteotomies with a 4-mm advancement only (Group I), three received Le Fort I osteotomies with a 5-mm advancement and a 2.5-mm impaction (Group II), and eight monkeys served as controls. Transosseous wires without maxillomandibular fixation were used to fix the maxilla into its final position. The mean anterior (horizontal) displacement of the premaxilla in Groups I and II was reduced 37 per cent and 67 per cent, respectively, in relation to the control group 12 months after surgery. With respect to the vertical dimension, the overall incremental change in anterior facial height of the control group, especially of the lower facial height, was significantly greater than that of the experimental groups. The Group II animals, in which the maxilla had been superiorly repositioned as well as advanced, demonstrated the greatest decrease in overall maxillary growth. The authors conclude that injury to the nasal septal complex may have inhibited maxillary growth and displacement. Excision of the nasal septal cartilage *retarded* but *did not stop* the anterior growth of the maxilla. The mandible followed the maxillary growth pattern in both experimental groups.

POSTSURGICAL STABILITY OF THE MAXILLA

Postsurgical stability must be considered if the surgical effects on growth are to be addressed. Previous studies of nongrowing patients having undergone Le Fort I osteotomy *without* rigid fixation have demonstrated that immediately after surgery and during the fixation period (generally 6 weeks), the maxilla was somewhat unstable and continued to move upward, as well as slightly posteriorly at A-point; after the fixation period the results were stable.[8,11,39,46] Interestingly, Denison et al[14] reported greater stability of superiorly repositioned maxillae in nongrowing patients without open bite than in those with open bite malocclusions.

By contrast, Hennes et al[24] studied the stability of maxillary osteotomies with superior repositioning and concomitant mandibular advancement using rigid fixation in nongrowing patients. Postoperatively, the maxilla showed no significant superior vertical movement, although there was a slight tendency for posterior movement at A-point during the 9-month postsurgical period. Similarly Turvey et al[56] found a tendency toward posterior and inferior rotation of the entire maxillomandibular complex following superior repositioning of the maxilla and mandibular advancement using wire fixation. They concluded that double-jaw surgery is more stable than mandibular advancement alone when vertical maxillary excess or open bite is associated with mandibular deficiency. Skoczylas and coworkers[54] examined the short-term (4 to 8 weeks) stability of rigid versus skeletal wire fixation in 30 patients who had undergone superior maxillary repositioning and mandibular advancement. They found no significant difference in stability between the two techniques with regard to nondental maxillary landmarks, although they did note a significantly greater amount of vertical molar movement postsurgically in the skeletal wire fixation group.

Finally, Satrom[43] recently examined the long-term (15 months) stability of rigid internal fixation versus skeletal wire fixation in 33 nongrowing patients who had also undergone superior repositioning of the maxilla with simultaneous mandibular advancement. He found that the maxilla was very stable both horizontally and vertically for both fixation methods. While the rigid fixation sample was moved forward 1.6 mm more at A-point, it showed no tendency for posterior movement at A-point. The wire sample showed a "nonsignificant" tendency for posterior movement postsurgically and a slightly greater tendency for inferior movement of the maxilla after surgery.

SURGERY IN VERTICALLY EXCESSIVE INDIVIDUALS

Few studies examining maxillary postsurgical growth in VME patients have been reported. Epker et al[19] and Washburn et al[58] reported on the effects of superior maxillary positioning in 12 individuals 10 to 16 years of age, treated between 1973 and 1977 with intermaxillary fixation and suspension wiring for stabilization. The average superior movement of the maxilla was 5.3 mm; neither the duration of postsurgical fixation nor the type of surgical splint worn was indicated. The authors found that "slightly less than normal" vertical growth occurred following surgery, and there was no significant change in the anteroposterior dimension of the maxilla with growth. It was concluded that in view of the damage to nasal septal cartilage during maxillary surgery, the surgeon should consider the use of complete maxillary alveolar osteotomy,[18] which requires virtually no septal resection. Some decrease in vertical maxillary growth in these patients was attributed to increased masticatory efficiency following surgery. Later animal studies by Nanda et al[38] supported the view that total alveolar osteotomy may be the treatment of choice for younger individuals.

Recently, Vig and Turvey[57] examined the presurgical and postsurgical lateral cephalograms of 17 females and 3 males between 13.7 and 16.5 years at the time of maxillary superior repositioning. The mean age at surgery was 14.9 years. The "longest follow-up records" ranged from 2 to 7 years, with a mean of 3.3 years.

Postsurgery was defined as the time of splint removal in these patients, all of whom were stabilized with interosseous wiring and intermaxillary fixation. Vig and Turvey found that, in general, the vertical dimension increased with time; increments in maxillary incisor and molar vertical distances were clinically and statistically the most significant findings. Further, the patients in the study exhibited post-treatment stability comparable to that following routine orthodontics. No statistical difference was found in the patients who simultaneously underwent mandibular surgery except with respect to the mandibular plane angle.

COMPARISON OF SURGICAL PATIENTS TO MATCHED CONTROLS

Identifying the effects of Le Fort I osteotomy on maxillary growth in adolescents is important so that the proper treatment plan may be implemented at the optimal time. Certainly, the most accurate assessment of Le Fort I osteotomy on growth would be made by comparing operated subjects to a longitudinally followed control sample with similar skeletal characteristics. To date, no study using a matched control sample has been reported in the literature. Furthermore, in examining the effects of this surgery in growing patients, no results have been reported in which rigid internal fixation, rather than skeletal wire fixation, was used to stabilize the maxilla postsurgically.

For these reasons, Mogavero[35] recently completed a retrospective study designed to determine the effects of superior repositioning of the maxilla by Le Fort I osteotomy on subsequent maxillary growth in the adolescent using both rigid and nonrigid fixation. Growth was evaluated by comparing experimental subjects to controls matched on the basis of sex, age, the mandibular plane angle (MPA), and the ANB angle. The study involved 48 patients who had undergone surgery for correction of VME: 23 patients were stabilized with rigid internal fixation and 25 with skeletal wire fixation. Most of the patients had segmental maxillary osteotomies performed, and approximately one half had simultaneous mandibular surgery. All surgery was performed by Dr. Larry Wolford.

Surgical Technique

The patients in the rigid fixation group underwent a Le Fort I step osteotomy as described by Bennett and Wolford.[7] The segments were stabilized using either Champy or Wurzburg miniplates. At least two bone plates were placed on each side of the maxilla for stabilization (four plates were used on each patient), with two screws above and two screws below the surgical bony cut for each plate. Additional plates were used as needed. The period of intermaxillary fixation ranged from 0 to 3 days.

A majority of patients in the skeletal wire fixation group underwent a standard Le Fort I osteotomy without a step, since the step osteotomy had not yet been developed when most of these patients had surgery. Stabilization in this group was achieved by means of intraosseous wiring, with intermaxillary fixation plus vertical infraorbital suspension wires and circummandibular wires in most cases.

In both groups, surgical bone cuts were made 4 to 5 mm above the apices of the cuspids. The nasal septum (septal cartilage and vomer) was separated from the maxilla, and the pterygoid plates were separated from the maxillary tuberosities prior to downfracturing of the maxilla.

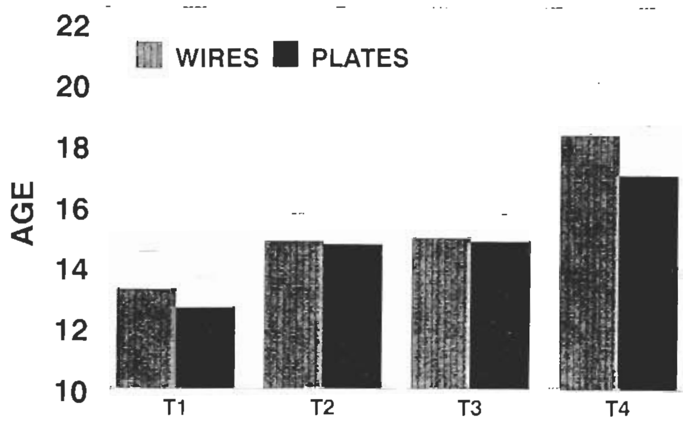


FIGURE 54-1. Mean ages (years) and standard deviations for the plate fixation and wire fixation experimental groups at each occasion.

Data Collection

Each individual had longitudinal cephalograms taken approximately 1 year or more before surgery (T1), immediately prior to surgery (T2), immediately following surgery (T3), and at least 1 year after surgery (T4).

The mean surgery age, which occurred during the interval between T2 and T3, was 14.6 years for the plates group and 14.7 years for the wire group (Fig. 54-1). The median presurgical time interval between T1 and T2 for the plates group was 2.3 years (range 0.9 to 4.5 years), while for the wires group this interval was 1.29 years (range 0.6 to 4.4 years). The median postsurgical interval (T3 and T4) was 1.9 years (range 1.0 to 4.24 years) for the plates group and 2.3 years (range 1.0 to 7.4 years) for the wires group.

Untreated Controls

The control sample consists of untreated French-Canadian children drawn from three school districts in Montreal, chosen to represent different socioeconomic sectors of the larger population. The data are derived from serial lateral cephalograms collected by the Human Growth Research Center, University of Montreal.[13] The cephalometric methodology has been described.[5]

Control subjects were matched to experimental subjects on the basis of age, sex, ANB angle (A-point to nasion to B-point), and MPA (mandibular plane to S-N minus 7 degrees). The analyses pertain to six anteroposterior, five vertical, and two angular measurements (Fig. 54-2).

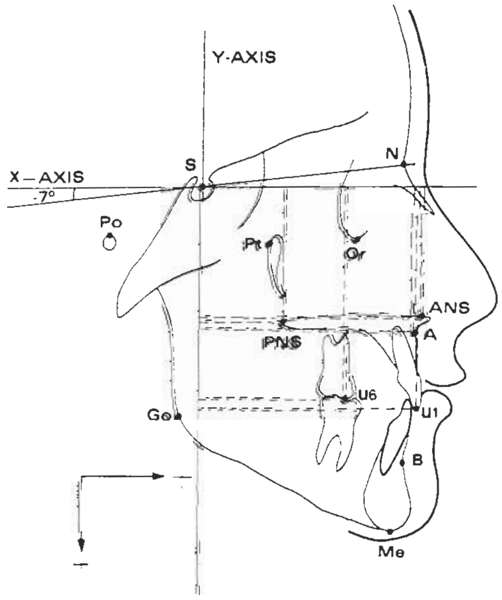


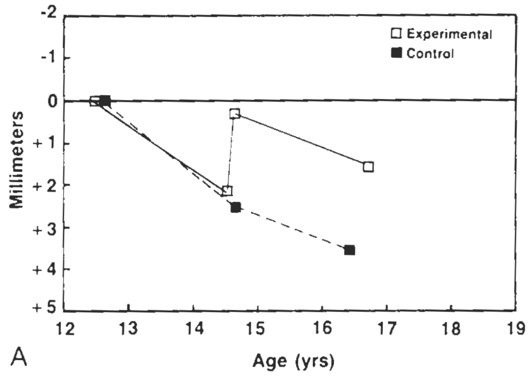
FIGURE 54-2. Digitized cephalometric landmarks and reference planes. Horizontal measurements were taken along the x-axis and vertical measurements were taken along the y-axis. The reference planes were oriented at 7 degrees to the sella-nasion line. Anterior and inferior changes are assigned a positive sign.

Results

Presurgically, both plate fixation and wire fixation groups demonstrated significant inferior vertical growth, which was similar in magnitude and not statistically different from that of their matched controls. Vertical growth was excessive compared to published norms for both experimental and control subjects. Both experimental groups and their controls demonstrated modest presurgical horizontal growth, although somewhat reduced in comparison to normally growing children.

There were no differences between the plate fixation and wire fixation groups with respect to median surgical moves. This was important for the comparison of postsurgical effects between the two groups.

Postsurgical vertical growth for both the plate fixation and the wire fixation samples was again excessive compared to published norms, but not significantly different from that of the matched controls. Postsurgical vertical changes for both rigid and wire fixation groups, while not different from those of controls, were somewhat less than presurgical changes. This decrease in vertical growth is expected because most of the patients were past their peak growth following surgery. Vertical growth and treatment changes for ANS and PNS are illustrated in Figures 54-3 and 54-4.



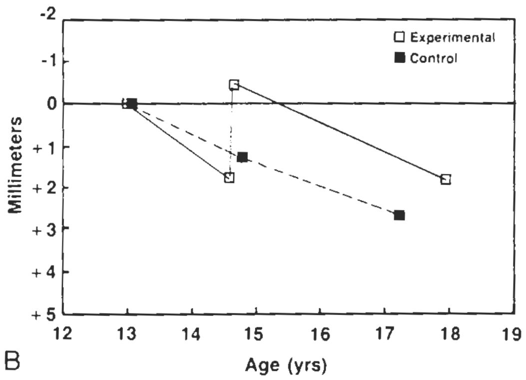
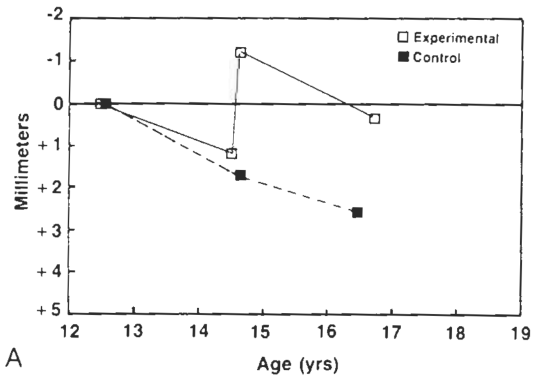


FIGURE 54-3. Vertical changes at ANS (mm) from the initial position show that the growth rates between the experimental subjects and their controls were essentially parallel both presurgically and postsurgically. The sharp step in the experimental curves indicates surgical change between the T2 and T3 occasions. *A*, Plate fixation group. *B*, Wire fixation group.



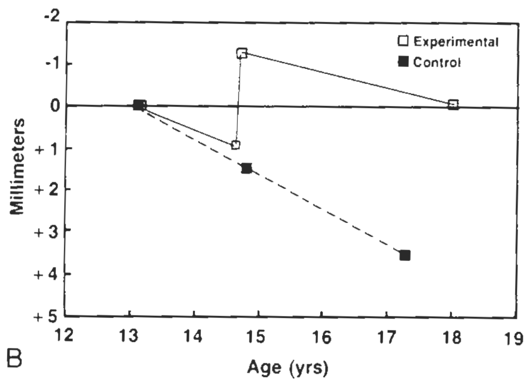


FIGURE 54-4. Vertical changes at PNS (mm) from the initial position show that the growth rates between the experimental subjects and their controls were essentially parallel both presurgically and postsurgically. The sharp step in the experimental curves indicates surgical change between the T2 and T3 occasions. *A*, Plate fixation group. *B*, Wire fixation group.

TABLE 54-1. POSTSURGICAL GROWTH DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUPS (WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST)

MEASURES	PLATES	WIRES
Horizontal		
A-point	0.010	<0.001
ANS	NS	<0.001
PNS	NS	NS
U1	0.038	0.006
U6	NS	0.007
PNS-A	0.013	<0.001
Angular		
SNA	NS	<0.001

Greater postsurgical variability existed in the horizontal dimensions. The posterior maxilla and palate of the plate fixation group did not show evidence of relapse or decreased growth compared to that of controls except for differences at A-point, reflected in the palatal length PNS-A, and at the upper incisor. Because ANS and the upper molar were not affected, these changes were attributed to postsurgical orthodontics (Table 54-1). Conversely, subjects in the wire fixation group experienced a general horizontal posterior relapse of the entire maxilla. They showed highly significant differences from controls in a posterior direction at every maxillary point except PNS. Horizontal changes with age are illustrated in Figures 54-5 to 54-7.

The larger posterior changes seen postsurgically in the wire fixation sample versus the plate fixation sample are comparable to those seen in previous studies on nongrowing patients, whereas inferior vertical changes demonstrated were much greater than those seen in the literature pertaining to Le Fort I osteotomies performed on nongrowing patients. The observed vertical growth and lack of horizontal growth were not surprising, because according to Enlow[15] and others, the human maxilla is expected to grow vertically, with little anterior component, during adolescence.

Clinical Significance of Results

Several conclusions were drawn from Mogavero's study:

1. Le Fort I osteotomy has little or no effect on postsurgical vertical growth.

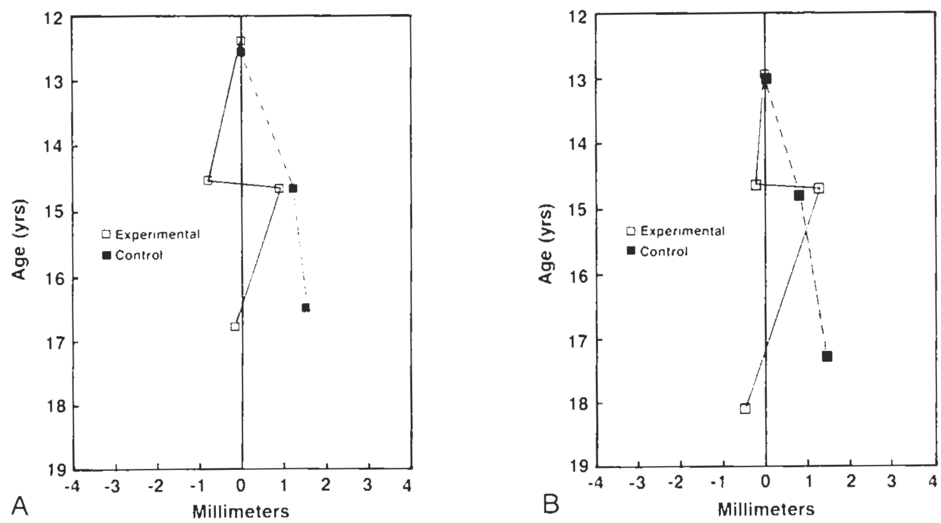


FIGURE 54-5. Horizontal changes at A-point (mm) from the initial position. Differences between experimental subjects and their controls were seen in both groups both presurgically and postsurgically, presumably a result of presurgical and postsurgical orthodontic changes involving the maxillary incisor. The sharp step in the experimental curves indicates surgical change between the T2 and T3 occasions. *A*, Plate fixation group. *B*, Wire fixation group.

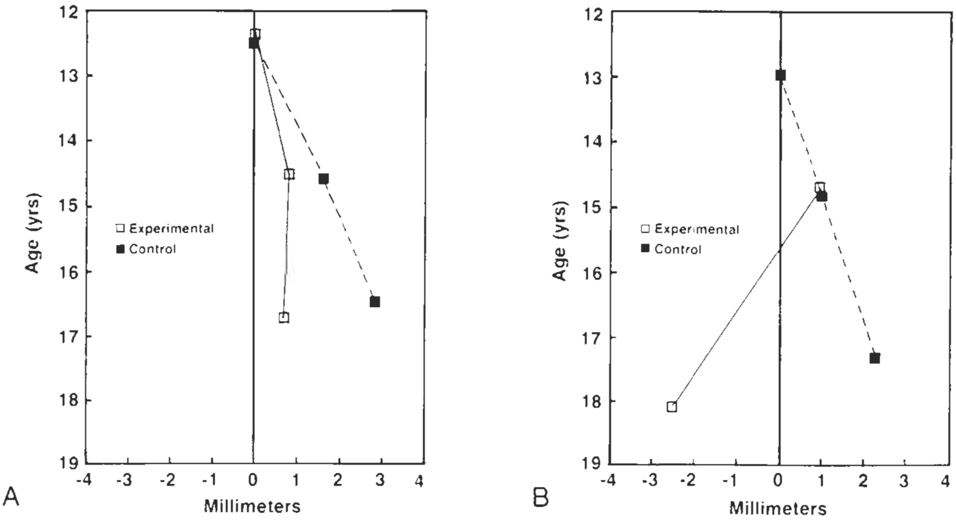


FIGURE 54–6. Horizontal changes at ANS (mm) from the initial position. No presurgical differences from controls are seen for either group, as indicated by the nearly parallel curves. Postsurgically, the wire fixation group demonstrated significant posterior relapse, whereas the plate fixation group was not significantly different from controls. The sharp step in the experimental curves indicates surgical change between the T2 and T3 occasions. *A*, Plate fixation group. *B*, Wire fixation group.

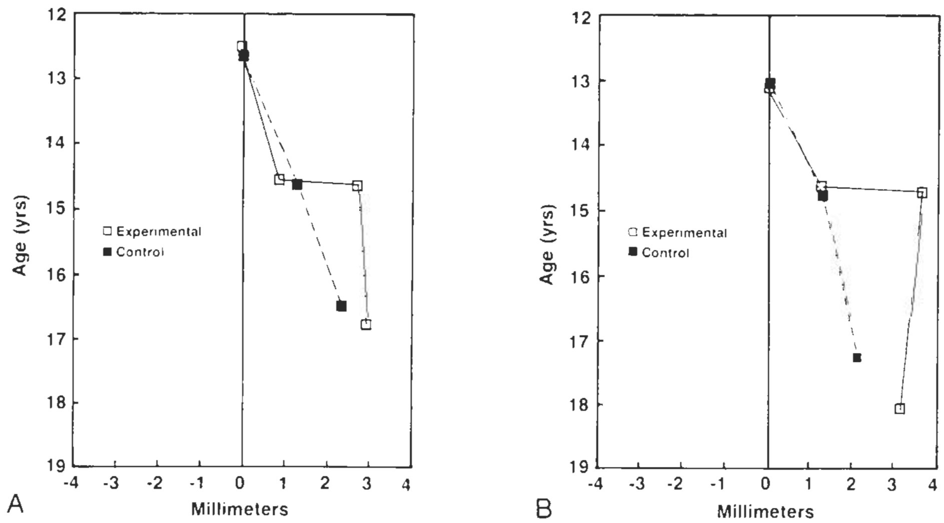


FIGURE 54–7. Horizontal changes at the upper first molar, from the initial position. No presurgical differences from controls are seen for either group. Postsurgically, the wire fixation group demonstrated significant posterior relapse, whereas the plate fixation group was not significantly different from controls. The sharp step in the experimental curves indicates surgical change between the T2 and T3 occasions. *A*, Plate fixation group. *B*, Wire fixation group.

2. Following superior repositioning of the maxilla in growing patients, rigid fixation appears to provide superior long-term anteroposterior and vertical stability compared to skeletal wire fixation.
3. While their use may be indicated during the finishing stage of orthodontics, Class II elastics should be used carefully to minimize posterior and inferior movement of the upper incisor and A-point postsurgically.
4. Adolescent patients anticipating surgery to correct vertical maxillary excess should be informed that slight posterior horizontal relapse of the maxilla may occur and that future surgery may be necessary to correct problems that may develop.
5. It may be indicated in select cases for the orthodontist to use a light reverse-pull headgear or facemask postsurgically, as suggested by Kokich and Shapiro[25] in their study on growing monkeys. However, these mechanics were not necessary or attempted on any of the patients in this study. In addition, because these patients are still growing vertically in excess of norms postsurgically, it may be useful in extreme cases to use a high-pull headgear after surgery to help decrease excessive postsurgical vertical growth.

USE OF THE SURGICAL-ORTHODONTIC APPROACH IN THE VERTICALLY GROWING ADOLESCENT

In growing preadolescents with vertical maxillary excess, a nonsurgical approach is usually the treatment of choice. Conventionally, an appliance that retards vertical growth of the maxilla is employed in these patients. Standard approaches to the treatment of vertically growing patients include high-pull headgear with fixed orthodontic appliances, bite blocks, or a combination headgear-activator appliance that may also position the mandible forward to act as a functional appliance. In addition, airway obstruction, allergies, tongue posture, and habits are usually evaluated as possible contributing factors to the vertical growth pattern.

In the nongrowing adult with vertical maxillary excess with or without open bite, the treatment plan of choice usually includes orthognathic surgery. Since these patients often exhibit a narrow maxillary arch with an associated posterior crossbite and excessive posterior vertical growth, a segmental Le Fort I osteotomy allows superior repositioning, expansion of the maxilla, and leveling of the occlusal plane. Vertical positioning of the anterior maxilla at the time of surgery depends on the presurgical position of the incisors and lip length. Mandibular surgery may also be indicated, as this type of patient often displays a retruded mandible but can also display mandibular prognathism. The mandibular prognathism may not be obvious with a coexisting vertical maxillary excess, since the mandible is rotated downward and backward, decreasing the AP projection of the mandible.

With the availability of current refined orthognathic surgical techniques, it is no longer acceptable for the orthodontist and surgeon to use the esthetic compromise of premolar extractions and incisor retraction simply to fit the teeth together. A surgical treatment plan can provide a well-balanced facial result as well as a functional occlusion for patients with skeletal deformities.

Thus, some generalizations can be made in reference to vertical maxillary excess deformities. Some vertically growing preadolescents can be treated with growth-modifying orthopedic appliances, but these should be used only if indicated and if correction of the problem is reasonably predictable. If there is a coexisting mandibular deformity, then it may be best to surgically correct the problems simultaneously at a later time. Most adults with "long face syndrome" should be treated by means of an orthodontic-surgical approach for optimal dental and facial results. A gray area remains: Should adolescents with vertical maxillary excess, which would require surgery in the adult, be treated with orthodontics alone, or should an orthodontic-surgical approach be planned from the start, and at what age should surgery be done?

According to Proffit and White,[40] "the best plan for adolescents with questionable growth potential follows logically: attempt growth modification, using headgear to a functional appliance . . . or to a fixed appliance, and counsel the patient and parents that if this conservative approach does not succeed, surgical treatment will be needed." Proffit and White further state that "unlike attempts at camouflage, growth modification treatment does no harm, and it can improve . . . relationships." However, the long-term effects of such nonsurgical approaches to correct excessive vertical maxillary growth have not been adequately studied using appropriate scientific methods. These patients may end up on an "uncomfortable borderline," since "their occlusion may be corrected reasonably well, but both facial esthetics and long-term stability are questionable." Unless cases are carefully selected for nonsurgical treatment, patients could be put into a treatment protocol that may require an unnecessarily long treatment program, with little gain and unsatisfactory results that may still require surgical correction.

Certainly, some adolescents are borderline surgical versus orthodontic cases from the start. Nonsurgical growth-modifying treatment could be attempted in these patients as long as the patient and parents understand the effects and expected outcome of nonsurgical versus surgical treatment, even though the individual may require orthognathic surgery at a later time. Conversely, other adolescents present with severe posterior vertical maxillary excess and a disfiguring "gummy smile" with or without open bite, constricted maxilla, and/or retrusive mandible. It is not reasonable to expect orthodontic treatment alone to provide an acceptable result in these severe cases. Growth modification, which can possibly halt vertical growth, has never been shown to reverse that which has already been expressed.

Rather than wait until growth has been completed, it seems prudent to carry out the correct treatment plan from the beginning and operate on these severe cases early in order to provide the optimal dental, skeletal, functional, and esthetic results. Importantly, earlier treatment might also allow the patient to avoid going through his or her adolescent years with a poor self-image due to an uncorrected skeletal deformity. Proffit and coworkers,[39] in a study of 61 patients who had undergone Le Fort I osteotomy with superior repositioning of the maxilla, separately examined the postsurgical stability of the patients who were less than 18 years old at the time of surgery. One third of the patients were 18 or younger, but the youngest were 14 and mature females. All patients were stabilized using wire fixation. No difference in stability emerged between the younger and older groups, and it was concluded that "after the completion of the adolescent growth spurt, surgical repositioning of the maxilla is as stable as it will be later."

The study by Mogavero[35] is especially relevant because it examined growth compared to matched controls using both rigid and wire fixation. By comparing changes in the experimental groups to those in their matched controls, the presence of vertical growth without horizontal growth could be positively identified in these subjects, just as observed in the untreated controls. Despite this continued vertical growth, the surgeon (LMW) could identify no more generalized long-term postsurgical problems of stability, function, or esthetics in the operated growing patients than he has observed in the nongrowing adult patients in his practice. Even with the continued vertical growth occurring postsurgically, these patients apparently grow in proportion and do not appear to "grow back into a long face syndrome." Nevertheless, a few patients did demonstrate an increase in their tooth-to-lip relationships from the immediate to the long-term postsurgical period.

Mogavero further reported that following superior repositioning of the maxilla in adolescents, rigid fixation appears to provide superior long-term anteroposterior and vertical stability compared to skeletal wire fixation in growing patients. This result is supported by the literature.

It is our conclusion that superior repositioning of the maxilla to correct vertical maxillary excess may be safely undertaken in the adolescent without increased potential for the patient to "grow out" of the surgery, as is known to occur in true mandibular prognathism. This conclusion is supported by Vig and Turvey.[57]

Orthognathic surgery may not be indicated for every patient with vertical maxillary excess, and, like orthodontics, it is not without its own set of inherent problems and failures. Nevertheless, early surgical correction of severe vertical maxillary excess can provide excellent functional and esthetic results in the adolescent, providing the patient with both a beautiful smile and a better self-image.

CASE PRESENTATIONS

CASE 1

This 12-year, 6-month-old female was seen for surgical evaluation to correct her "gummy smile" (see Chapter 9). She had been under orthodontic treatment for approximately 1 year with a good orthodontic result. She had difficulty getting her lips together when chewing and for speech. In addition, she had significant inflammation and hypertrophy of her maxillary gingiva, particularly around the anterior teeth. There was a periodontal concern as well as an esthetic concern (Fig. 54–8).

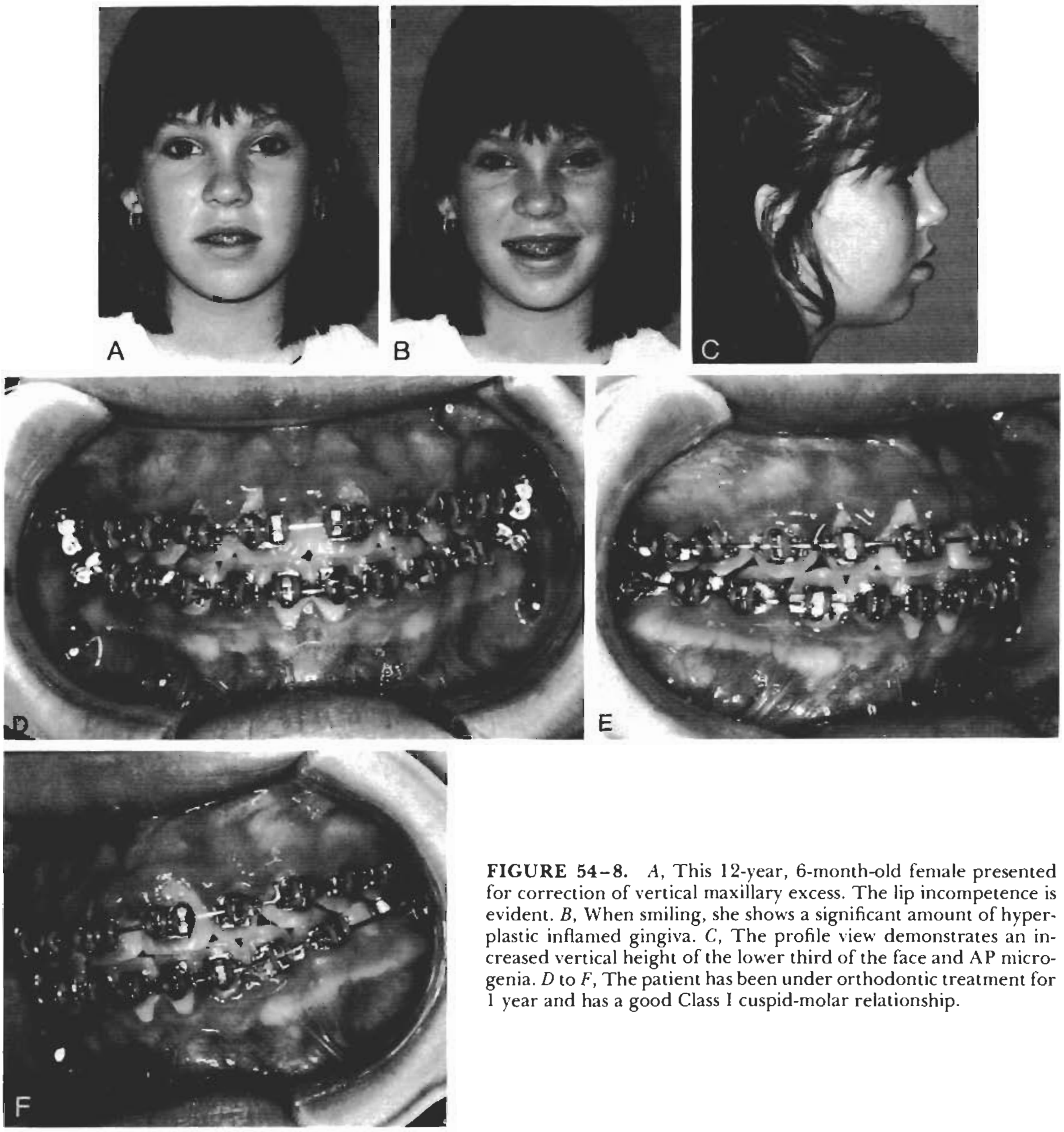


FIGURE 54–8. *A*, This 12-year, 6-month-old female presented for correction of vertical maxillary excess. The lip incompetence is evident. *B*, When smiling, she shows a significant amount of hyperplastic inflamed gingiva. *C*, The profile view demonstrates an increased vertical height of the lower third of the face and AP microgenia. *D* to *F*, The patient has been under orthodontic treatment for 1 year and has a good Class I cuspid-molar relationship.

Problem List

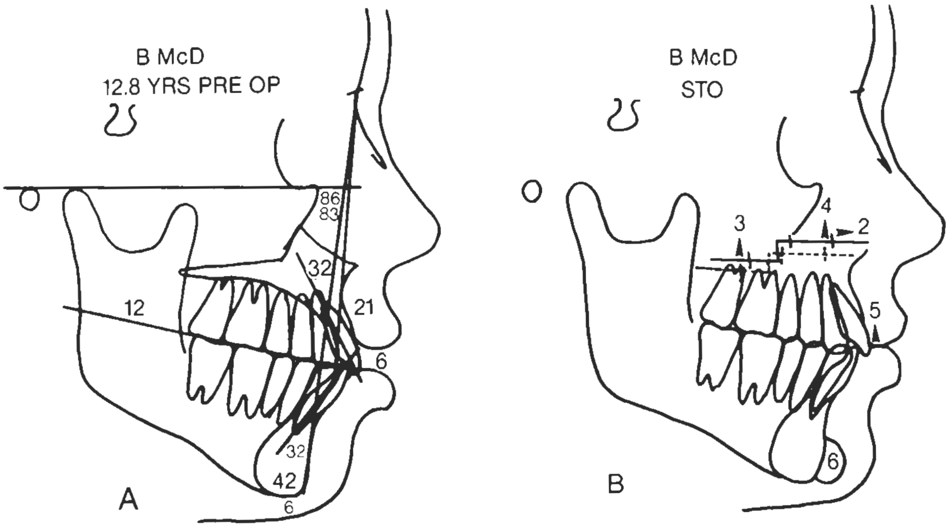
Esthetics. In the frontal view, with her lips relaxed, she had significant lip incompetence (Fig. 54–8*A*). In smiling, she showed a significant amount of teeth (6 mm) and gingiva with gingival inflammation and hypertrophy (Fig. 54–8*B*). In profile view, she had a long lower third of the face and significant lip incompetence in a relaxed position. With her lips together, she had hyperfunction of the mentalis muscle. Also, she demonstrated AP deficiency of the chin (Fig. 54–8*C*).

Cephalometric Analysis. Cephalometric analysis demonstrated vertical maxillary excess and AP maxillary deficiency. Also, there was AP microgenia present. The lower third of the face was excessively long secondary to the VME (Fig. 54–9*A*).

Occlusion. The patient had been under orthodontic treatment for approximately 1 year prior to surgical evaluation. The occlusion was essentially a Class I cuspid-molar relationship (Fig. 54–8*D* to *F*).

Treatment Plan

Orthodontic Treatment. The orthodontics had been completed to align and level the teeth and establish a Class I cuspid-molar relationship. No additional orthodontic recommendations were made.



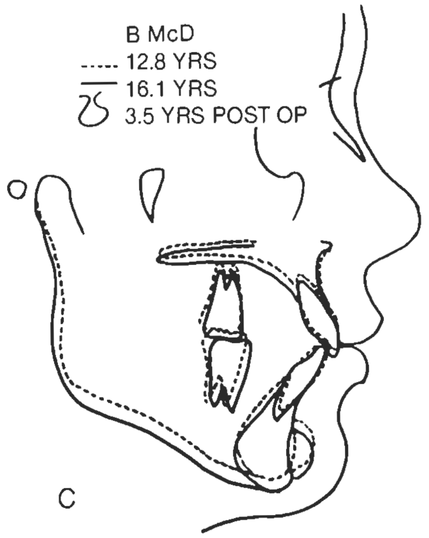


FIGURE 54–9. *A*, Cephalometric analysis demonstrates vertical maxillary excess and slight AP maxillary deficiency. AP microgenia is present, and the lower third of the face is excessively long. *B*, The surgical treatment objective demonstrates superior movement of the maxillary incisors 5 mm and a maxillary advancement of 2 mm. A 6-mm alloplastic chin augmentation was also planned. *C*, Superimposition of the immediate postoperative and 3-year, 5-month follow-up radiographs demonstrates predominantly vertical growth of the maxilla and mandible. The jaws appear to have grown harmoniously.

Surgical Treatment

1. Multiple maxillary osteotomies were performed using the maxillary step osteotomy designed to move the maxilla superiorly and slightly forward. Stabilization was achieved with bone plates. The maxilla was moved superiorly 5 mm at the incisor tip (Fig. 54–9*B*).
2. Augmentation genioplasty of 6 mm to improve chin projection.

Active Treatment. The patient was operated on at the age of 12 years, 8 months. The Class I cuspid-molar relationship was maintained with the surgical procedure, and the maxilla was placed into proper vertical position. Bone plates were used to stabilize the maxilla. No intermaxillary fixation was used, but light anterior vertical elastics were used for approximately 2 or 3 weeks to help control the occlusion. The orthodontic appliances were removed 3 months after surgery.

Long-Term Follow-up. The patient was followed periodically with long-term follow-up at 3 years, 5 months after surgery (Fig. 54–10*A* to *C*). She has continued to have harmonious growth between the maxilla and mandible. The growth vector, however, has been predominantly vertical (see Fig. 54–9*C*). A good Class I cuspid-molar relationship has been maintained, and she has excellent jaw function with no TMJ and/or myofacial pain problems (Fig. 54–10*D* to *F*).

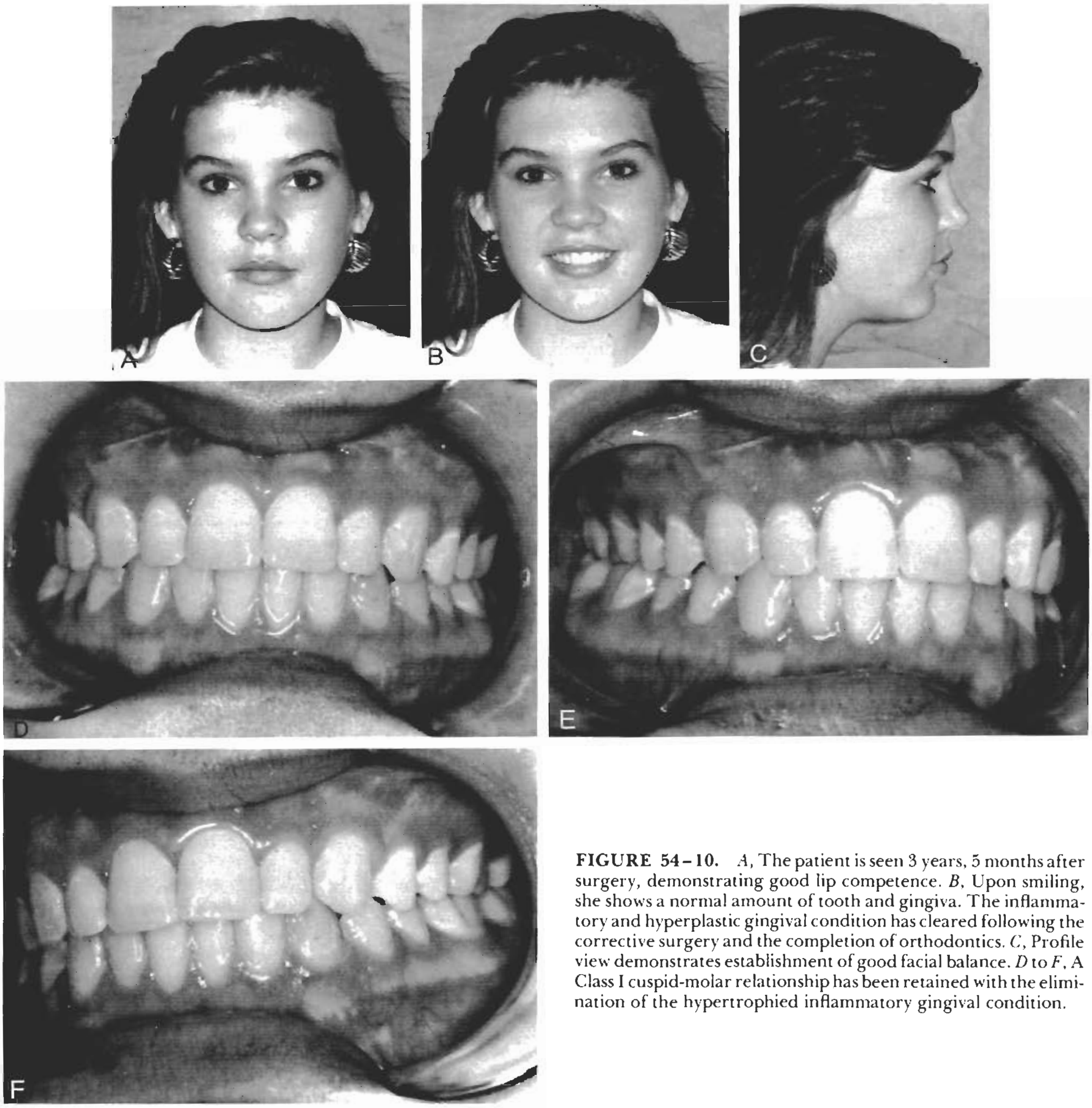


FIGURE 54-10. *A*, The patient is seen 3 years, 5 months after surgery, demonstrating good lip competence. *B*, Upon smiling, she shows a normal amount of tooth and gingiva. The inflammatory and hyperplastic gingival condition has cleared following the corrective surgery and the completion of orthodontics. *C*, Profile view demonstrates establishment of good facial balance. *D* to *F*, A Class I cuspid-molar relationship has been retained with the elimination of the hypertrophied inflammatory gingival condition.

CASE 2

This 13-year, 1-month-old male was evaluated for surgical correction of his facial deformity. The patient's primary concerns were his upper teeth and the peer pressure he was under because of the deformity (Fig. 54–11*A* and *B*). He was 13 years, 8 months of age at surgery. The patient actually began orthodontic treatment approximately 5 years earlier and wore a headgear for about 1 year, as well as some appliances and a retainer to try to correct the vertical growth problem of the maxilla, all without success.

PROBLEMS LIST

Esthetics. Frontal view demonstrated significant lip incompetence, an excessive tooth-to-lip relationship (7 mm), and an excessive amount of gingiva when smiling (Fig. 54–11*A*). In profile view, he had a protrusive upper lip and the nasal tip is upturned. The chin appeared deficient anteroposteriorly (Fig. 54–11*B*).

Cephalometric Analysis. A cephalometric analysis showed AP maxillary protrusion, VME, AP mandibular deficiency, and AP microgenia. The maxillary and mandibular incisors were overangulated. Tooth-to-lip relationship prior to surgery was 9 mm (Fig. 54–12*A*).

Occlusion. The patient had a Class II end-on occlusion with an anterior deep-bite relationship of about 4 to 5 mm. There was an overjet of 7 mm. He had a bilateral posterior crossbite tendency when placed in a Class I cuspid-molar relationship (Fig. 54–11*C* to *E*). A tooth size discrepancy of approximately 3 mm existed. There was also some gingival inflammation in the maxillary anterior arch. Panographically, there were bony impacted maxillary and mandibular third molars.

TREATMENT PLAN

Presurgical Orthodontics

1. Align the maxilla in three segments:
   Segment 1—left cuspid through second molar

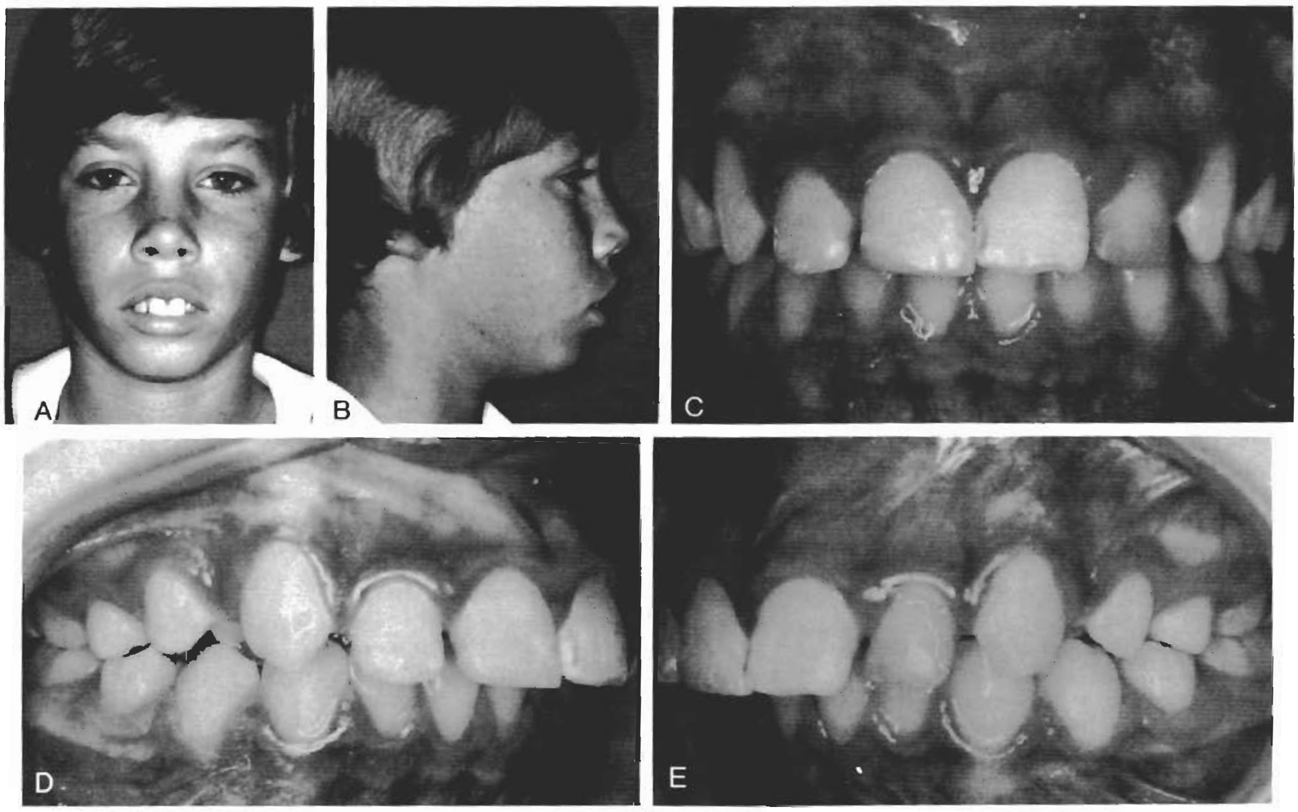


FIGURE 54–11. *A*, This 13-year, 1-month-old male demonstrated significant lip incompetence and an excessive tooth-to-lip relationship. *B*, Profile view demonstrates significant prominence of the maxilla and anterior teeth, and the chin appears retruded anteroposteriorly. *C* to *E*, The patient has a Class II end-on occlusion with an anterior deep bite. There is an overjet of approximately 7 mm.

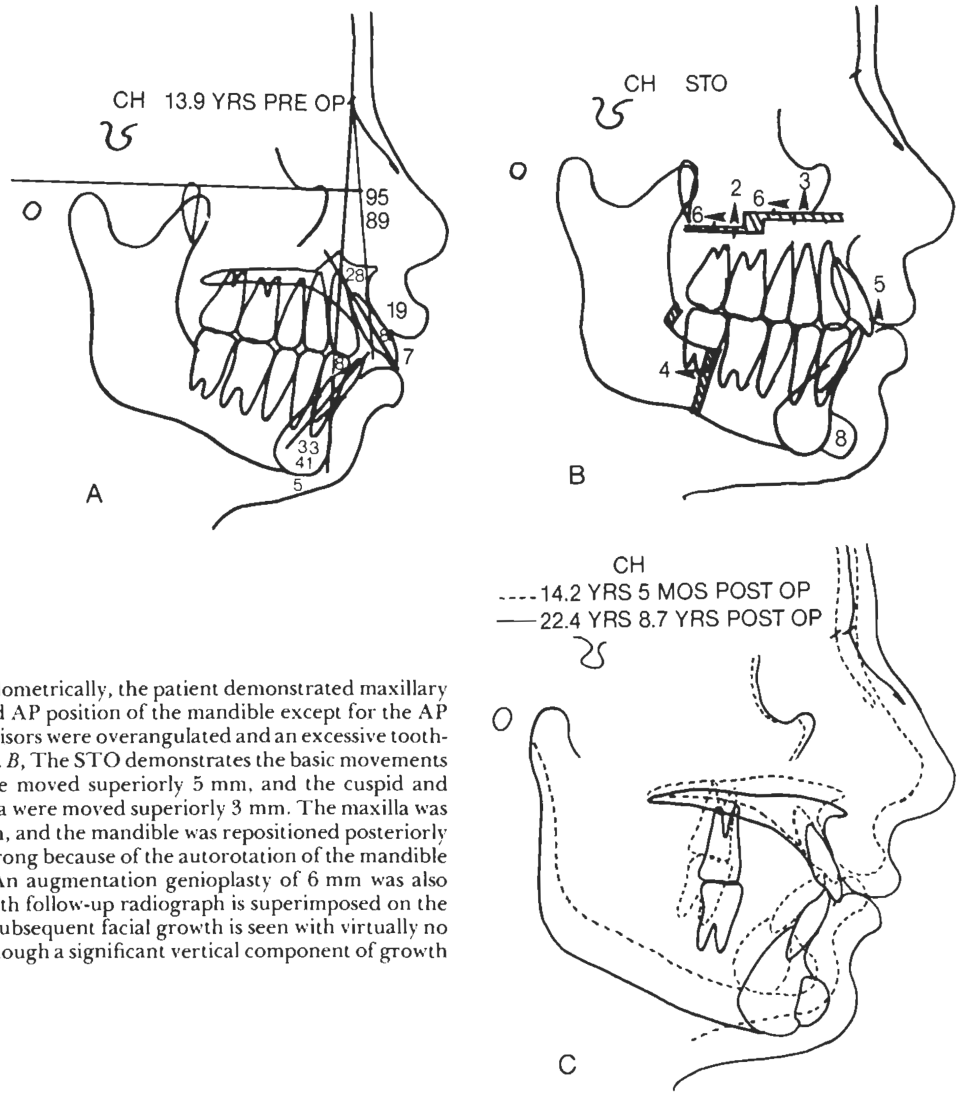


FIGURE 54-12. *A*, Cephalometrically, the patient demonstrated maxillary protrusion and relatively good AP position of the mandible except for the AP microgenia. The maxillary incisors were overangulated and an excessive tooth-to-lip relationship was present. *B*, The STO demonstrates the basic movements made. Maxillary incisors were moved superiorly 5 mm, and the cuspid and posterior aspects of the maxilla were moved superiorly 3 mm. The maxilla was repositioned posteriorly 6 mm, and the mandible was repositioned posteriorly 5 mm, since it would be too strong because of the autorotation of the mandible with the maxillary surgery. An augmentation genioplasty of 6 mm was also planned. *C*, An 8-year, 7-month follow-up radiograph is superimposed on the presurgical radiograph. The subsequent facial growth is seen with virtually no AP growth of the maxilla, although a significant vertical component of growth has occurred.

Segment 2—left lateral incisor through right lateral incisor
Segment 3—right cuspid through right second molar

2. Maintain spacing of 1.5 mm around each maxillary lateral incisor to compensate for the significant tooth size discrepancy.
3. Align and level the lower arch.

Surgical Treatment

1. Multiple maxillary osteotomy to move the maxilla superiorly and posteriorly. Upright anterior four teeth to decrease this axial inclination (Fig. 54-12*B*).
2. Bilateral mandibular ramus osteotomies to rotate the mandible in a counterclockwise direction and to establish a Class I cuspid-molar relationship.
3. Augmentation genioplasty.
4. Surgical removal of the four bony impacted third molars.

Active Treatment. The patient was 13 years, 8 months of age at the time of surgery and was treated prior to the use of rigid fixation. The desired occlusion was obtained with the surgical procedure, establishing the proper vertical and AP dimensions of the maxilla and mandible. Intraorbital suspension wires were used to stabilize the maxilla along with an occlusal splint and interosseous wiring. The mandible was stabilized with interosseous wires and circummandibular skeletal stabilization wires. Intermaxillary fixation was maintained for 6 weeks and then released. Orthodontic treatment was resumed at approximately 8 weeks after surgery, and the oral suspension wires and occlusal splint were also removed at that time. Orthodontic appliances were removed 8 months after surgery.

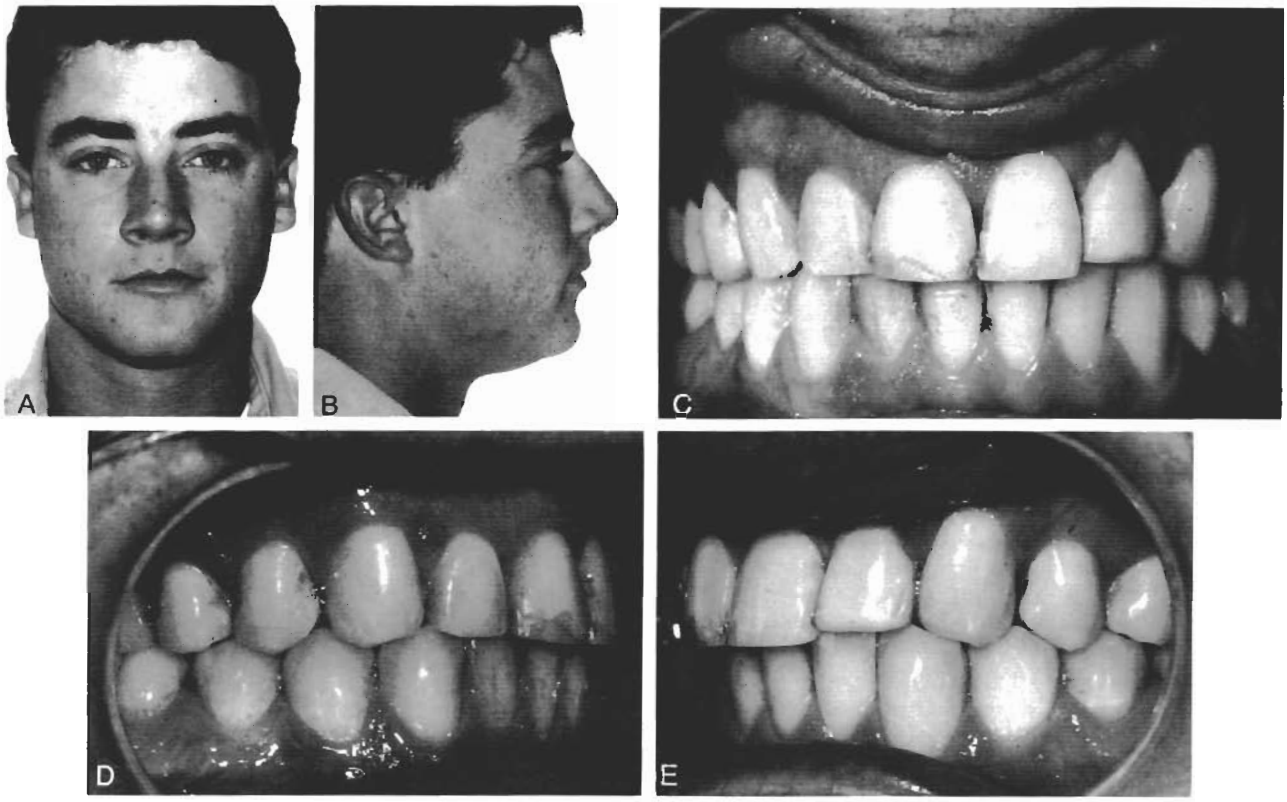


FIGURE 54–13. *A*, The patient is seen 8 years, 7 months after surgery, demonstrating good facial growth and harmony between the jaw structures. *B*, Profile view demonstrates good vertical facial dimension and balance. There appears to be good harmonious growth since surgery. *C* to *E*, The patient's occlusion has remained stable over the 8-year, 7-month postoperative time period.

Long-Term Follow-up. The patient was evaluated periodically, and the longest follow-up records were taken at 8 years, 7 months after surgery. He demonstrated good harmonious growth between the maxilla and mandible and showed maintenance of good, stable Class I occlusion (Fig. 54–13). There was virtually no AP growth of the maxilla, but significant vertical growth occurred (see Fig. 54–12*C*).

CASE 3

This 12-year, 5-month-old boy presented, on referral from his orthodontist, for surgical treatment considerations (Fig. 54–14). Clinical, radiographic, and dental model analysis revealed the following problem list.

Problem List

Esthetics. Frontal view demonstrated lip incompetence, excessive tooth-to-lip relationship (6 mm), and an excessive amount of gingiva when smiling (Fig. 54–14*A* and *B*). Profile view demonstrated lip incompetence in the long lower third of the face. The chin appeared slightly retruded (Fig. 54–14*C*).

Cephalometric Analysis. This revealed a relatively normal maxillary depth but AP mandibular deficiency. The maxilla was vertically excessive, and the lower incisors were slightly overangulated. Occlusal plane angulation was 15 degrees (Fig. 54–15*A*).

Occlusion. The patient had a Class I cuspid-molar relationship on the right side and a Class II end-on cuspid-molar relationship on the left side. There was a tendency toward crossbite posteriorly, particularly on the left side. There was significant crowding in the lower anterior arch (Fig. 54–14*D* to *F*). The patient also had impacted maxillary and mandibular third molars.

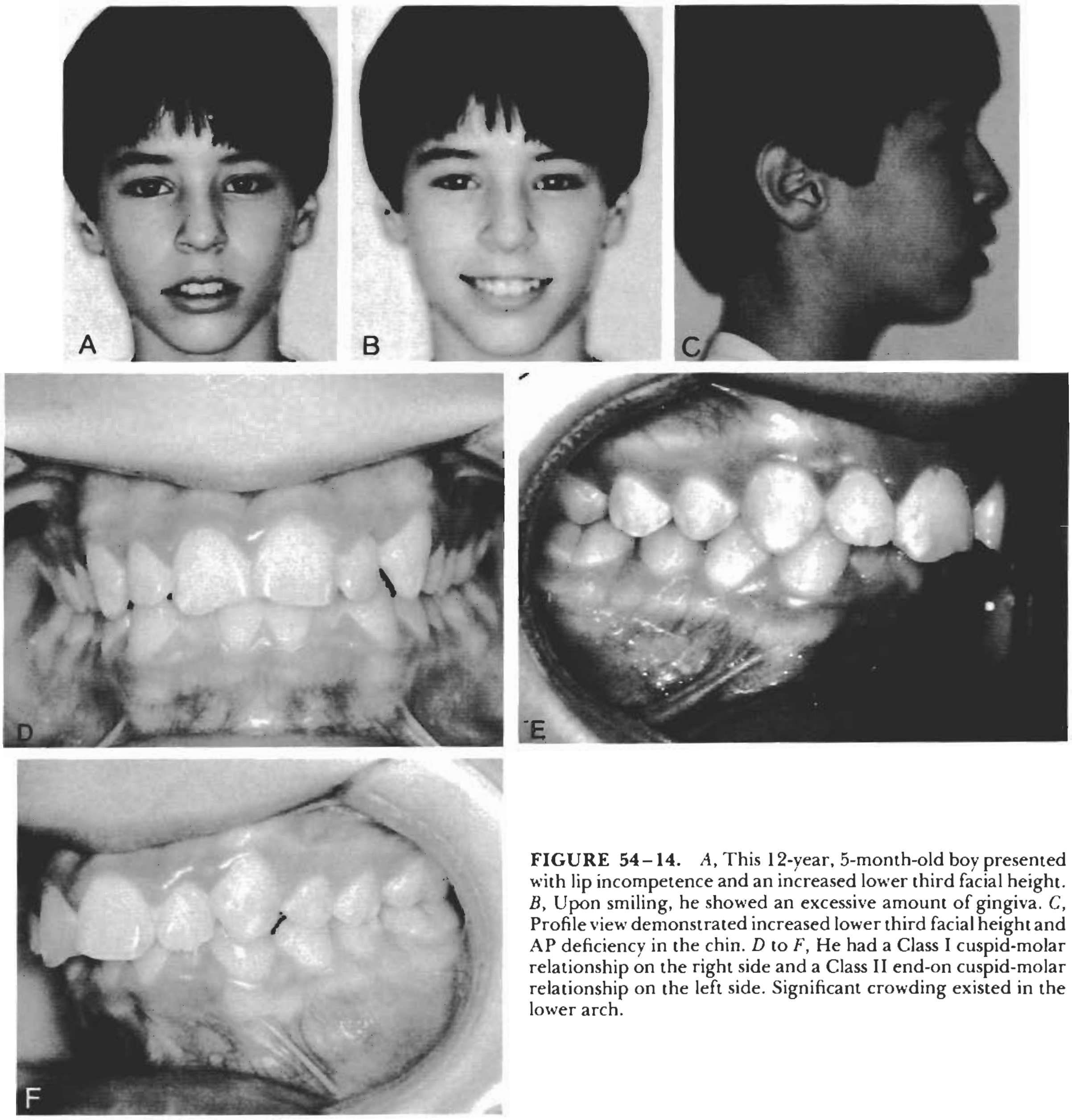


FIGURE 54–14. *A*, This 12-year, 5-month-old boy presented with lip incompetence and an increased lower third facial height. *B*, Upon smiling, he showed an excessive amount of gingiva. *C*, Profile view demonstrated increased lower third facial height and AP deficiency in the chin. *D* to *F*, He had a Class I cuspid-molar relationship on the right side and a Class II end-on cuspid-molar relationship on the left side. Significant crowding existed in the lower arch.

Treatment Plan

Preorthodontic Treatment

1. Remove maxillary left and right second bicuspids.
2. Remove mandibular left and right first bicuspids.
3. Remove mandibular impacted third molars.

Orthodontic Treatment

1. Align and level maxillary arch, closing the extraction space. Lose posterior anchorage so that the anterior teeth are not retracted significantly.
2. Align and level mandibular arch, closing the extraction space and uprighting the teeth over basal bone (Fig. 54–15*B*).

Surgical Treatment

1. Superior repositioning of the anterior maxilla 4 mm and posterior maxilla 2 mm, with expansion of the posterior aspect (Fig. 54–15*C*).
2. Mandibular advancement in a counterclockwise rotation.
3. Augmentation genioplasty with Proplast.

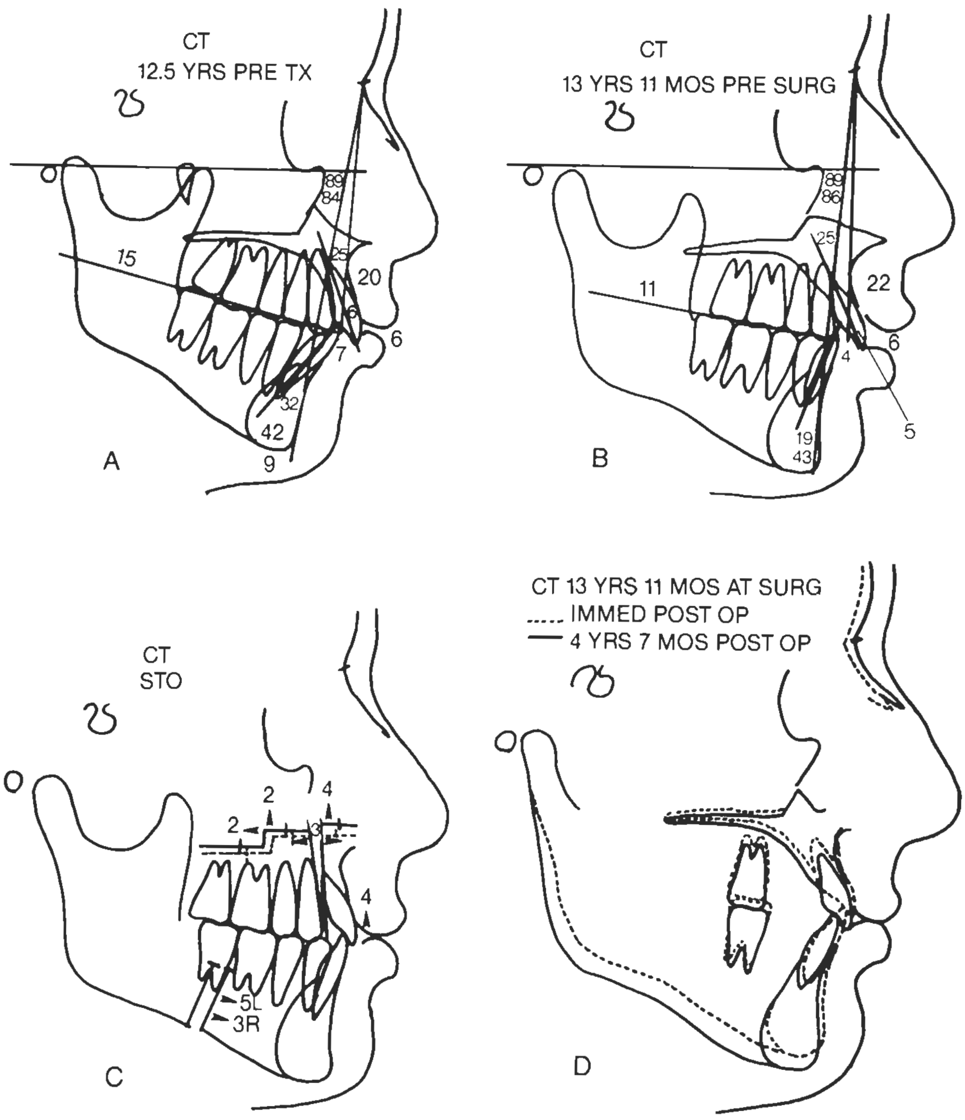


FIGURE 54–15. *A*, Cephalometric analysis demonstrated AP mandibular deficiency and overangulation of the lower incisors. The occlusal plane was overangulated by 15 degrees. Excessive tooth-to-lip relationship of 6 mm was noted. *B*, The patient was re-evaluated cephalometrically following extraction of four bicuspids and presurgical orthodontics. A 6-mm tooth-to-lip relationship existed, but the incisors were better positioned. *C*, The surgical treatment objective demonstrated superior movement of the maxillary central incisors of 4 mm and a posterior movement in the posterior aspect of the maxilla of 2 mm. Bilateral osteotomy cuts were performed between the lateral incisors and cuspids. The mandible was advanced asymmetrically, with the left side advancing 5 mm and the right side 3 mm. *D*, Superimposition of the immediate postsurgical cephalometric radiograph and a 4-year, 7-month postoperative radiograph demonstrates virtually no AP growth of the maxilla and mandible. There is a downward and posterior rotation of the maxilla and mandible as a result of subsequent growth.

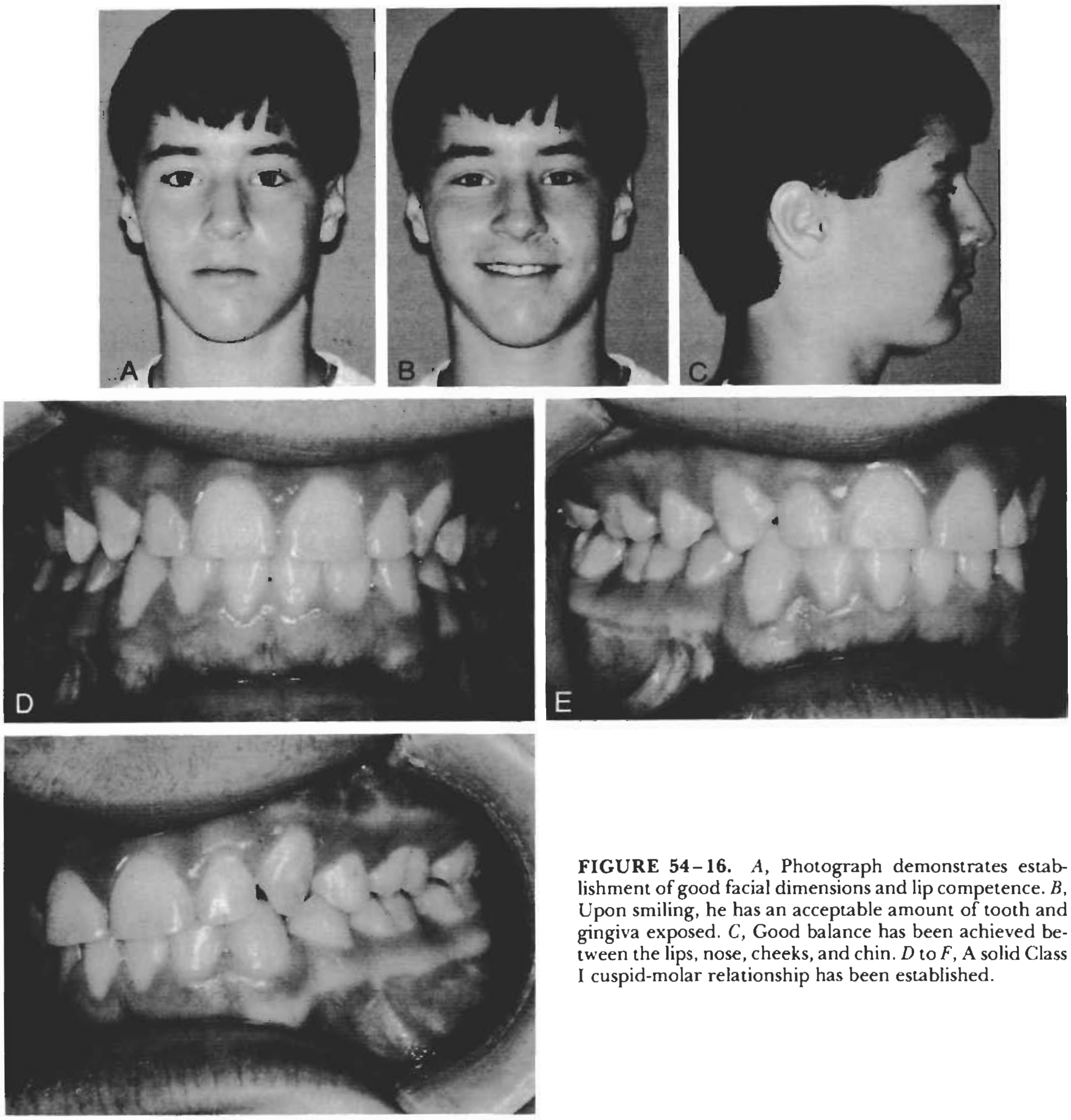


FIGURE 54–16. *A*, Photograph demonstrates establishment of good facial dimensions and lip competence. *B*, Upon smiling, he has an acceptable amount of tooth and gingiva exposed. *C*, Good balance has been achieved between the lips, nose, cheeks, and chin. *D* to *F*, A solid Class I cuspid-molar relationship has been established.

Postsurgical Orthodontics. Refine occlusion.

Active Treatment. The surgery was performed when the patient was 13 years, 11 months of age. A maxillary step osteotomy was performed with superior movement and expansion of the maxilla. Stabilization was achieved using four bone plates with two screws above and two screws below the osteotomy site with each bone plate. Bone screws were used to stabilize the mandible in its new position. An alar base cinch suture was used to control the width of the nose, together with a V-Y closure of the maxillary vestibular incision. No intermaxillary fixation was used following surgery. Light interarch elastics were used after surgery to guide his occlusion. The surgical stabilizing splint was used and removed 1 week after surgery. He progressed extremely well.

Long-Term Follow-Up. The patient was last evaluated 4 years, 7 months after surgery at the age of 18 years, 6 months. Good facial esthetics and balance have been achieved (Fig. 54–16*A* to *C*). Occlusion is good and stable (Fig. 54–16*D* to *F*), and facial growth appears to be harmonious and relatively complete. A significant component of vertical growth has occurred with no AP growth (see Fig. 54–15*D*).

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