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Understanding Asymmetry-A Review

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INTRODUCTION

Every person has numerable common features when comparing with general population. At the same time, every individual on earth is different and unique which points to the handiwork of the Creator. It is this unending combination of size, shape, and relationship of the dental, skeletal, and soft tissue facial structures that give individuality to every person.

Perfect right & left body symmetry is more of a hypothetical concept that seldom exists in living organisms. Bilateral differences occur everywhere in nature. In general, animals & humans have marked asymmetry as to the anatomy in the body.

It is also a fact that Man experiences functional as well as morphologic asymmetries (e.g., right and left handedness as well as a preference for one eye or one leg). Some of these asymmetries are of embryonical origin.

Oxford Concise Medical Dictionary defines symmetry as "correspondence of form on either side of a plane or axis".[1] Clinically, symmetry means balance, whereas significant asymmetry means imbalance.

Facial asymmetry, being a common phenomenon, was probably first observed by the Greek artists who recorded what they had found in nature - normal facial asymmetry.[2] Asymmetry in the craniofacial areas can be attributed as the differences in the size or relationships of the two sides of the face. This may be due to differences either in the form of individual bones or a malposition of one or more bones in the craniofacial complex. Sometimes the asymmetry may be just because of the overlying soft tissues.[3]

Peck and Peck[4] assessed bilateral facial symmetry in 52 "exceptionally well-balanced" adults and observed that there is less asymmetry and more dimensional stability as the cranium is approached.

The line at which normal asymmetry crosses to be abnormal cannot be easily defined and is often determined by the clinician's sense of balance and the patient's perception of the imbalance.

In Clinical scenarios, facial asymmetry in the craniofacial complex ranges from the barely detectable to gross discrepancies between the right and left halves of the face. This can be better perceived by collating photographs of the right and left sides of normal faces with their respective mirror images - three faces can be visualized: the original, the two left sides, and the two right sides. Most often these three faces of the same individual are distinctly different.[4-6]

Even in ancient Egyptian skulls it was found that the bones of the cranium showed asymmetry, the right frontal, temporal, and parietal bones being larger. The contra-lateral side of the facial complex exhibited an asymmetry with the left zygoma and maxilla being larger.[7]

In a more recent study to determine the symmetry of the various parts of the face, Vig and Hewitt[8] evaluated 63 postero-anterior cephalograms of normal children who were 9 to 18 years of age. An overall asymmetry was found in most of the children with the left side being larger. The cranial base and mandibular regions exhibited a left side excess, whereas the maxillary region showed a larger right side. The dentoalveolar region exhibited the greatest degree of symmetry. They concluded that compensatory changes seem to operate in the development of the dentoalveolar structures. These changes enable bilateral symmetric function and maximum intercuspation to occur, thus minimizing the effects of the underlying asymmetry in the arrangement and size of the jaws.[8, 9]

Melnik[10] in a longitudinal study evaluating the changes in mandibular asymmetry, found no significant gender differences by the age of 14 years. He also observed that relative to 6 years of age, there was an equal probability for mandibular asymmetry to improve by the age of 16 years.

Etiology

Genetic or Non-Genetic

Genetic origin has been attributed to certain conditions like multiple neurofibromatosis & hemifacial microsomia associated with asymmetry.[11] Facial Clefting Syndromes have also been associated with asymmetry.[12]

Non-Genetic

Intrauterine pressure during pregnancy – generally restores within a few weeks to several months.[13]

Pathological Factors – Osteochondroma of mandibular condyle,[14] trauma & infection to TMJ and nerve.[15]

Environmental Factors - sucking habits, asymmetric chewing habits caused by dental caries, extractions and trauma.[2]

2. Discrepancies in the form of individual bones
3. Dental Asymmetries in one or both arches
4. Functional Shifts during opening & closing
5. Asymmetry of the overlying soft tissue.

Classification

Asymmetry can also be described as either *qualitative* (differences in the size of teeth, the location of teeth in the arches, or the overall position of the arches in the head) or *quantitative* (differences in the number of teeth on each side or the presence of a cleft lip and palate).[2]

Anomalies, which in many cases are associated with mandibulofacial asymmetries, have further been separated by Cohen[16] into three classes:

(1) Malformations with abnormal developmental processes at the embryonic stage;
(2) Deformations caused by non-disruptive mechanical forces during the fetal period and characterized by an abnormal form or position of a part of the body, and
(3) Disruptions caused by breakdown of an otherwise normal developmental process and having their onset later than that of malformations. The incidence of disruptions is low, and the variation in their expression large. According to Cohen, [16] these three classes are interrelated and overlapping in some cases, and it is therefore not always possible to classify an anomaly.

Asymmetries can also be classified according to the structures that are involved as dental, skeletal, muscular & soft tissue and functional.[17]

Dental Asymmetries

Dental asymmetries can be caused by local factors such as early loss of primary teeth, congenitally missing teeth, and habits such as thumb sucking. Lack of exactness in genetic expression affects the teeth on the right and left sides, causing asymmetries in mesio-distal crown diameters.[2]

Garn et al[18] found that tooth asymmetry generally does not involve the entire arch. On the other hand, teeth in the same morphologic class tend to have the same direction asymmetry. For example, if the maxillary first premolar is larger on the right side, the maxillary second premolar will also tend to be larger on the right side but the molars need not be larger on that side. In addition,

asymmetry tends to be greater for the more distal tooth in each morphologic class (i.e., the lateral incisors, second premolars, and third molars). Asymmetry may also be confined to the shape of the dental arches.

Skeletal Asymmetries

The skeletal asymmetries may involve one bone such as the maxilla or the mandible. Or they may involve a number of skeletal and muscular structures on one side of the face. (e.g., in hemifacial microsomia)

Muscular and Soft Tissue Asymmetries

Certain conditions like hemifacial atrophy or cerebral palsy,[19] masseter hypertrophy[20] or dermatomyositis and certain cancers[21] result in facial disproportions and midline discrepancies

Functional Asymmetries

Functional asymmetries are caused when the mandible is being deflected laterally or antero-posteriorly due to occlusal interferences which in turn prevent proper intercuspation in centric relation. These functional deviations may be caused by a constricted maxillary arch or by a more localized factor such as a malposed tooth.

Felisio et al[22] assessed and quantified the different components that can lead to mandibular asymmetry during or at the end of the growth period. They found that 75% of the patients had structural asymmetry, whereas 10% had displacement asymmetry.

A combination of these factors can be present. Therefore each patient needs to be carefully evaluated by the clinician to arrive at a proper diagnosis.

Diagnosis

An important aspect of diagnosing asymmetries is obtaining a thorough dental and medical history including a history of trauma, arthritis, and progressive changes in the occlusion.

To methodically diagnose facial and dental asymmetries, a detailed history taking, a thorough clinical examination, radiographic analysis and cast analysis are necessary to determine the extent of the soft tissue, skeletal, dental, and functional involvement.

Clinical examination

Clinical examination can reveal asymmetry in the vertical, antero-posterior or transverse directions.

Systematic Evaluation of Dental and Facial Asymmetry

The systematic sequence of facial examination for symmetry should include the following series of measurements.

Nasal Tip to Midsagittal Plane

The position of the nasal tip is best visualized by having the patient elevate the head slightly and evaluating the position of the tip by visualizing the midsagittal plane along the long axis of the face. Deviation of the nasal tip from the midsagittal plane may be secondary to the following:

1. Previous traumatic injury to the nose.
2. Deviation of the nasal septal cartilage, sometimes including the vomer.
3. Unfortunate stigmata of nasal plastic surgery.
4. Congenital nasal stenosis, which in the vestibule can affect the lateral angle.
5. Nasal deformities that occur in unilateral cleft-lip nose.

The nasal tip in facial examinations is included for obvious reasons. If the nasal tip is *5* mm to the right of midsagittal plane, selecting where to place the dental midline becomes a problem. Nasal asymmetry may be a result of septal dislocations induced by the trauma of birth delivery, traumatic injury, and iatrogenic deformity secondary to rhinoplasty.

Maxillary dental midline to midsagittal plane

This relationship is also best visualized by looking at the patient with his or her head slightly elevated. Deviations of the maxillary dental midline from the midsagittal plane may include the following:

1. Maxillary dental midline discrepancy - Look for a unilaterally missing tooth (teeth) as a possible cause of this discrepancy. The most common cause of a severe maxillary midline shift is generally associated with either a congenitally missing lateral incisor, or cases

in which a crowded maxillary cuspid has been removed during adolescence in an effort to decrowd teeth without comprehensive orthodontic treatment.

2. Maxillary rotation - This is rarely encountered and is usually seen only in association with posttraumatic maxillary reconstruction. Maxillary rotation generally exhibits dental cross bite. For example, a rotation of the maxilla to the right would be characterized by lingual cross bite in the right posterior dentition and a buccal cross bite in the left posterior dentition.

Maxillary Dental Midline to Mandibular Dental Midline

The clinical examination should include an evaluation of the dental midlines in the following positions:

1. mouth open,
2. in centric relation,
3. at initial contact, and
4. in centric occlusion.

It is desirable that these midlines should be coincident. A discrepancy between these two midlines may be a result of the following:

1. Maxillary dental midline shift
2. Mandibular dental midline shift
3. Maxillary dental midline shift due to tipping with no apical base discrepancy
4. Mandiular dental midline shift due to tipping with no apical base discrepancy
5. Mandibular asymmetry
6. Functional shift of the mandible laterally
7. Dental midlines correspond due to compensatory tipping but with apical base discrepancy

Mandibular Dental Midline to Midsymphysis

This relationship is best visualized by standing behind the patient and viewing the lower arch from above. Have the patient open his or her mouth to see the lower arch and its midline relation to the body of the mandible and the symphysis. Lower dental midline discrepancies from the midsymphysis are generally a result of:

1. Dental crowding with a shift of the lower incisors.
2. Prematurely missing primary canines or other primary teeth in the adolescent.
3. Congenitally missing teeth or premature loss of teeth with a resultant midline movement.
4. A missing lower incisor.

Midsymphysis to Midsagittal Plane

Facial symmetry is a characteristic that is visualized clinically and cephalometrically. Peck et al established that symmetry is universally present, and dominance to right or left sidedness is not statistically significant. The relationship of the midsymphysis to the midsagittal plane is best visualized through a submental view. Have the patient elevate his or her head so that you can see straight up the midsagittal plane. Deviation of the midsymphysis from the midsagittal plane is most often a result of a functional mandibular shift or a true mandibular asymmetry.

Mandibular asymmetry is suspected when the midsymphysis is not coincident with the midsagittal plane. An important diagnostic factor is whether a lateral functional shift is present secondary to a functional shift of the mandible due to crossbite. When the patient is manipulated to centric relation, a bilateral, end-to-end crossbite usually is present and as the patient moves his or her teeth into full occlusion, the patient must choose a side to move his or her mandible to maximum intercuspation. This lateral shift is not indicative of true mandibular asymmetry but of transverse maxillary deficiency and a resultant functional shift of the mandible.

True asymmetries of skeletal or dental origins, if uncomplicated by other factors, exhibit similar midline discrepancies in centric relation and in centric occlusion. On the other hand, asymmetries caused by occlusal interferences may result in a mandibular functional shift following initial tooth contact. The shift can be either in the same or opposite direction of the dental or skeletal discrepancy and may either accentuate or mask the asymmetry.

If the systematic evaluation has dental and skeletal midlines and vertical relations of the maxilla normal and lower facial asymmetry is noted, then the asymmetry may be isolated to the chin. Measurement of the midsymphysis to the

midsagittal plane is a logical indicator of chin asymmetry, but the parasymphyseal heights should also be measured when chin asymmetry is suspected. The decision for correcting vertical parasymphyseal discrepancy depends on whether one side is too long or too short -or some of both.

As stated previously, the patient should also be evaluated to detect functional asymmetries related to TMJ derangements.

Vertical Occlusal Evaluation

The presence of a canted occlusal plane could be the result of a unilateral increase in the vertical length of the condyle and ramus. Similarly, the maxilla or temporal bone supporting the glenoid fossa could be at different levels on each side of the head. Such asymmetries are often detected by clinically evaluating the patient. The cant in the occlusal plane can be readily observed by asking the patient to bite on a tongue blade to determine how it relates to the interpupillary plane.

Vertical skeletal asymmetries associated with progressively developing unilateral open bites may be the result of condylar hyperplasia.

Transverse and Anteroposterior Occlusal Evaluations

Asymmetry in the bucco-lingual relationship and mesio-distal relationship should be carefully diagnosed to determine if it is skeletal, dental, or functional. As stated previously, if there is a mandibular deviation from centric relation to centric occlusion, the lower dental midline and chin point should be compared with other midsagittal dental, skeletal, and soft tissue landmarks in the open, initial contact, and closed mandibular positions.[23]

In some cases such a clinical examination is insufficient to detect a functional shift that has been acquired for a prolonged period. When this is suspected, an occlusal splint may need to be constructed for the patient to wear. The appliance allows the musculature to freely guide the mandible to its proper relationship without the distracting influence of the occlusal interferences.

Examination of the overall shape of the maxillary and mandibular arches from an occlusal view may disclose not only side-to-side asymmetries but also differences in the buccolingual angulation of the teeth. It is important to realize that expansion of dental units to correct a crossbite in the presence of a skeletal constriction may adversely influence the stability of the correction. Similarly, moving already tipped posterior teeth further buccally to correct the crossbite will be associated with greater relapse.

Arch asymmetry could also be caused by rotation of the whole maxilla or mandible. The diagnosis of a rotary displacement of the maxilla may require further evaluation by mounting the dental casts on an anatomic articulator using a face bow transfer.[24]

Maxillo-mandibular Asymmetry - *Transverse Cant of the Maxilla*

Mandibular asymmetry is often accompanied by maxillary compensation, which is reflected clinically by a transverse cant of the maxilla. This means that our evaluation of mandibular deformity should now include the possibility of maxillo-mandibular deformity. This transverse cant is not always present and should be determined clinically at the time of initial examination. Transverse tilting of the maxilla may be detectable cephalometrically but is most evident through clinical observation. This is generally measured in clinical descriptive terms as *left maxilla* 3 *mm more superior than right.*

Transverse cant should be measured at the canine, in terms of gingival display on smile or percentage of canine show on smile. Evaluation of transverse maxillary cant is facilitated by the use of a tongue blade or Fox plane placed against the maxillary occlusal plane. This provides a reference by which the maxillary occlusal plane can be visualized clinically.

Transverse Facial, Skeletal, and Soft Tissue Evaluation

The evaluation of facial asymmetry is one of the most important aspects of the clinical evaluation. During the facial evaluation the clinician should compare bilateral structures in both the transverse direction (rule of fifths) and vertical

direction (rule of thirds) and check for the presence of other abnormalities. In addition body posture should be observed. Other than the bilateral structural comparisons, deviations in the dorsum and tip of the nose as well as the philtrum[25] and chin point need to be determined. However body posture, mannerisms and hairstyle may hide asymmetry and mislead the treatment plan.[26]

Asymmetries in the mandible may be observed clinically from a frontal view by observing the point of the chin as it relates to the rest of the facial structures. Looking at the mandible from an inferior view sometimes helps determine the extent of its involvement in relation to the rest of the face.

It is obvious from this description that the clinical evaluation plays an important role in the diagnosis of asymmetries. It is also obvious that, in many cases, the clinical examination needs to be supplemented by other diagnostic records such as dental casts, face bow transfers, and various imaging techniques to accurately localize the structures involved in the asymmetry.

Radiographic examination

In addition to the clinical evaluation, the differentiation between various types of asymmetries can be aided by the use of radiographs. A number of projections are available to properly identify the location and cause of the asymmetry.

Lateral Cephalometric Radiograph

A lateral cephalometric radiographic projection, although commonly available to the clinician, provides little useful information on asymmetries in ramal height, mandibular length, and gonial angle.

It is limited by the fact that the right and left structures are superimposed on each other and are at different distances from the film and x-ray source, which results in significant differences in magnifications.

Criticisms of lateral projections have also been made because of the predetermined orientation using the ear rods. In other words, the assumption is made that the position of the external auditory meatus is symmetric, whereas in reality it may vary in more than one plane of space. Therefore the interpretation of the lateral cephalogram in diagnosing asymmetries is of limited value.

Panoramic Radiograph

A panoramic radiograph is a useful projection to survey the dental and bony structures of the maxilla and mandible and to determine the presence of a gross pathologic condition, missing or supernumerary teeth. In addition, the shape of the mandibular ramus and condyles on both sides can be grossly compared. Because of the inherent characteristics of this projection, geometric distortions are significant and vary from one area of the film to another.

TMJ Imaging

Radiographs and other imaging modalities should be used to investigate the TMJ when the patient presents with facial asymmetries and a continuously changing intermaxillary relationship or when there is a history of trauma, crepitation of the joint or history of inflammatory disease. Comprehensive TMJ imaging may include one or more of the following procedures:

1. Conventional radiographs
2. Conventional tomography
3. Computerized tomography
4. Arthroscopy and video fluoroscopy
5. Magnetic resonance imaging
6. Radionuclide imaging to determine bone turnover activities

Posteroanterior Projection

Posteroanterior projection is a valuable tool in the study of the right and left structures because the structures are located at relatively equal distances from the film and x-ray source. As a result the effects of unequal enlargement by the diverging rays are minimized and the distortion is reduced. Comparison between sides is therefore more accurate because the midlines of the face and dentition can be recorded and evaluated. Posteroanterior cephalograms can be obtained in centric occlusion as well as with the mouth open. The latter position might help determine the extent of the functional deviation, if any is present.

Localization of the Asymmetry from the PA Ceph

Once a posteroanterior film has been obtained, it must be qualitatively and quantitatively evaluated to determine the extent of the asymmetry present. The structures to be used in the construction of the midsagittal reference plane need to have a relatively high degree of symmetry.

Anatomic Approach

Harvold[27] found that the zygomatico-frontal sutures and crista galli are relatively symmetric structures as compared to other facial landmarks that are further distant from the cranial base. He recommended the construction of a horizontal line through the zygomatico-frontal sutures to act as the horizontal axis. A vertical line perpendicular to the horizontal axis is constructed to pass through and bisect the base of crista galli. This vertical line approximates the anatomic midsagittal plane of the head. Harvold noted that nasion and the anterior nasal spine tend to fall on or near this midsagittal plane 90% of the time. Perpendiculars from bilateral structures can now be constructed to this midsagittal vertical reference line.

The differences between the projections from the two sides are then measured and compared to quantify discrepancies in height as well as in the distances between the bilateral structures and the midline. In addition, the maxillary and mandibular dental midlines are compared to the skeletal midline.

Bisection Approach

In cases where it is difficult to accurately identify crista galli or the zygomatico-frontal sutures, the bisection approach may be used. With the bisection approach bilateral landmarks are located and bisected.[17]

A reference line is then constructed, passing through as many of the midpoints of these bilateral landmarks. If a midpoint is obviously off in relation to most other midpoints of the cranium and face, it may be advisable to exclude such a point when constructing the midline. Evaluation of the bilateral asymmetry then follows the same principles as with the anatomic approach.

Triangulation Approach

The triangulation approach can be used to study the relative asymmetry of the component areas of the facial complex.[8] Following the identification of bilateral structures and the midline on the radiograph, triangles are constructed that divide the face into various components. The right and left triangles are then compared for symmetry.

Grayson et al[28] described a technique in which posteroanterior and basilar cephalograms can be analyzed at various depths to determine the plane of the asymmetry.

Other Imaging Options

Stereo-photo-grammetry using two or more cameras, configured as a stereo-pair to generate a 3-dimensional image of the face by triangulation, has been reported. This provides a useful three-dimensional assessment of facial soft tissue asymmetry before and after orthognathic surgery.[29]

More recent devices for 3-dimensional photography have been used. The image can be used for comparison and quantitative measurement. The precision and accuracy of the 3-dimensional photographs have been validated[30-32]. The soft tissue images captured from 3-dimensional photogrammetry are comparable to those obtained from traditional cephalogrammetry.[33]

Other radiographic modalities in the assessment of facial asymmetry include tomography and computed tomography (CT). CT scans both in 2-dimensional and 3-dimensional views can provide excellent details necessary for proper diagnosis and treatment. In addition, three dimensional CT images can also provide information for the fabrication of three-dimensional acrylic skeletal models to facilitate evaluation and surgical planning.[34] Cone beam CT scanning has become popular in many dental and maxillofacial centres for assessment of asymmetry.[35]

Treatment

A detailed study of the various diagnostic records obtained on the patient is necessary to determine the cause, location, and extent of the asymmetry. This enables the clinician to formulate the proper treatment plan.

Options for correction of Functional Asymmetries

1. Mild deviations - minor occlusal adjustments.
2. Severe deviations - need orthodontic treatment
3. Occlusal splints may be necessary to properly evaluate the presence and extent of the functional shift

Options for correction of Dental Asymmetries

1. Unilateral extraction and orthodontic movement.
2. traumatic maxillary rotation - orthodontic compensation or orthognathic surgery.
3. Subapical procedures to rotate midlines.
4. Orthodontic space opening where the missing tooth originally occupied & restore later.
5. Orthodontic space opening in cases of premature tooth loss.
6. Asymmetric extraction sequences and asymmetric mechanics (e.g., Class III elastics on one side and Class II elastics on the other with oblique elastics anteriorly)
7. Composite build-ups or prosthodontic restorations may be indicated with pronounced tooth irregularities.

Options for correction of Skeletal Asymmetries

The severity and nature of the skeletal asymmetry dictate whether the discrepancy can be completely or partially resolved solely through orthodontic treatment & that needs to be explained to the patient before treatment is initiated.

Abnormalities of the coronoid and condylar processes as well as in the position and shape of the articular disks should be considered when limited opening, acute malocclusions, or mandibular deviations are found.

Correction of Maxillary Asymmetry

1. In adult - Surgically assisted maxillary expansion.
2. In growing patients - Rapid or Slow palatal expansion, Quad-helixes
3. Two-piece LeForte I osteotomy.
4. Three-piece LeForte I osteotomy.
5. Distraction Osteogenesis.

Correction of Transverse Cant of Maxilla (Maxillo-Mandibular Symmetry)

1. "Hybrid" functional appliances
2. Maxillo-mandibular surgery

Correction of Mandibular Asymmetry

Functional mandibular shift

Adolescent

1. Maxillary sutural expansion
2. Arch coordination and crossbite elastics

Adult

1. Two- or three-piece maxillary expansion via LeFort I osteotomy
2. Surgically assisted maxillary expansion
3. Arch coordination via orthodontics
4. Distraction Osteogenesis

True mandibular asymmetry

Adolescent

"Hybrid" functional appliance may help improve unilateral mandibular growth. This treatment approach may at least minimize the compensatory cant that occurs in the maxilla, but most treatments are ineffective.

Adult

1. Bilateral ramus osteotomies.
2. Camouflage through bone grafting or alloplastic augmentation.

Correction of Chin Asymmetry

1. Lateral or vertical movement of chin via inferior border osteotomy.
2. Camouflage via bone graft, ostectomy, or alloplastic augmentation.

Options for correction of Soft Tissue Asymmetries

1. Rhinoplasty for correction of the "crooked nose".
2. Camouflage grafting of the tip and/or dorsum.

CONCLUSION

The point at which normal asymmetry becomes abnormal cannot be easily defined and is often determined by the *clinicians sense of balance* and the *patients sense of imbalance.*

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