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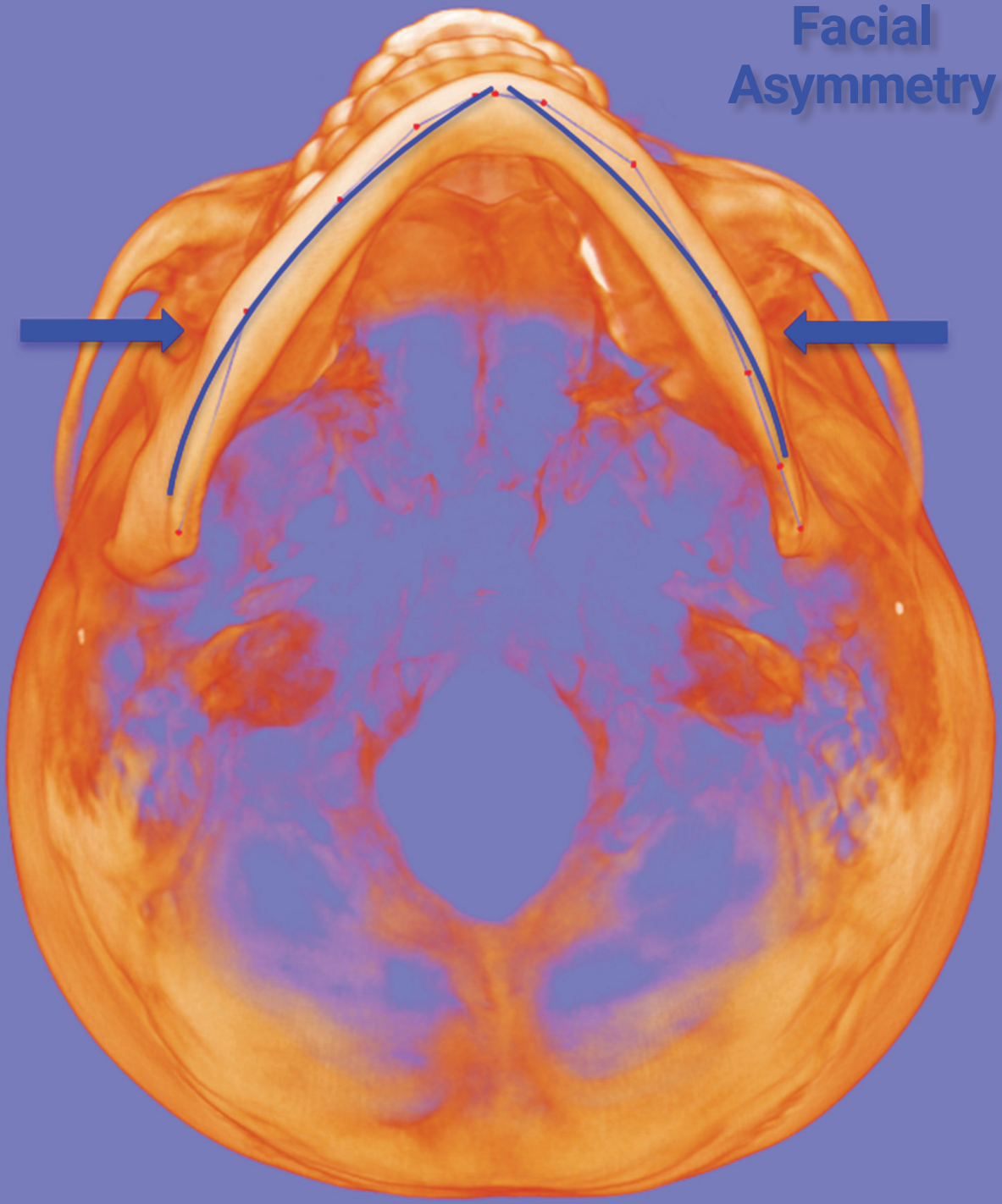
Facial Asymmetry



OVERVIEW

A Current Review of Asymmetry

SIREESHA VEERANKI, BDS, MDS, DMD
JAE HYUN PARK, DMD, MSD, MS, PhD
DAWN PRUZANSKY, DMD
MASATO TAKAGI, DDS, PhD
KIYOSHI TAI, DDS, PhD

Editor's Note: *In this regular column, JCO provides an overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.*

As patients become more aware of dentofacial esthetics, orthodontists need to rise to the challenge of heightened patient expectations. The prevalence of asymmetry in the general population—estimated to be as high as 85%[1,2]—combined with an increased perception of asymmetry may affect the degree of patient satisfaction with the outcome of orthodontic treatment. More severe asymmetries have been correlated with clinical depression, neurosis, inferiority complex, poor self-esteem, and a generally poor quality of life.[3,4]


Dr. Veeranki


Dr. Park


Dr. Pruzansky


Dr. Takagi


Dr. Tai

Dr. Veeranki is a former postgraduate resident, Dr. Park is a Professor and Chair, Dr. Pruzansky is an Adjunct Faculty, and Dr. Tai is a visiting Adjunct Professor, Postgraduate Orthodontic Program, Arizona School of Dentistry and Oral Health, A.T. Still University, 5835 E. Still Circle, Mesa, AZ 85206. Dr. Veeranki is also in the private practice of orthodontics in Phoenix. Dr. Park is also a Contributing Editor of the *Journal of Clinical Orthodontics* and an International Scholar, Graduate School of Dentistry, Kyung Hee University, Seoul, Korea; e-mail: jpark@atsu.edu. Drs. Takagi and Tai are also in the private practice of orthodontics in Okayama, Japan.

For many years, asymmetry has been misconstrued as a defect in only one plane of space, even though it is truly a three-dimensional deformity and must be analyzed and treated as such. While the soft tissues can mask skeletal deviations of as much as 4mm, asymmetrical deviations of the lower face are more frequent and severe than those of the middle or upper face[5] (Fig. 1). This is attributable to the longer growth period of the mandible and to the rigid attachment of the maxilla to stable cranial base synchondroses.[6-8]

When facial asymmetry is underdiagnosed or misdiagnosed, the possibility of treatment failure rises, especially in growing patients. In addition, asymmetrical development of the pharynx and larynx are associated with an increased risk of speech impairment, aspiration, airway obstruction, and snoring or obstructive sleep apnea.[9,10] Early recognition and appropriate treatment can help avoid these problems.

Incorrect diagnosis can result in a treatment plan involving irreversible tooth extractions or inappropriate mechanics aimed solely at leveling and aligning the dentition. These actions may exacerbate rather than diminish the appearance or consequences of asymmetry, thus affecting treatment outcomes and patient satisfaction. Therefore, it is imperative that we recognize asymmetry in our initial diagnoses.

Recent advances in imaging such as cone-beam computed tomography (CBCT) have made visualization and quantification of a deformity possible in all planes of space.[11] Single-photon emission computed tomography (SPECT) radioisotope studies have improved our ability to recognize the cessation of growth.[12] In light of these technologies, it is not necessary to identify the etiology of an asymmetry as long as pathology has been eliminated.[13-19] An interdisciplinary approach can be particularly helpful in limiting the deformity and will ultimately require less intervention than would otherwise be needed.

This overview is intended to present information pertinent to the identification and quantification of asymmetry and to assist the practitioner in ascertaining growth status and creating a plan of action appropriate for each patient's age and condition.

Etiology and Pathogenesis

Asymmetry is the aftermath of an anomalous growth process, expressed as a discrepancy in the amount of growth between the right and left sides. The etiologies of such deviant growth processes vary, but generally arise from prenatal or postnatal factors creating malformations, deformities, and disruptions.[20-34] It is important to understand the etiology and pathophysiology of asymmetry in order to perform appropriate identification and triage. Treatment will differ between patients who need only rehabilitative care and

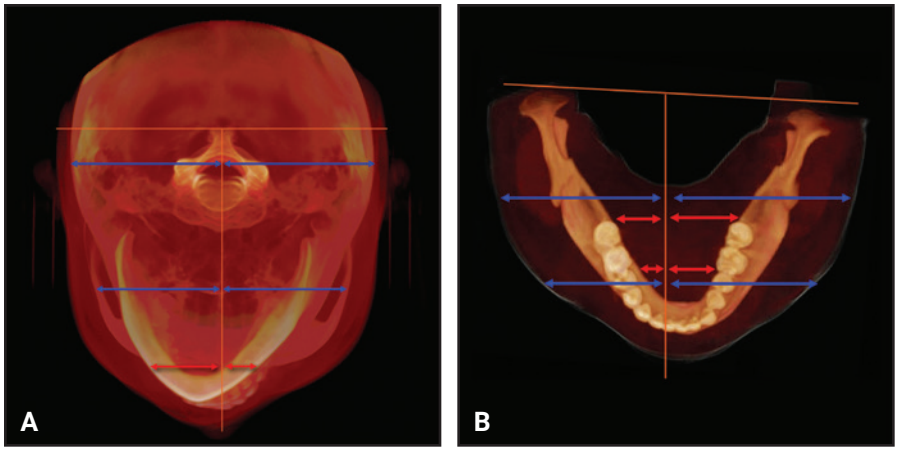


Fig. 1 A. Measurements of midline to cranial base, zygomatic arches, and mandibular body outlines demonstrate greater deviations in mandible than in cranial base or maxilla. B. Measurements of midline to bone and midline to soft-tissue outline demonstrate soft-tissue compensation for underlying skeletal asymmetry.

those who need more extensive intervention related to survival.

Condylar hyperplasia is the most extensively studied contributory mechanism of asymmetry. Hyperplasia, a rare pathology unique to the TMJ, was first described in 1836 as an overgrowth of the mandibular condyle.[13] It is characterized by a diffuse enlargement of the condyle, condylar neck, ramus, and mandibular body. A disturbance in the growth of the condyle is self-limiting, but as long as it progresses, the asymmetry and related malocclusion will progress as well. Numerous authors have investigated and categorized the effects of condylar hyperplasia to help diagnose and treat resultant asymmetries.[11,35-40]

Hemimandibular hyperplasia and hemimandibular elongation are distinguished by clinical findings, radiographic appearance, and histological patterns within the condylar bone (Fig. 2, Table 1).[36] Since 3D reconstructions from computed tomography data do not show much difference between these conditions, they are usually described by clinical presentation of vertical and transverse components.[13] This clinical diagnosis is maintained in Wolford's classification, which is commonly used to determine the surgical approaches needed to treat condylar hyperplasia.[40]

The pathogenesis of condylar hyperplasia is unclear. Some research has found equal occurrence in males and females, while other studies have reported a higher prevalence in one sex or the other.[14,41-43] Likewise, genetic predispositions to the right or left side cannot be ascertained from available studies.[8,13,15] A substantial amount of research has been done to determine whether asymmetrical growth is more prevalent in one plane of space than another.[13,15] Since growth in the vertical dimension is thought to occur for a longer period than growth in the transverse or sagittal plane, asymmetry should logically be more evident in that plane. Nevertheless, one study reported transverse deformities in 66.7% of its cases, vertical discrepancies in 22.2%, and a combination of both in 11.1%.[15] Nitzan and colleagues observed that the radiological appearance of condyles in asymmetry cases seems to be random, with no correlation to the type of deformity.[13] They also found no relationship between patient age and the type or severity of asymmetry, inferring that facial asymmetry due to condylar hyperplasia can occur at any age. Histological appearance, on the other hand, has correlated significantly with the

ETIOLOGICAL FACTORS CAUSING ASYMMETRY[20-34]

Prenatal

Developmental

- Hemifacial microsomia
- Hemifacial atrophy
- Bencze syndrome
- Unicoronal synostosis/ anterior plagiocephaly
- Congenital hemifacial hyperplasia
- Masseteric hypertrophy
- Cleft lip and palate
- Congenital facial nerve palsy
- Osteoma

Postnatal

Hormonal

- Acromegaly
- Craniofacial polyostotic fibrous dysplasia

Genetic

- Neurofibromatosis
- Nerve sheath tumors
- Von Recklinghausen disease of the newborn
- Craniofacial polyostotic fibrous dysplasia

Trauma

- Condylar trauma
- Condylar fractures

Pathologic

- Condylar hyperplasia
- Osteoarthritis

Functional

- Malocclusion or functional interferences

TABLE 1
HEMIMANDIBULAR HYPERPLASIA VS. HEMIMANDIBULAR ELONGATION[36]

Hemimandibular Hyperplasia	Hemimandibular Elongation
Three-dimensional enlargement of half of mandible	Horizontal displacement of mandible and chin toward unaffected side
Vertical excess of mandibular ramus	Horizontal excess of mandibular body
Unilateral downward projection of ramus and angle of mandible on affected side	No vertical discrepancy between two sides of mandible
Open bite on affected side if maxilla is unable to catch up to excessive mandibular growth	Crossbite on unaffected side due to excessive lateral mandibular growth
Mandibular anterior teeth tilted toward affected side	Mandibular dental midline deviated toward unaffected side
Continuation of growth past skeletal maturity	Cessation of growth with skeletal maturity

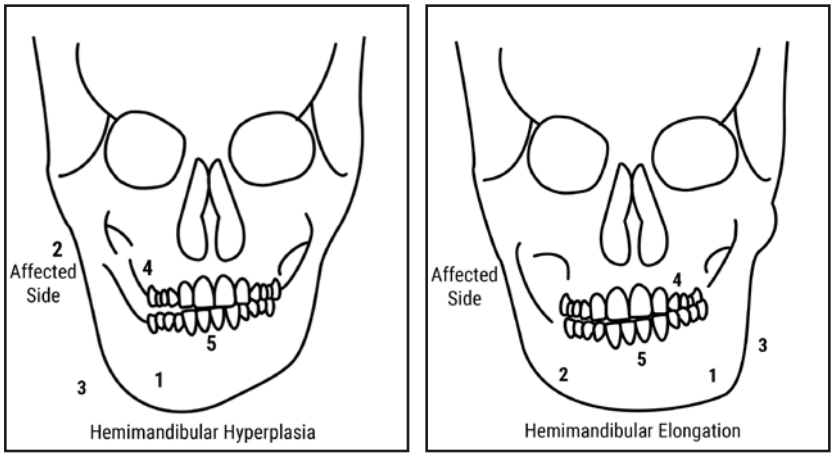


Fig. 2 Hemimandibular hyperplasia vs. hemimandibular elongation (1, 2 = three-dimensional enlargement of half of mandible in hyperplasia vs. horizontal excess and mandibular deviation to opposite side in elongation; 3, 4 = downward projection of ramus and angle of mandible with open bite on one side in hyperplasia vs. lateral displacement of ramus and angle with contralateral crossbite in elongation; 5 = mandibular anterior teeth tilted to affected side in hyperplasia vs. mandibular dental midline deviated to unaffected side in elongation).[36]

presence or absence of symptoms. One particular histological type (observed during chondroblastic activity) is associated with pain and joint sounds, while all other types (proliferative and fibrotic) are asymptomatic.[44] Although pain has been reported during some stages of excessive growth associated with asymmetry, most patients complain about the functional side effects produced by physical changes in the length, form, and size of the condyle and occasionally the resulting malocclusion.[13]

It can be concluded that there is no significant association between the type of hyperplasia and its radiological or histological features, nor are there predilections to hyperplasia based on gender or age.[13-19] Therefore, it is not important to distinguish between the various forms of hyperplasia or the growth conditions causing asymmetry. As long as CBCT imaging is able to present a clear picture of the deformity and condylar activity can be verified, appropriate measures can be taken to correct the asymmetry.

Diagnostic Considerations

The mandible is a curved, horseshoe-shaped bone that functions with two joints as a single unit. Although it translates downward and forward with growth, the results of asymmetrical growth are manifested in all three dimensions. Given the unique morphology of the mandible, it is difficult to pinpoint the locations of excess growth increments. The three essential components of an accurate 3D assessment are identification, to recognize the condition; quantification, to delineate the size, shape, and location of the deformity; and determination of growth status, to confirm the cessation of growth in certain cases. Both clinical and radiological evaluations are needed to plan for correction of the asymmetry.

A posterior crossbite or a deviation of the maxillary or mandibular midline is generally diagnosed during evaluation of the transverse dimension, but a cant is not routinely included among initial examination criteria. About 45% of asymmetry cases present with a soft-tissue cant in relation to the corners of the mouth, while a cant in the occlusal plane is observed in 48% of patients with mandibular asymmetry.[45,46] A cant should not be mistaken for skewed axial inclinations of the incisors.[47] Holding a tongue blade as far posteriorly as possible between the upper and lower arches is an easy way to discern a canted occlusal plane. Any difference in the levels of the lower border of the mandible on the right and left sides, observed clinically or in radiographs, points to an asymmetry in the vertical plane. A posterior open bite on one side should prompt further evaluation to rule out asymmetrical vertical growth of the mandible. An asymmetrical increment of growth in the sagittal plane can present as a crossbite on the same side and an anterior crossbite with or without excessive posterior overjet on the unaffected side.

Following clinical assessment, the asymmetry must be quantified to allow an objective decision regarding the need for treatment. Although it is difficult to diagnose a 3D deformity from a 2D panoramic radiograph, the linear and angular measurements from a panoramic x-ray can provide important evidence of an asymmetry (Fig. 3A).[48] A 3D assessment of the mandibular body curve is recommended over linear measurements in comparing the right and left sides of the mandible (Fig. 3B).[49]

Relevant measurements can also be taken from lateral and postero-anterior (PA) cephalograms. CBCT and other 3D imaging techniques have made it easier to observe and quantify

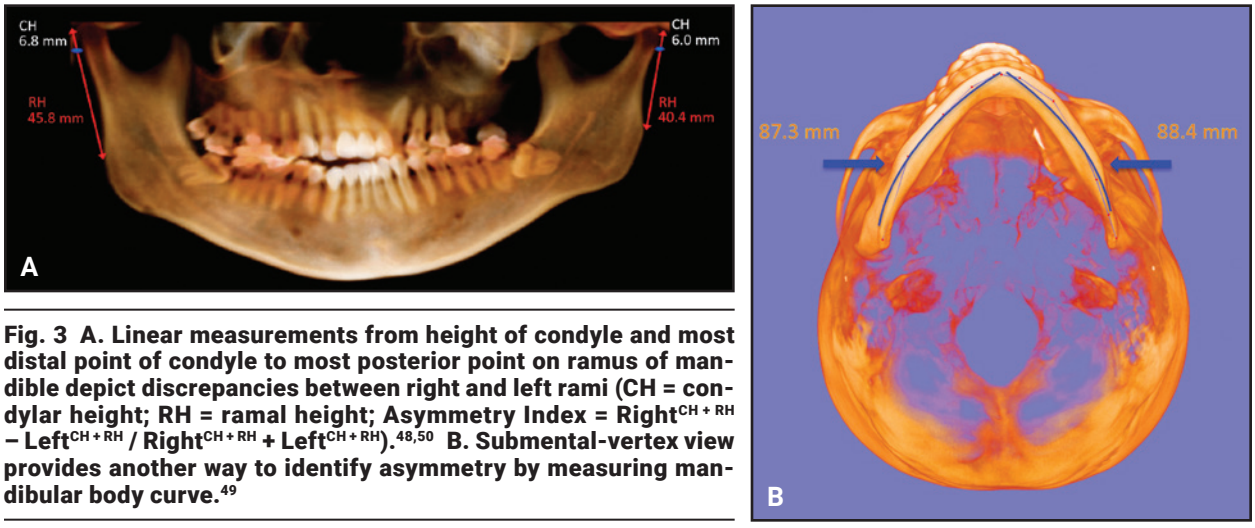


Fig. 3 A. Linear measurements from height of condyle and most distal point of condyle to most posterior point on ramus of mandible depict discrepancies between right and left rami (CH = condylar height; RH = ramal height; Asymmetry Index = $Right^{CH+RH} - Left^{CH+RH} / Right^{CH+RH} + Left^{CH+RH}$).[48,50] B. Submental-vertex view provides another way to identify asymmetry by measuring mandibular body curve.[49]

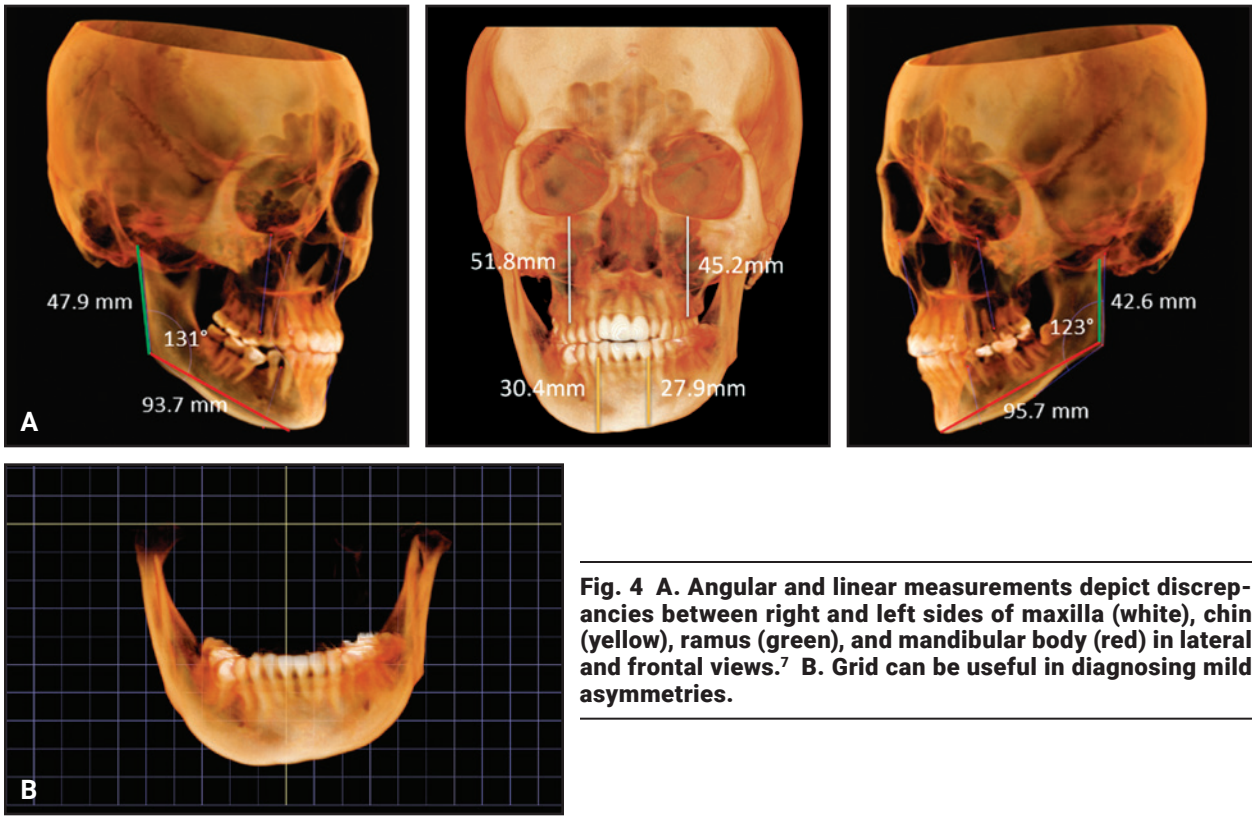


Fig. 4 A. Angular and linear measurements depict discrepancies between right and left sides of maxilla (white), chin (yellow), ramus (green), and mandibular body (red) in lateral and frontal views.[7] B. Grid can be useful in diagnosing mild asymmetries.

TABLE 2
BONE SCINTIGRAPHY TECHNIQUES[12,14,19,41,52-55]

Scan Technique	Image Dimensions	Radioisotope	Advantages	Disadvantages
Planar bone scan (bone scintigraphy)	2D	Technetium Tc 99m methylene diphosphonate	High sensitivity (.71), pooled specificity (.92)	False positives for TMJ disease; difficult to perform or reproduce
Single-photon emission computed tomography (SPECT)	3D	Technetium Tc 99m methylene diphosphonate	Greater sensitivity (.90), pooled specificity (.95)	Radiation exposure: .0057 mSv/MBq*; bone surfaces receive greatest exposure
Positron emission tomography (PET)	3D	Sodium fluoride F-18	Better spatial resolution	Radiation exposure: .024 mSv/MBq*; kidney receives greatest exposure

*Millisieverts per megabecquerel.

TABLE 3
THREE-DIMENSIONAL ENVELOPE OF OBSERVATION[58-61]

Clinical Presentation	Acceptable Norm
Transverse plane	
Midlines deviating from midfacial axis	< 2.2mm
Midline cant	< 10°
Sagittal plane	
Class II	< 4mm chin retrusion*
Class III	< 2mm chin protrusion**
Vertical plane	
Occlusal cant	< 4°
Chin deviation	
Asymmetrical chin	< 5.6 ± 2.7mm

* > 10mm corrected by surgery. ** > 6mm corrected by surgery.

condylar deformities from all possible aspects (Fig. 4).[7,50] CBCT superimposition techniques, 3D stereophotogrammetry, and 3D cephalometric analysis can more accurately evaluate the extent of an asymmetry.[51]

Growth status helps predict the potential for relapse of a surgical correction. Although periodic lateral cephalograms are useful in determining whether growth is complete, nuclear imaging provides physiological details that cannot be discerned from cephalometric radiographs (Table 2).[12,14,19,41,52-55] Bone scintigraphy can confirm the cessation of asymmetrical growth, based on the supposition that the difference in uptake values of the left and right condylar regions does not exceed 10% in the normal population.[12] False positive results are possible, however, in cases with TMJ disease, and the test may be useless in the bilateral form of the disease.[52] SPECT provides better diagnostic information than planar scanning, owing to its greater sensitivity and its isolation of the condyles without superimposition.[12,16,53] Bone scintigraphy and SPECT studies have therefore become indispensable standards for diagnosis, treatment planning, and management of facial and mandibular asymmetries, as long as any joint pathology has been eliminated.[56,57]

Treatment Planning and Treatment

Once an asymmetry has been accurately identified and quantified and growth cessation has been confirmed, treatment can be planned to correct the deformity. Familiarity with the most current literature related to the esthetic acceptability of deviations in various planes of space can be helpful in decision-making (Table 3).[58-61] Because more severe deviations are considered to be discernible, every effort should be made to attain an outcome within this envelope of correction. The measurements provide both clinician and patient with an objective gauge of how much correction is needed to achieve at least an acceptable result. In concert with Proffit's envelope of discrepancy[62] or Squire's limitations of orthodontic treatment,[63] these ranges make it possible to decide whether growth modification and/or orthodontics will be sufficient to correct the deformity or whether surgery is warranted.

Appropriate timing is an essential attribute of a comprehensive treatment plan. When a young, growing patient presents with a developing asymmetry, it is critical to determine whether the deviation is functional in nature.[64] A functional asymmetry

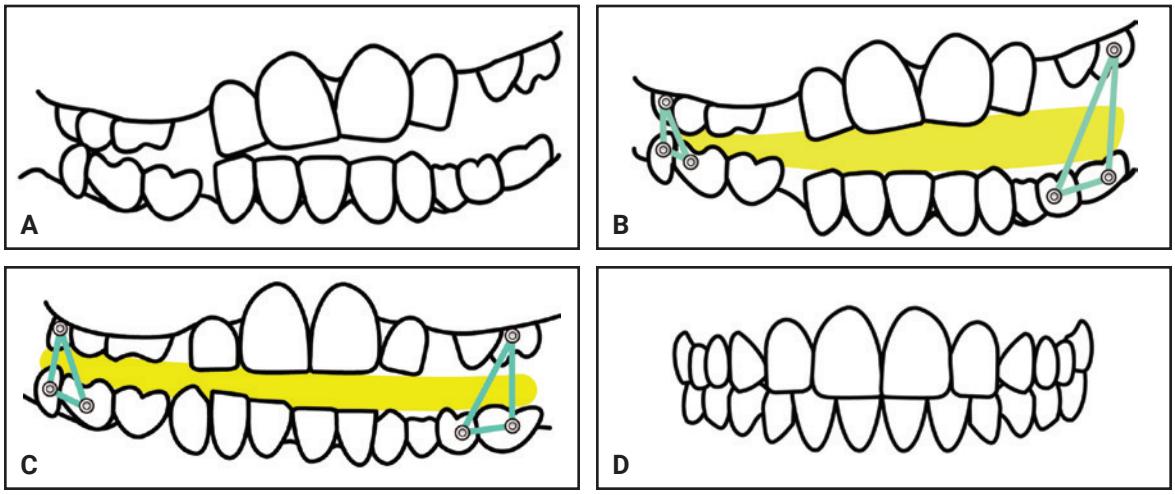


Fig. 5 Appliance used for correction of vertical asymmetry in mixed dentition. A. Open bite on left side resulting from maxilla being unable to catch up to excessive vertical growth of mandible. B. Selective trimming of appliance, with intermaxillary elastics used to erupt teeth on left side and stabilizing elastics worn on right side. C. Maxillary cant corrected and appliance progressively trimmed to maintain correction and limit asymmetrical increments of mandibular growth. D. Final occlusion following definitive treatment for asymmetry.

will present with a discrepancy between centric relation and maximum intercuspal position. After the interference is removed, any remaining effects must be negated and provisions made to prevent recurrence. Maxillary expansion is an example of a time-sensitive intervention to eliminate functional interferences that might lock the growing mandible and cause asymmetry. Expansion can produce an ideal maxillary skeletal arch width, correct a transverse asymmetry in the maxilla, and allow the mandible to grow in an unrestrained environment.

Correction of asymmetry in the sagittal plane is sometimes possible by means of asymmetrically activated functional orthopedic appliances, asymmetrical elastics, or asymmetrical extractions to compensate for an underlying skeletal discrepancy. This approach, using dentofacial orthopedic techniques such as headgear or Class II functional appliances, is known as camouflage treatment. In the vertical dimension, a difference between the two sides of the mandible can be offset with asymmetrical bite ramps or biteplanes. Such appliances rely on the effect of differential eruption: elastics are used to erupt teeth into spaces created by relieving acrylic on the bite blocks, and intrusion is accomplished by interposing the biteplane between upper and lower teeth (Fig. 5). Once the desired plane of occlusion has been achieved, the same appliance can be adjusted to keep further maxillary compensations from developing during the patient's growth phase.[4,65] When employing asymmetrical mechanics in one plane of space, it is extremely important to anticipate adverse effects in the other two planes and to build compensations into the appliance design.[66,67]

An adolescent patient with asymmetry can benefit from intervention designed to resolve anterior and posterior crossbites. In children and adolescents, a timely intervention may reduce the magnitude of correction needed later and promote stability as well.[65] Older asymmetry patients have fewer options in terms of orthopedic correction. Since little growth modification is possible, orthodontic management of adults mainly involves camouflage treatment of the occlusal asymmetry. Minor asymmetries can be corrected with orthodontic treatment alone, but moderate to severe deviations will require further correction.

Early intervention is critical in a skeletally immature patient with severe asymmetry, especially

TABLE 4
SURGICAL CORRECTION OF ASYMMETRY

Surgical Intervention	Description and Desired Result
Condylar shaving	Removal of top 2-3mm of condylar head to arrest aberrant growth in proliferating zone of condyle.[15]
High condylectomy	Removal of 4-5mm from upper pole of affected condyle, including medial and lateral poles, to prevent excessive growth increments in involved condyles.[17,68-71]
Low condylectomy	Removal of condyle at condylar base and preservation of neck to function as new condyle; recommended when condyle is significantly deformed.[72]
Condylar surgery (total condylectomy)	Removal of condyle on affected side to eradicate growth site and correct discrepancy in height and size of condyle; pathology may also necessitate condylectomy.[73]
Distraction osteogenesis	Employed when significant increase (8-10mm) in length of mandible is needed.[74,75]
Ramal osteotomies (unilateral or bilateral) with or without Le Fort procedures	Used for nonprogressive deformity (bilateral if unilateral procedure results in excessive rotation of condyle, especially in case of prognathism); surgical procedures may also be needed in maxilla to correct skeletal compensations.[16,43,72,76,77]
High condylectomy with articular disc positioning and osteotomies in lower jaw	Employed in case of mandibular prognathism or retrognathism that cannot be addressed with condylectomies alone and display TMJ symptoms accompanying deformity.[40]
Total joint prosthesis (CAD/CAM)	Used in adult with unsalvageable disc or TMJ arthritis on contralateral side; may also require condylectomy and osteotomies on ipsilateral side.[40]
Inferior alveolar nerve preservation	Employed in case of mandibular body vertical excess with low position of inferior alveolar nerve, requiring relocation along with ostectomy to restore vertical symmetry.[40]
Genioplasty	Used to correct asymmetry of chin.[40]
Soft-tissue surgery	Facelift on affected side to remove excess tissue, or augmentation of opposite side; may require MEDPOR* ramus/body implant, dermis fat, or fat graft to soft tissues.[77]
Orbital correction	Intraoral zygomatic osteotomy.[78]

*Trademark of Stryker Corp., Kalamazoo, MI; www.stryker.com.

in the presence of a significant functional, psychosocial, or esthetic component.[65] Surgery may be indicated as an adjunctive procedure to facilitate normal growth and psychosocial development. More often, however, surgery is used to correct any asymmetry that remains after orthopedic and orthodontic treatment options have been exhausted (Table 4). The type of surgery will depend on the etiology and degree of the deformity, the condylar morphology, the position of the inferior alveolar

Fig. 6 37-year-old male with asymmetrical bite before treatment.

TABLE 5
3D IMAGE ANALYSIS OF FACIAL ASYMMETRY

	Pretreatment			Post-Treatment		
	Right	Left	Difference	Right	Left	Difference
Maxillary height	48.7mm	45.6mm	3.1mm	48.7mm	46.0mm	2.7mm
Ramal length	60.4mm	58.6mm	1.8mm	60.0mm	59.7mm	0.3mm
Mandibular body length	78.7mm	78.8mm	0.1mm	72.0mm	71.0mm	1.0mm
Chin height	30.8mm	31.5mm	0.7mm	30.9mm	31.7mm	0.8mm
Mandibular midline to gonion	85.6mm	85.0mm	0.6mm	76.6mm	76.4mm	0.2mm
Ramal inclination (lateral view)	15.9°	15.4°	0.5°	16.0°	16.4°	0.4°
Ramal inclination (rear view)	15.3°	11.1°	4.2°	13.9°	12.0°	1.9°

Fig. 7 After three months of presurgical orthodontic treatment. Upper second premolars with extensive restorations were extracted instead of first premolars so that upper incisors could be retroclined.

nerve, the remaining growth potential of the condyle, the airway space analysis, the patient's age, and a growth-pattern prediction to allow overcorrection if early intervention is attempted.

The individual case assessment will determine which treatment will be most beneficial, with the least likelihood for relapse and need for retreatment. For example, a 37-year-old male presented with the chief complaint of being unable to chew efficiently with his asymmetrical bite (Fig. 6, Table 5). Three months of presurgical orthodontics (Fig. 7) were followed by two-jaw surgery to protract the maxilla and set back the mandible in an asymmetrical fashion, using resorbable plates (Fig. 8). This patient's facial esthetic and functional problems were both significantly improved after surgery (Table 5). Total treatment time was 22 months (Fig. 9).

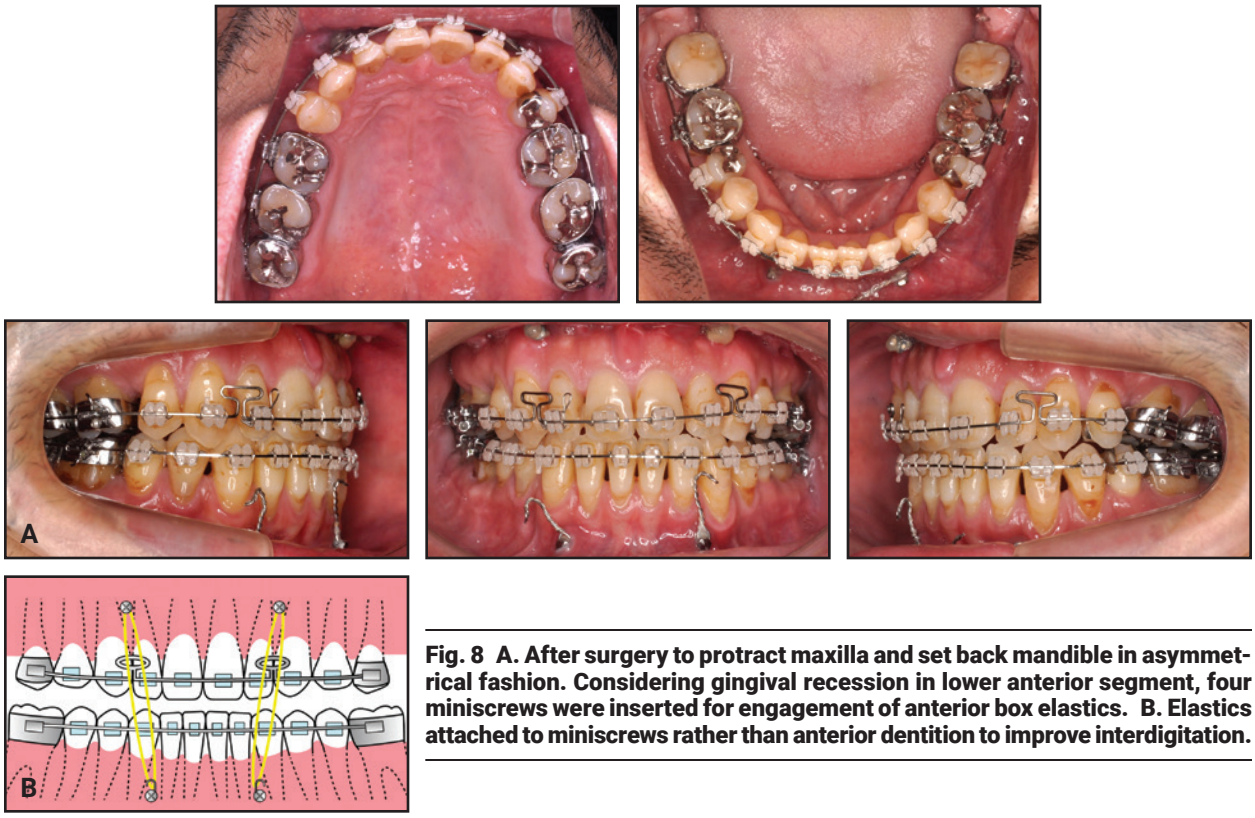


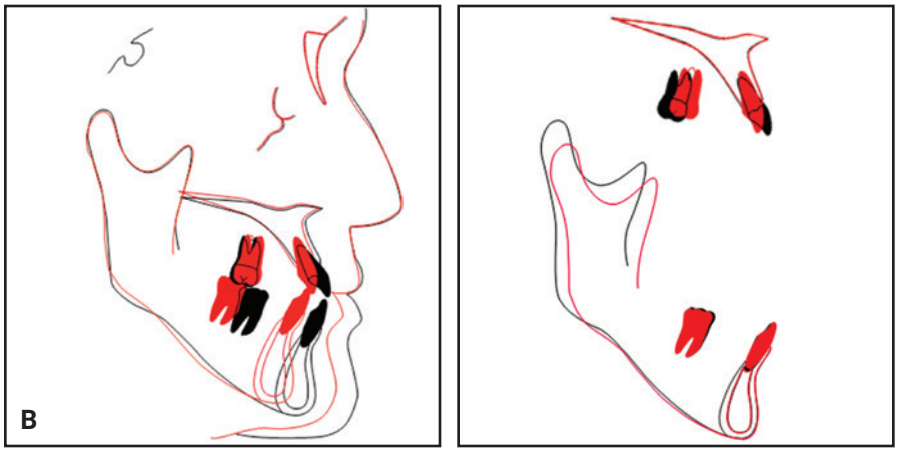
Fig. 8 A. After surgery to protract maxilla and set back mandible in asymmetrical fashion. Considering gingival recession in lower anterior segment, four miniscrews were inserted for engagement of anterior box elastics. B. Elastics attached to miniscrews rather than anterior dentition to improve interdigitation.

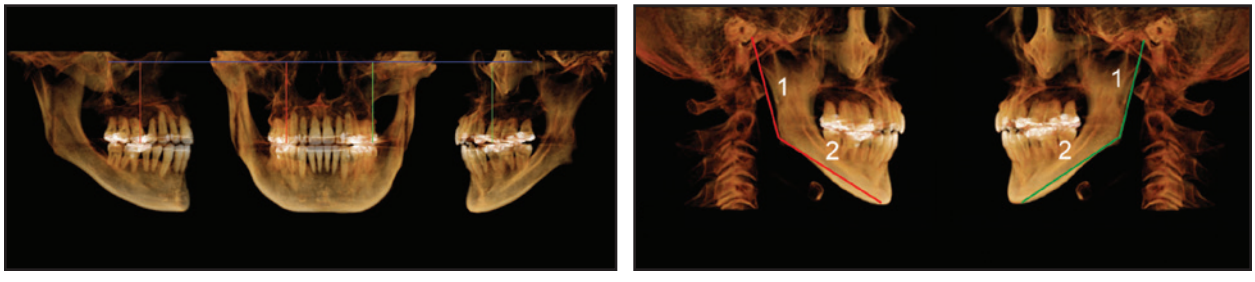
Titanium plates have traditionally been used in the surgical correction of asymmetry because of their strength. A second surgery is sometimes needed, however, to remove the plates and reduce the chance of infection.[79] Kim and colleagues observed local tissue destruction near titanium plates, suggesting that they should be removed after bone healing.[80] Other studies showing long-term stability of titanium plates have not recommended routine removal in asymptomatic cases.[81,82] Regardless, a secondary surgery is not needed for resorbable plates, which decompose in vivo. Resorption plates using poly-L-lactic acid have displayed disadvantages such as foreign-body reactions and osteolysis around the screws, but polyglycolide composite fields have been found to resolve some of these problems.[82] Stronger resorbable plates and screws have recently been used in cases of jaw deviation.[83,84]

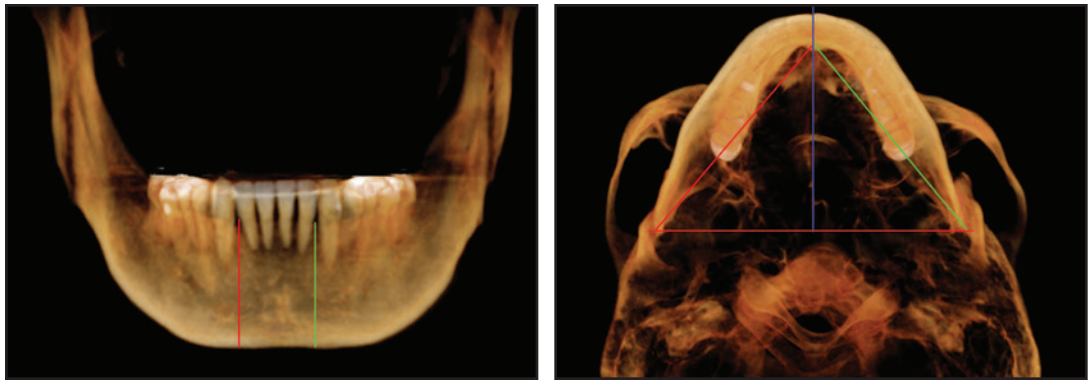
Genioplasty, soft-tissue implants, and fillers are able to mask asymmetries to a certain extent. Mild to moderate cases of unilateral condylar hyperplasia can be effectively treated in their inactive phase with condylectomy, sometimes without accompanying jaw surgery.[71,72,77,85] Although condylectomy has been linked to TMD,[85,86] a high condylectomy has become the procedure of choice for active cases of condylar hyperplasia in both adults and growing patients. Appreciable functional alterations are rare if the surgery is followed by successful functional rehabilitation.[76]

Orthognathic surgery for correction of asymmetry generally involves osteotomies. The mandible can be lengthened by placing a graft between cut segments or by making a planar section that allows the halves to slide apart over one another. Studies have shown, however, that increases of more than 8-10mm are unstable and unpredictable

Fig. 9 A. Patient after 22 months of treatment (resorbable surgical plates and screws not visible on radiographs) (continued on next page).







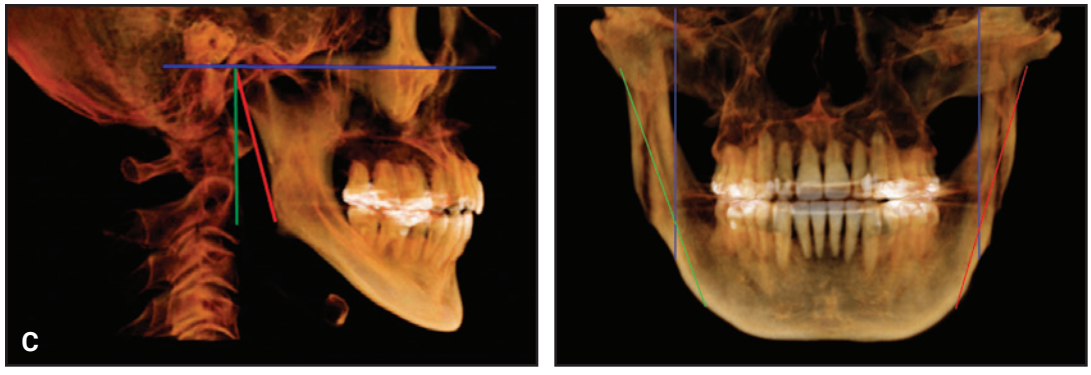


Fig. 9 (cont.) B. Superimposition of pre- and post-treatment cephalometric tracings. C. Cone-beam computed tomography images confirming symmetry of maxillary height, ramal (1) and mandibular body (2) lengths, chin height, mandibular midline to gonion, and ramal inclination (lateral and rear views).[7,50]

over the long term.[86,87] As an alternative, distraction osteogenesis can produce substantial lengthening of the ramus or mandibular body.[73,74]

When double-jaw surgery is required to correct asymmetry with condylar hyperplasia in an adult patient, it must be done in a particular order. After maxillary osteotomies and fixation, condylectomies are performed to remove the growth sites. The post-condylectomy mandible is then adjusted to occlude with the corrected maxilla. Some authors recommend that every condylar hyperplasia surgery be accompanied by a condylectomy to reduce the risk of future activity and reemergence of asymmetry.[42,88]

Conclusion

The longer facial asymmetry goes undiagnosed, the greater the chance of treatment failure, especially in cases involving inappropriate extraction of permanent teeth or improper treatment mechanics. This is particularly important in children, whose facial asymmetries generally become more severe with growth and time. Although early recognition is imperative, unsuitable early orthodontic treatment can accentuate an asymmetry rather than improving it. Underdiagnosis and resulting lack of treatment of upper airway obstructions will further exacerbate the severity of facial asymmetries.

Appropriate treatment can improve and resolve facial asymmetries by harnessing growth potential, employing beneficial orthodontic mechanics and surgical intervention as necessary. Thorough evaluation on a case-by-case basis is essential to success.

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