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RESEARCH ARTICLE

UNVEILING FACIAL ASYMMETRY

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ABSTRACT

Symmetry of the face is the one of the most important features for the perception of attractiveness. Symmetry means both sides of the face, right and left, are alike. Many human body parts undergo development with bilateral symmetry. This implies that the right and left sides can be divided into identical mirror images, but the face often presents with a mild degree of asymmetry. The degree of asymmetry has a negative impact on functional and facial aesthetics. Anthropological research has shown that symmetry and averageness are important keys to the attractiveness of human faces. In today's era, facial attractiveness is valued the most and multiple measures are taken to maintain or achieve facial attractiveness. There are multiple causes to cause facial asymmetry in an individual. There are various etiological factors leading to facial asymmetry. It can be congenital, developmental, acquired or neurological. To diagnose asymmetry, a multiple steps take place starting from clinical examination to radiographic examination. Clinical examination includes visual inspection of the face. Medical history of the patient helps in determining the cause of asymmetry. Similarly, dental history records any history of trauma, previous extractions, caries etc. in extra oral examination, frontal evaluation is done to evaluate midline. Photographs with frontal view (relaxed and smiling), profile view and oblique view are used to assess any gross asymmetry between the two sides of the face. While clinical examination is an important step in diagnosis, radiographic examination is provide valuable information. Posterior-anterior cephalogram plays lead role in the diagnosis of asymmetry, alongside other modalities such as Lateral cephalogram, orthopantomogram, MRI, CBCT scan, CT scan. Treatment modalities can be surgical or non surgical. Treatment planning also depends on the asymmetry diagnosed during what age group i.e. children, adolescents or adults.

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INTRODUCTION

To diagnose facial asymmetry, various steps are taken: clinical examination, medical history, dental history, extra-oral examination, intraoral examination, photographic assessment and radiographic examination. Clinical examination includes visual inspection of the face, palpation to differentiate soft tissue and bony defects, mandibular deviation, temporomandibular joint, evaluation of malocclusion, etc. The medical history of the patient helps in determining the cause of asymmetry. Similarly, dental history records any history of trauma, previous extractions, caries, etc. In the extra-oral examination, frontal evaluation is done to evaluate the midline.[1] There are two more views; the Submental view and superior view help in evaluating dental and skeletal midlines.[2] Evaluation of facial and dental midline helps in the evaluation of transverse relation and vertical relation. Photographs with a frontal view (relaxed and smiling), profile view and oblique view are used to assess any gross asymmetry between the two sides of the face. For photographic assessment; multiple landmarks, reference lines and measurements are done to detect facial asymmetry.

Radiographic examination for facial asymmetry provides valuable information to differentiate various transverse discrepancies. These include posterior-anterior cephalogram, lateral cephalogram, orthopantomogram, CT scans, CBCT scans, and 3D MRI. PA view is the most important radiograph done for asymmetry.[1]

DIAGNOSTIC TOOLS

Clinical examination: One of the challenges in treatment planning and treatment of transverse problems is the proper alignment of maxillary and mandibular dental midlines. Not only should they be coincident with each other, but they must also exhibit a definite relationship with the face. The clinical examination is of vital importance as it enables the clinician to carry out a dynamic assessment of these discrepancies.

It also involves:

- Visual inspection of the entire face
- Palpation to differentiate soft tissue and bony defects
- Comparison of the dental midline with the facial midline
- Inspection of symmetry between the bilateral gonial angle and mandibular body lower border

- Determination of the amount of gingival show per side
- Evaluation of malocclusion
- Occlusal canting
- The inclination of the anterior teeth
- Open bites
- Maximal inter-incisal opening
- Mandibular deviation
- The temporomandibular joint.[3]

Medical history: According to Maheshwari et al, 2005 [4]; A thorough medical history of the patient would aid in diagnosing the exact cause of the asymmetry. The patient should be asked for any prolonged illness or infections during childhood. Any history of trauma to the craniofacial region should be noted.

Dental history: The necessary information regarding any trauma to the dentition, history of previous extractions, caries, and premature loss of teeth or presence of supernumerary teeth should be recorded.[1]

Extraoral examination: Extra oral assessment comprehends visual inspection of facial morphology, associated with soft, hard tissues and TMJ palpation. A thorough facial analysis must be conducted, giving special attention to the center of the chin, leveling of lip commissures, and bilateral symmetry of gonial angles and mandibular body contours. At smiling, the analysis should assess whether dental midlines coincide with facial midline, inclination of the occlusal plane and the amount of bilateral gingival exposure.[5]

- **Frontal evaluation**
- **Functional evaluation**

- **Frontal evaluation:** (Maheshwari *et al.,* 2015); The patient should be evaluated from the frontal view. A gross evaluation of the facial proportions can be done by dividing the face into equal fifths (Farkas and Munro 1980).[5]

Evaluation of facial and dental midline: The facial midline is represented by a vertical plane passing through the nasion or glabella, perpendicular to the pupillary plane and ear plane. It allows us to compare the degree of left-to-right asymmetry and transverse facial width discrepancies of various facial structures (e.g., orbits, pupils, malar eminences, nose, commissures, and mandibular angles). Deviation of midline structures to the right or left, such as the nose, chin, or dental midline, however, is not considered to be normal. [6] The dental midline should be evaluated in the following positions: opening mouth, in centric relation, at initial contact, and in centric occlusion. True dental and skeletal asymmetry will show similar midline discrepancies in centric relation and in centric occlusion. Assessment of midline structures such as the nasal bridge, nasal tip, philtrum, and the chin point should also be carried out. Submental (worm's-eye) and superior (bird's-eye) views are very useful in assessing deviation of the abovementioned structures (figure 1a,b).

Evaluation of vertical relation (roll): description of the vertical position of the teeth when there is a difference on the right and left sides, viewing up-down deviations around the transverse axes. The cant of both the maxillary and mandibular planes should be evaluated. The patient is made to bite on a tongue blade and is assessed for parallelism with the interpupillary plane. The cant in the occlusal plane (bite on plate or tongue blade) is employed to determine how it relates to the inter-pupillary plane. A tongue blade or thin ruler can be placed between the maxillary and mandibular canines and premolars to assess the presence of a cant in relation to the papillary plane. Comparing the vertical heights from the pupillary plane to the canine tips on either side can help quantify the cant. An occlusal plane inclination of greater than 4° is said to cause significant perceptible asymmetry (Figure 1c). [7]

Evaluation of transverse relation (yaw): evaluation of dental midline in the following position: mouth open; in centric relation; at initial contact; in centric occlusion.

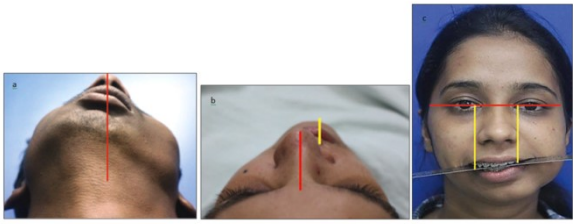

Figure 1. a, Submental (worm's-eye) view; b, Superior (bird's-eye) view; c, Occlusal cant in relation to the pupillary plane.

True asymmetry exhibits similar midline discrepancies in centric relation (CR) and centric occlusion (CO).[2]

- **Functional evaluation:** The patient is made to perform various functional movements such as the opening of the mouth, protrusive movements and the lateral movements of the mandible and any imbalance between the two sides is recorded. A note of the maximum inter-incisal opening is made along with the inter-occlusal gap. Temporomandibular joint evaluation is done to check any symptoms of clicking, popping or tenderness to rule out any temporomandibular joint dysfunction disorder. An accurate registration of the centric relation must be made. The use of diagnostic splints has been recommended by Joondeph 2000 to deprogram the muscle memory and correct recording of the centric relation.

Intraoral examination: Intraoral clinical examination should focus on assessing malocclusion, tipping of posterior and anterior teeth, crossbite and the presence of functional deviation of the mandible. Dental arch asymmetries could occur because of local factors such as early loss of a deciduous tooth or they could be associated with the rotation of the entire dental arch and its supporting skeletal base. Assessment 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 bucco-lingual angulation of the teeth. In summary, to best diagnose and treat asymmetries, the clinician should consider several guidelines:

- Thoroughly evaluate the initial history and diagnostic records.
- Always check for a functional component to the malocclusion and take the appropriate records in centric relation.
- Recognize the early signs of a progressive asymmetry.
- Understand the dentoalveolar compensations associated with the various types of asymmetries.
- Take progress records and reevaluate if there is reason to suspect that the patient has an underlying progressive asymmetry. [1]

Study models: The study models can be used to assess the presence of constricted arches and crossbites, which might be the cause of functional asymmetry in the patient. The articulated study models give a comprehensive three-dimensional view of dental relations. Bilateral symmetry can be established by using oriented occlusograms on the dental casts. Characteristic dental anomalies have been reported in the facial asymmetry group, including asymmetry of the curve of Spee, molar inclination, dental arch form, lateral overjet, and slanting of the occlusal plane (Maheshwari et al., 2015)[4]. Properly trimmed study models simulating the anatomy provide a more comprehensive three-dimensional view of dental relationships, with the added advantage of enabling the occlusion to be viewed from the lingual aspect. Mounting the dental casts in centric relation by face-bow transfer onto an adjustable anatomic articulator helps in further evaluation of the diagnosis of rotary displacement of the maxilla. However, for mounting study models with the best simulation of the patient's specific asymmetry, the SAM Occlusal Plane Indicator (OPI) provides better accuracy as compared to the conventional facebow transfer. [8]

Photographic assessment: Photographic assessment of the routine frontal-relaxed and smiling, profile view and oblique view photographs of the patient are taken. The photographs are assessed for any gross asymmetry between the two sides of the face. An asymmetry analysis by digitizing standard photographs was proposed by Edler et al.[9] in 2002. The four ratios to be measured are the area (relative size of the right and left mandibular segments), perimeter or length of outlines, compactness (shape), and moment on each side of the lower half of the face to assess the asymmetry. A dedicated photography room where extra-oral and intra-oral photographs are taken under standardized settings (e.g., lighting, background, focal length, and distance-to-subject) is ideal. Extra-oral photographs of the frontal (with and without smile, occlusal and mandibular inferior border cant), three-quarter, submental, and superior views are essential for the assessment of facial asymmetry. Intra-oral frontal, lateral, superior (45° to the occlusal plane from above), and inferior (45° to the occlusal plane from below) views with the teeth in occlusion are essential for dento-alveolar assessment.[7]

Robinson et al [10] reported that a beautiful face should be harmonious with comparable size and position of the skeletal structures and soft tissues. They stated that a favorable face can be shown by the soft tissues. Lee et al used soft tissue landmarks (Figure 2).

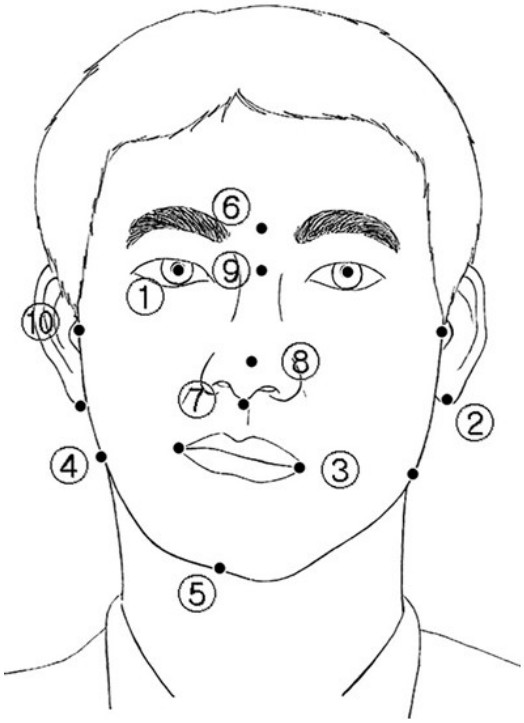

Figure 2. Landmarks on the facial soft tissues: 1, Pp (pupil); 2, O´ (otobasioninferius); 3, Ch (cheilion); 4, Go´ (soft-tissue gonion); 5, Me´ (soft-tissue menton); 6, G (glabella); 7, Sn (subnasale); 8, Pr (pronasale); 9, Na´ (soft-tissue nasion); 10, Pre (preaureculare).

Nine angular and 2 linear measurements were made. The angular measurements were eye canting, o to basion canting, lip canting, gonion canting, nose deviation, chin deviation, ramal inclination difference, body inclination difference, and gonial angle difference. Eye canting, o to basion canting, lip canting, and gonion canting were measured by using the horizontal reference line. Nose deviation, chin deviation, ramal inclination, and body inclination were measured by using the midsagittal reference line. The ramal inclination difference, body inclination difference, and gonial angle difference were measured to calculate the difference between the right and left angles. All angular measurements were used as absolute quantities.[11]

Radiographic examination: While clinical examination is an important step in diagnostic procedures for the orthodontist to assess dynamic relationships of orofacial complex, certain radiographic projections provide valuable information to differentiate between various types of transverse discrepancies. A number of radiographic projections are available for accurate identification of the location and etiopathology of transverse problems. A number of radiographic projections are available for accurate identification of the location and etiopathology of transverse problems. Changes in the form of the mandibular condyles can usually be seen on the panoramic radiograph, but it must be ensured that the patient's head is not even slightly rotated. Even so, the inherent characteristics of this projection make significant geometric distortions.

Various radiographic examination aids are:

- Orthopantomogram (OPG)
- Lateral cephalogram
- Posterior-anterior cephalogram
- Submento-vertex radiograph
- CT scans
- Cone beam CT scanning
- Single positron emission computed tomography
- 3D MRI
- Stereophotogrammetry
- Stereolithographic (SLA) models

- **Orthopantomogram (OPG):** The OPG is an excellent tool to evaluate mandibular asymmetry and dental status. The anatomy of the condyle—ramus unit, body, and inferior border of the mandible is readily discernible. Increase or decrease in dimensions or changes in mandibular morphology can be studied. In cases of unilateral asymmetry, the affected side can be compared to the normal side. The course of the inferior alveolar nerve can also be assessed and is of vital importance if an inferior border osteotomy is being performed.[7] A panoramic radiograph gives the details of the mandibular ramus and body along with the entire dentition. An analysis to calculate the asymmetry index based on the values of ramus height and the condylar height was proposed by Habets *et al.* (1988).[12] This index helps in the assessment of the morphological asymmetry between the two sides of the mandible. The limitations of an orthopantomographic analysis are that such radiographs are prone to distortion and thus might give an impression of false asymmetry between the two sides.

- **Lateral cephalogram:** It is used to assess hard tissue and soft tissue relationships in 2D, i.e., anteroposterior and vertical dimensions. This tool is less commonly used to assess facial asymmetry. The head is placed into a reproducible position within the cephalost at with the help of the nasal bridge indicator and ear roads which closely approximates the clinical Frankfort horizontal plane. The patient keep should also be instructed to keep the jaws in centric relation with the teeth lightly touching and the lips slightly parted or relaxed. The ability of the cephalostat to reproduce near about the same position every time allows for comparative cephalometric analysis and super-imposition of tracings.[5]

- **Posterior-anterior cephalogram(Craniofacial Frontal Analysis):** The PA cephalogram allows a comparative study of the symmetry between the structures of the right and left sides. Projections can be obtained in both open mouth position and centric occlusion with the head oriented in natural head position to identify the full extent of static and dynamic (functional) asymmetry. The horizontal reference plane is represented by a line passing through the bilateral zygomatico-frontal sutures. The vertical reference plane is a line perpendicular to the horizontal plane passing through crista galli. Transverse and vertical distances of various facial structures are measured by drawing perpendicular lines drawn from the structures in question to the vertical and horizontal reference planes. By comparing the distances measured bilaterally, the type and extent of the underlying asymmetry can be assessed. Additionally, a shift in the dental midlines can be assessed by

comparing them to the skeletal midline. The Grummons and Ricketts analyses are commonly used PA cephalometric analyses for the evaluation of facial asymmetry.[7]

According to Shah and Joshi [13], A Triangulation Method was suggested: The head was fixed with ear posts and the orbital indicator with the head oriented in the Frankfort horizontal plane. The distance between the transporionic axis and film was kept constant for each subject to minimize the magnification error. The central ray of X-rays passed through the center of the midsagittal plane so the magnification of the right and left sides of the face was the same. The following triangles were drawn:

- Triangle A, between the extreme superior extent of the head of the condyle, mesial extent of the head of the condyle and sella to represent the cranial base regions.
- Triangle B, by joining sella, mastoidale and the root of the zygoma to represent the lateral maxillary regions.
- Triangle C, by joining sella, anterior nasal spine and root of zygoma to represent the upper maxillary region.
- Triangle D, drawn between the root of the zygoma, molar points and the anterior nasal spine representing the right and left middle maxillary regions.
- Triangle E, by joining the anterior nasal spine, molar points and the point of intersection of a line drawn between the bilateral molar points and the midline axis representing the right and left lower maxillary regions.
- Triangle F, drawn between molar points, incisor point and the point of intersection of a line joining the molar points and the midline axis representing right and left dental regions.
- Triangle G, between the condylar point, gonion and menton to represent the mandibular region.

The triangulation method, despite some limitations, is a valuable and conventional diagnostic procedure for the analysis of overall facial asymmetry in terms of its components. It represents the face in various regions, cranial base, maxillary, mandibular, and dentoalveolar. Symmetry or asymmetry of the face can be correlated in terms of its component areas.

- **Submento-vertex radiograph:** The coordinates of the submental radiographic view were proposed by Ritucci and Burstone. The analysis of a submento-vertex radiograph was suggested by Forsberg et al. (1984). This analysis helps an investigator in the calculation of asymmetry on the cranial base, zygomatic complex and mandible. A submental vertex film, which adds an additional dimension, can be added to the radiographic examination. This is most useful when the mandibular ramus is severely deformed as well as the zygoma and zygomatic arches. It is possible to combine information from lateral, PA, and submental vertex films to allow a three-dimensional reconstruction of the mandibular ramus and with less accuracy, parts of the maxilla.[1]

- **CT scans:** Facial asymmetry is a relatively common feature in patients with craniofacial deformities. Traditionally, lateral and coronal (frontal) cephalometric radiographs have been the primary radiographic methods to analyze the morphology of the craniofacial bones. However, with these images it is difficult and sometimes impossible to evaluate facial asymmetry 3-dimensionally because of the many overlapping anatomical structures.[14] CT scans both in 2-dimensional and 3-dimensionalviews 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.

- **Cone beam CT scanning:** Three-dimensional CT scans are excellent in assessing the facial asymmetry and in developing a treatment plan. The three-dimensional radiography Cone beam computed tomography (CBCT) images can be used to localize the exact position of the skeletal asymmetry. CBCT images have been measured for the following parameters to localize facial asymmetry:

Various parameters include

- Arbitrary horizontal reference plane assuming orbits are normal (black);
- FH plane (purple);
- mandibular height [canine to mandibular plane (orange)];
- maxillary height (first molar to FH) (red);
- ramal length (Co superior to Go inferior) (green);
- occlusal plane (yellow);
- lateral ramal inclination (Co superior to Go posterior to FH) (brown);
- midsagittal plane (light blue) (Figure 3a.b)

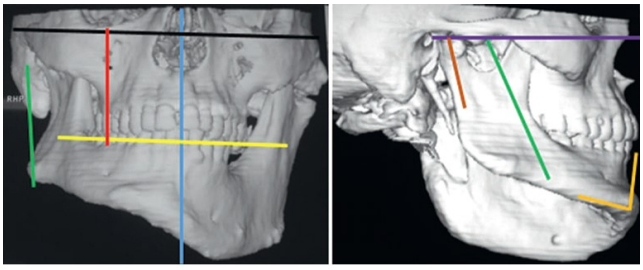

Figure 3 a, b. 3D-CT face analysis for assessing the facial asymmetry

- **Single positron emission computed tomography:** Single positron emission computed tomography is an essential diagnostic tool for visualizing hyperactivity in condyle. The radioactive isotope technetium 99 methylene bisphosphonate is injected into the patient and evaluated on a computed tomogram for signs of increased unilateral condylar activity in the form of hot spots. The difference in activity of 10% or more between the two condyles is indicative of condylar hyperplasia.

- **3D MRI:** Three dimensional MRI is an excellent tool in assessing soft tissue deformities.Technetium-99 is a radioactive isotope that localizes in areas of greatest bone turnover. Technetium-99 bone scans are frequently used to determine the condylar growth activity in progressive asymmetry. After injecting the isotope intravenously the radiation emission is assessed using a gamma counter. If the activity is pronounced in one joint, condylar resection or high condylectomy is warranted.

- **Stereophotogrammetry:** Three-dimensional photographic imaging can act as an aid in evaluating the degree of asymmetry between the two sides of the face. Stereophotogrammetry uses two or more cameras, configured as a stereo pair to generate a three-dimensional image of the face. This provides a useful three-dimensional assessment of facial soft tissue asymmetry before and after orthognathic surgery. The images can be used for comparison and quantitative measurement. Stereophotogrammetry 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. 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. The soft tissue images captured from 3-dimensional photogrammetry are comparable to those obtained from traditional cephalogrammetry.[4]

- **Stereolithographic (SLA) models:** Medical modeling involves first acquiring a CT, CBCT, or MRI. This data consists of a series of cross-sectional images of the region being studied. The selected part is now created in a layer-by-layer fashion using photopolymerization ultimately forming a three-dimensional solid. The use of such models in maxillofacial surgery has significantly improved the predictability of clinical outcomes in facial asymmetry cases when compared to similar treatments without its use. The models facilitate direct visualization of complex 3D facial asymmetry, decrease operating time due to better treatment planning, and can also be used as an educational tool for patients.[7]

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