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*Research Article*

# Unmasking Facial Asymmetry: A Clinical Perspective

**Dr. Antra Negi[1*], Dr. P Narayana Prasad[2], Dr. Tarun Kumar[3], Dr. Manika Singhal[4], Dr. Neelesh Kumar Srivastava[5], Dr. Pranshu Tomer[6]**

*[1*]Department Of Orthodontics and Dentofacial Orthopaedics, Seema Dental College and Hospital, Rishikesh*
*[2]Department of Orthodontics and Dentofacial Orthopaedics, Seema Dental College and Hospital, Rishikesh*
*[3]Department of Orthodontics Faculty of Dental Sciences SGT University Gurugram Haryana*
*[4]Department Of Orthodontics and Dentofacial Orthopaedics, Seema Dental College and Hospital, Rishikesh*
*[5]Department Of Orthodontics and Dentofacial Orthopaedics, Seema Dental College and Hospital, Rishikesh*
*[6]Department Of Orthodontics and Dentofacial Orthopaedics, Seema dental college and hospital Rishikesh*

**ABSTRACT**
Faces are the focus of attention during all human interactions. Evolutionary biologists propose that a preference for symmetry is an indication of health and genetic quality, making it a key factor in facial attractiveness. Clinically, symmetry implies balance, while significant asymmetry indicates imbalance. In facial morphology, symmetry refers to the correspondence in the size, shape, and arrangement of facial features on opposite sides of the median sagittal plane. Soft tissues, bones, and teeth contribute to symmetry, while asymmetry denotes disturbances among these components, altering structural balance. In orthodontics, accurate localization and quantification of facial asymmetry are crucial for diagnosis and establishing treatment goals, especially when severe asymmetries are combined with other skeletal deformities requiring surgical intervention.

**KEYWORDS:** facial asymmetry, clinical diagnosis, symmetry

**Author for correspondence: Email: negiant09@gmail.com*

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## INTRODUCTION

Facial asymmetry can be described as differences in size or relationship between the two sides of the face. The term "symmetry" derives from the Greek words "syn" (together) and "metron" (meter), meaning that both sides of the face, right and left, are alike.[2] Severt and Proffit note that the frequencies of facial laterality are 5%, 36%, and 74% in the upper, middle, and lower thirds of the face, respectively. Minor facial asymmetry is common even in normal-appearing individuals, with the left side often being larger than the right.[4] Historically, facial symmetry has been associated with attractiveness, and severe asymmetry can have psychosocial impacts.[5]

## HISTORY

Facial aesthetics and its importance in orthodontics can be traced back to classical art. Egyptian artists from the Old Kingdom dynasties (2600 to 2000 BC) used a simplified grid system to draw figures with ideal proportions (fig.1) .This ancient method is considered an early precursor to the proportional mesh diagram, defined by Moorrees, used in modern cephalometric analysis.[28]

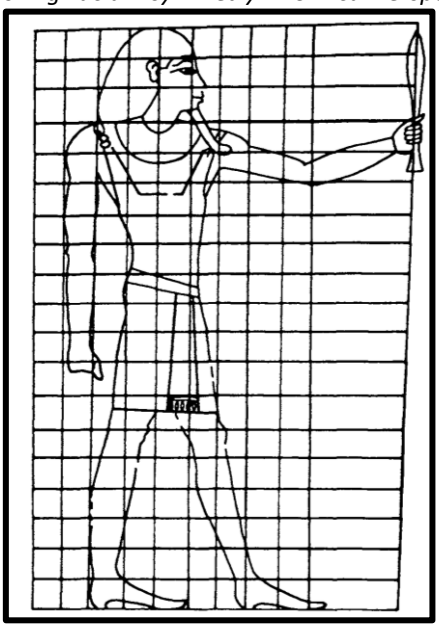

**Figure no. 1 Square grid**

## ETIOLOGY

Facial asymmetries can arise from congenital, developmental, or acquired conditions, affecting hard or soft facial, maxillofacial, and oral tissues. Acquired asymmetries result from postnatal pathologies or trauma in previously normal individuals. These can be triggered by significant physical, psychological, or psychosocial distress during formative years. Thorough assessment and management are essential to prevent severe functional and aesthetic complications. Classifications of the asymmetries are ever evolving and are summarised in the Table no. 1.

**Table no. 1 Adapted from Iyer J, Hariharan A, Cao UM, Tran SD. Acquired facial, maxillofacial, and oral asymmetries—a review highlighting diagnosis and management Symmetry[96]**

| Author | Based on | Details |
|---|---|---|
| **Plint (1974)** | **Etiology** | ➢ **Laterocclusion :**<br>• **Apparent asymmetry due to occlusal disharmony**<br>➢ **Laterognathism :**<br>• **True facial asymmetry** |
| **Obwegeser and Makek (1986)(Mandible only)** | **Morphology** | ➢ **Hemi-mandibular elongation**<br>➢ **Hemimandibular hyperplasia**<br>➢ **Combined/hybrid forms** |
| **Bishara (1994)** | ➢ **Involved structures** | ➢ **Dental**<br>• **Congenitally missing tooth or teeth**<br>• **Premature loss of deciduous teeth**<br>• **Deleterious oral habits such as digit sucking resulting in asymmetric open bite**<br>• **Midline discrepancies**<br>• **Occlusal discrepancies in first-, second-, or third-order plane**<br>➢ **Skeletal**<br>• **Involving maxilla**<br>• **Involving mandible**<br>• **Involving number of skeletal structures on one side of face, as in Hemifacial microsomia and Treacher Collins syndrome**<br>➢ **Muscular**<br>• **Hemifacial microsomia**<br>• **Mobius syndrome**<br>• **Cerebral palsy**<br>• **Unilateral masseter or temporal muscle hypertrophy**<br>• **Long-term untreated cases of torticollis causing fifibrosis of the sternocleidomastoid muscle**<br>➢ **Functional**<br>• **Centric prematurities causing a lateral mandibular displacement of full closure from initial tooth contact position to habitual occlusal position** |

| | | |
|---|---|---|
| | | • **Presence of malpositioned tooth, dental crossbite, constricted maxillary arch, or anteriorly displaced articular disc usually results in functional deviations.**<br>➢ **Combination** |
| **Cohen (1995)** | **Morphology** | ➢ **Hemi-hyperplasia (hemifacial hypertrophy)**<br>➢ **Hemi-hypoplasia (hemifacial microsomia)**<br>➢ **Hemi-atrophy (Parry Romberg syndrome)**<br>➢ **Miscellaneous entities (hemi-maxillofacial dysplasia)** |
| **Chia (2008)** | **Etiology** | ➢ **Pathological**<br>➢ **Functional**<br>➢ **Traumatic**<br>➢ **Developmental** |
| **Haraguchi (2008)** | **Etiology** | ➢ **Hereditary factors of pre-natal origin**<br>➢ **Acquired factors of post-natal origin** |
| **Wolford (2009)** | **Etiology** | ➢ **Pseudo-asymmetry**<br>➢ **Occlusal interferences**<br>➢ **Neuromuscular dysfunction**<br>➢ **Habitual posturing**<br>➢ **Condylar dislocation**<br>➢ **Temporary unilateral facial swelling due to trauma/infection**<br>➢ **Normal facial asymmetry (non-pathologic)**<br>➢ **Genetics**<br>➢ **Intrauterine moulding**<br>➢ **Natural growth variance**<br>➢ **Unilateral overdevelopment**<br>➢ **Condylar hyperplasia/mandibular**<br>➢ **hyperplasia/deviant prognathism**<br>➢ **Osteochondroma/osteoma**<br>➢ **Unilateral muscle hyperplasia (masseteric muscle hypertrophy)**<br>➢ **Other benign/malignant tumors**<br>➢ **Neuromuscular disorders (facial nerve trauma, Bell's palsy, Ramsey-Hunt syndrome,**<br>➢ **Mobius syndrome, mastoid infections, and cerebral vascular accidents affecting the**<br>➢ **facial nerve)**<br>➢ **Unilateral underdevelopment**<br>➢ **Acquired: trauma, infection, TMJ ankylosis, and iatrogenicities (due to tumor resection,**<br>➢ **radiation, unstable orthognathic procedures and adverse surgical events), failed TMJ**<br>➢ **alloplastic implants, and failed autogenous tissue grafts**<br>➢ **Congenital deformities (unilateral cleft lip and palate, hemifacial microsomia, and Treacher Collins syndrome)**<br>➢ **Unilateral adolescent idiopathic condylar resorption**<br>➢ **Unilateral TMJ reactive (inflammatory) arthritis**<br>➢ **Connective tissue and autoimmune diseases (juvenile rheumatoid arthritis, ankylosing spondylitis, mixed connective tissue disease, etc)** |
| **Reyeneke (2010)** | **Etiology** | ➢ **Congenital**<br>➢ **Developmental**<br>➢ **Post-traumatic**<br>➢ **Pathology-related** |
| **Cheong (2012)** | **Etiology** | ➢ **Congenital factors (pre-natal origin)**<br>➢ **Acquired factors (injury or disease)**<br>➢ **Developmental factors**<br>➢ **Unknown origin** |
| **Waite (2012)** | **Etiology** | ➢ **Congenital**<br>➢ **Malformation**<br>➢ **Deformities**<br>➢ **Disruptions**<br>➢ **Developmental**<br>➢ **Primary growth deformities**<br>➢ **Secondary growth deformities**<br>➢ **Acquired**<br>➢ **Trauma**<br>➢ **Pathology**<br>➢ **Idiopathic** |

Another classification by J.P. Reyneke, P. Tsakiris, and F. Kienle classifies maxillomandibular asymmetry into four types, focusing on three major anatomical areas: the maxilla, dental midline, and mandible, with recommended surgical treatments for each type. (Fig no. 2) (Table no. 2)

Type I: that caused by asymmetry of the symphysis of the mandible. The maxilla and the body of the mandible are symmetric with the dental midlines in the center of the face.

Type II: where the discrepancy is primarily in the mandible's body, ramus, or condyle .The maxillary dental midline coincides with the facial midline and the mandibular dental midline coincides with the symphysial midline.

Type III: where the maxillary midline is still coincident with the facial midline but the mandibular midline is asymmetric to the maxillary midline and the symphysis is still more asymmetric to the mandible.

Type IV: Where the discrepancy involves the maxilla, mandible, and symphysis and the maxillary midline is asymmetric to the facial midline. In contrast, the body of the mandible to the maxillary midline is further asymmetric (mandibular midline is asymmetric), and the mandibular symphysis is asymmetric to the body of the mandible.

Subtypes Ic, IIc, IIIc, and IVc indicate that an occlusal cant discrepancy has been superimposed on types I, II, III, and IV.

Type C: depicts facial asymmetry caused by a cant in the occlusal plane while the maxillary and mandibular dental midlines and symphysis coincide.[30]

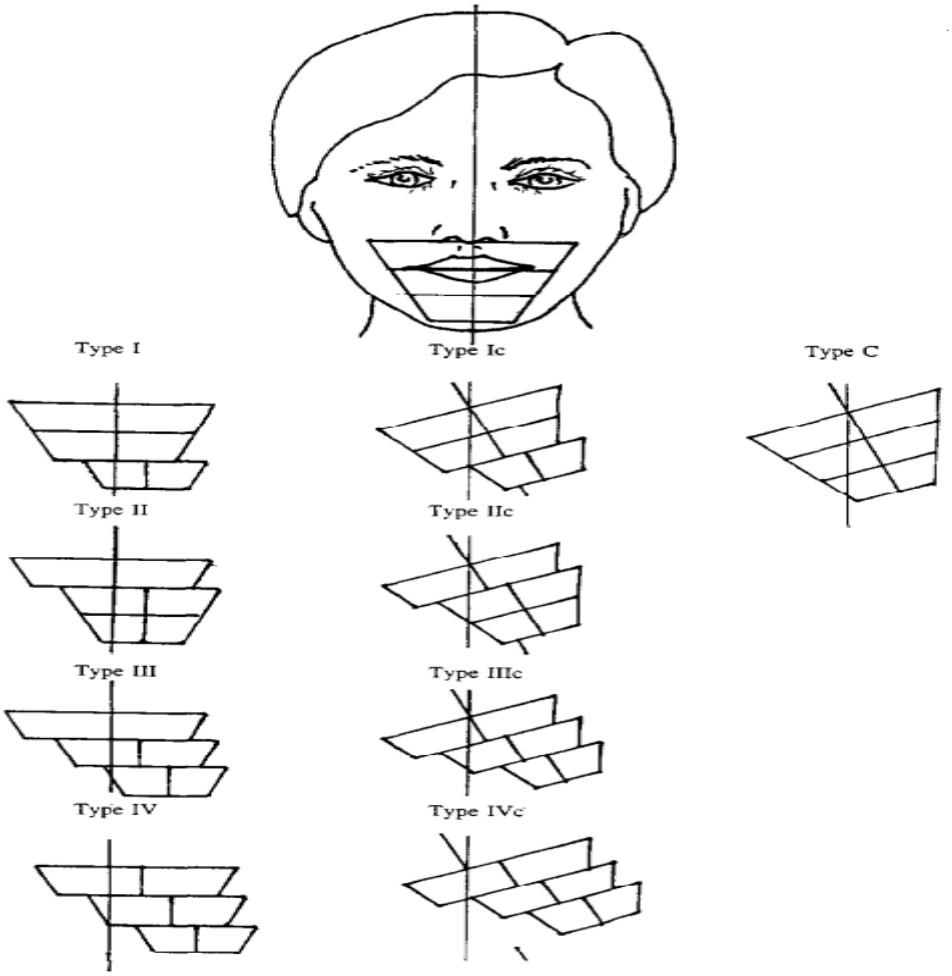


**Figure no. 2. Diagram showing the classification of maxillomandibular asymmetry according to the three levels of anatomical discrepancy. The interrupted vertical line represents the frontal facial midline and the interrupted horizontal line the occlusal cant. The midline shifts could be either to the right or left.**

**Table no. 2 : Plan of surgical treatment according to proposed classification of facial asymmetry**

| Type of asymmetry | Genioplasty | Mandibular surgery | Maxillary surgery |
|---|---|---|---|
| I | Yes | - | - |
| II | - | Yes | - |
| III | Yes | Yes | - |
| IV | Yes | Yes | Yes |
| Ic | Yes | Yes | Yes |
| IIC | - | Yes | Yes |
| IIIC | Yes | Yes | Yes |
| IVC | Yes | Yes | Yes |
| C | - | Yes | Yes |

**DIAGNOSIS OF FACIAL ASYMMETRIES**

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.[3]

**MEDICAL AND DENTAL HISTORY**

By evaluating the patient's chief complaint, medical, and dental history clinicians can identify the precise cause of asymmetry. Childhood traumas, craniofacial infections, and dental history, including abnormal eruption or premature tooth loss, should also be considered.[85]

**CLINICAL EXAMINATION**

Clinical examination can reveal asymmetry in **vertical, antero-posterior, or transverse directions.** This assessment is crucial and should be conducted systematically, with the patient seated comfortably, in natural head posture, teeth in centric occlusion, and lips relaxed.[61]

**EXTRAORAL AND INTRAORAL EXAMINATION**

Systematic Facial Symmetry Examination can be done by following the given series of measurement:

**Nasal Tip to Midsagittal Plane:** Assess midline landmarks (nasal bridge, nasal tip, filtrum, chin point) and dental midline (upper and lower incisor midlines). Visualize the nasal tip with the patient's head slightly elevated. 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 can complicate dental midline placement and may result from birth trauma, injury, or rhinoplasty.[3]

**Maxillary Dental Midline to Midsagittal Plane:** Visualize with the patient's head slightly elevated. Check for unilateral missing teeth or maxillary rotation in case of deviation.[3]

**Maxillary Dental Midline to Mandibular Dental Midline**: Evaluate dental midlines with the mouth open, in centric relation, at initial contact, and in centric occlusion.

**Mandibular Dental Midline to Midsymphysis:** Stand behind the patient and view the lower arch from above with the mouth open to assess the midline's relation to the mandible and symphysis.[3]

**Midsymphysis to Midsagittal Plane:** Use a submental view with the patient's head elevated to visualize the midsymphysis' relation to the midsagittal plane, noting any deviations due to functional shifts or true mandibular asymmetry. If dental and skeletal midlines and vertical relations of the maxilla are normal, but lower facial asymmetry is noted, the asymmetry may be isolated to the chin. Measure the midsymphysis to the midsagittal plane and parasymphyseal heights to assess chin asymmetry.[3]

**Vertical Occlusal Evaluation:** Detect a canted occlusal plane due to unilateral differences in the vertical length of the condyle, ramus, maxilla, or temporal bone by having the patient bite on a tongue blade and observing its relation to the interpupillary plane(Fig 3).

**1.** [3]

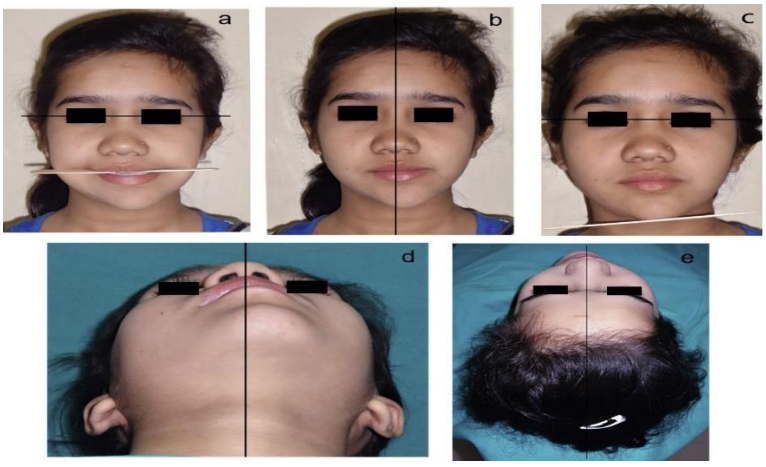


**Figure no.3. (a) Frontal view photograph showing assessment of cant of occlusal plane in relation to interpupillary plane. (b) true facial midline for documenting facial asymmetry with deviation of mandible toward left side.(c) cant of lower border of mandible. (d) Submental view photograph documenting mandibular asymmetry. (e) Superior (Bird's eye) view photograph.**

**Transverse and Anteroposterior Occlusal Evaluations:** Diagnose asymmetry in the bucco-lingual and mesio-distal relationships to determine if it is skeletal, dental, or functional. Examine maxillary and mandibular arch shapes for side-to-side asymmetries and buccolingual angulation differences. Arch asymmetry may result from maxillary or mandibular rotation, requiring further evaluation with dental casts on an anatomic articulator.

**Maxillo-mandibular Asymmetry** - Transverse Cant of the Maxilla: Mandibular asymmetry often causes maxillary compensation, reflected by a transverse cant of the maxilla. Measure this cant at the canine by gingival display or canine show on smile. Use a tongue blade or Fox plane against the maxillary occlusal plane to visualize the transverse cant.

**Transverse Facial, Skeletal, and Soft Tissue Evaluation:**

**Facial Form:** Assess facial harmony by the height-to-width proportion (1.3:1 for females, 1.35:1 for males). The bigonial

width should be about 30% less than the bizygomatic width. The chin should harmonize with the overall facial contour, forming a smooth line with the mandible's lower border. Females typically have smaller, oval chins, while males have larger, square chins.(fig 4 and 5)

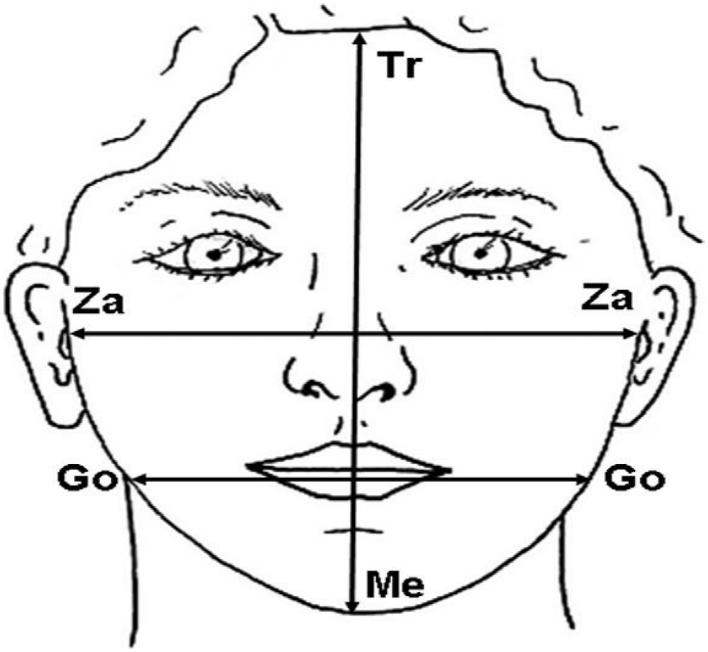


**Figure no. 4. The relationship of the height of the face (Tr-Me) to the width (Za-Za) should be 1.3:1 for females and 1.35 for males. The bigonial (Go-Go) width should be approximately 30% less than the bizygomatic (Za-Za) width.**


**Figure no. 5. Frontal view photographs illustrating facial asymmetry due to (a) deviate prognathism type. (b) hemimandibular hyperplasia type. (c) left TMJ ankyloses.(d) right sided hemifacial microsomia. (e) left side masseteric hypertrophy**

**Transverse Facial Dimensions:** Properly oriented photos help determine vertical and transverse asymmetry. The face is divided into 5 equal parts using the "rule of fifths," each part approximately the width of an eye.(fig 6)

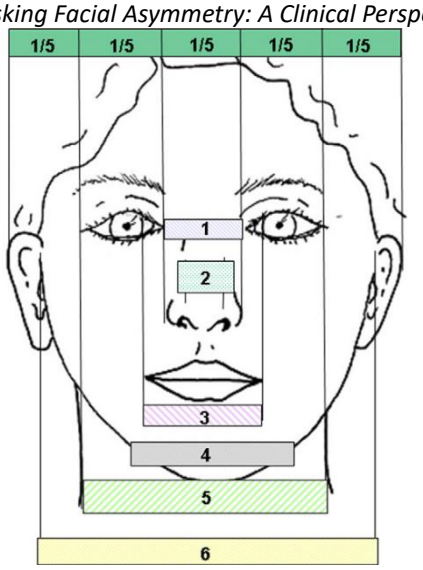


**Figure no. 6 Transverse facial proportions and facial form.The intercanthal width should be equal to the alar base width (1), the width of the nasal dorsum should be approximately half the alar base width (2), the width of the medial irides of the eyes should coincide with the corners of the mouth (3), the width and shape of the chin should be in harmony with the rest of the face (4), the Gonion should fall on a line drawn through the outer canthus of the eye (5), and the bigonial width is usually 30% less than the bizygomatic width (6)**

**Vertical Evaluation** (fig 7):

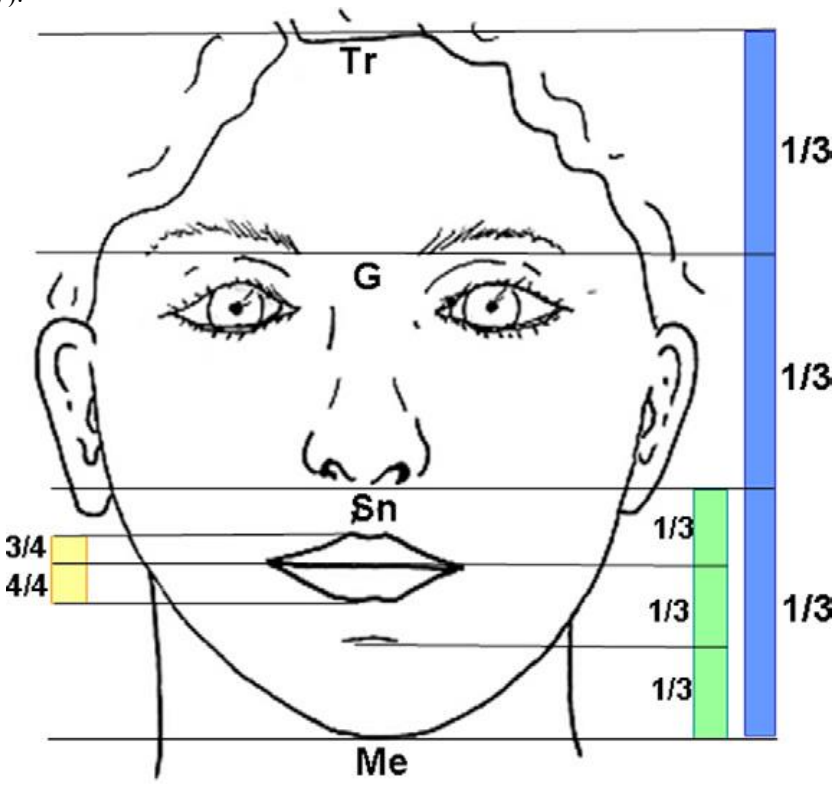


**Figure no. 7 Vertical relations. The face can be divided into 3 parts from trichion to menton. The upper third from trichion (Tr) to glabella (G), the middle third from glabella (G) to subnasale (Sn), and the lower third from subnasale (Sn) to menton (Me). The lower third can further be divided into an upper third, the upper lip, which from subnasale (Sn) extends to upper-lip vermillion, and a lower two-thirds, which extends from the lower-lip vermillion to menton (Me). The labiomental fold will divide the lower-lip/chin area into equal parts. The vermillion of the lower lip is usually about 25% larger than the upper-lip vermillion.**

**Upper Third:** Deformities may indicate craniofacial syndromes.
**Middle Third:** Orthodontics and orthognathic surgery can influence this area. The cheekbone–nasal base–upper lip–lower lip contour should form a smooth curve.(fig 8)


**Figure no. 8 The cheekbone–nasal base– upper lip–lower lip curve contour line from the frontal view. (A) The contour line is interrupted (arrow) in the nasal base area, indicating maxillary anteroposterior deficiency. (B) The improvement in the continuity of the contour of the patient in (A) is evident after maxillary advancement. The contour line forms a smooth continuous contour without interruptions. (C) There is a double break in the contour line in this patient. The interruption of the line in the nasal base area (top arrow) indicates maxillary anteroposterior deficiency, and in the lower-lip area, the interruption of the line (bottom arrow) is ahead of the curve, indicating mandibular anteroposterior excess.**

**Lower Third:** The vertical height ratio to the middle third should be 5:6.
Arnett and Bergman suggest the thirds should be 55-65 mm in height.

Another classification known as The Ferretti–Reyneke analysis divides the face into 5 zones of influence, modified by orthodontics and surgery (fig no.9).

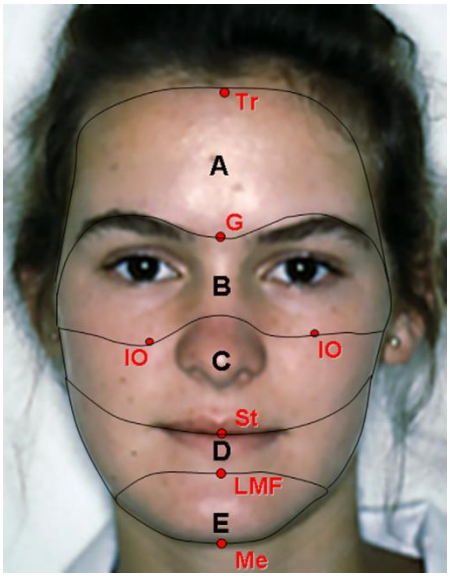


**Figure no. 9 : The Ferretti–Reyneke analysis divides the face into 5 zones to facilitate a systematic clinical evaluation in relation to treatment effects. (A) The forehead zone extends from trichion (Tr) to glabella (G). (B) The oculonasal zone extends from glabella (G) to nasal dorsum and inferior orbital foramen. (C) The maxillary gnathic zone extends from inferior orbital foramen to stomion (St). (D) The mandibular gnathic zone extends from stomion (St) to the lower border of the mandible. (E) The genial zone extends from labiomental fold (LMF) to menton (M).**

While clinical evaluations are crucial, additional diagnostic records like dental casts, face bow transfers, and imaging techniques may be needed to accurately localize asymmetries.

## RADIOGRAPHIC EXAMINATION

Several projections are available to identify the location and cause of asymmetry:
**Lateral Cephalometric Radiograph:** Limited for diagnosing asymmetries in ramal height, mandibular length, and gonial angle due to superimposition of right and left structures and differing distances from the film and x-ray source.
**Posteroanterior (PA) Projection:** Useful for studying right and left structures at equal distances from the film and x-ray source. Grummons and Kappeyne's (1887) method offers comprehensive and summary frontal asymmetry analyses.(fig no 10 and 11) Grayson et al.'s multiplane cephalometry technique analyzes PA and basilar cephalograms at various depths.

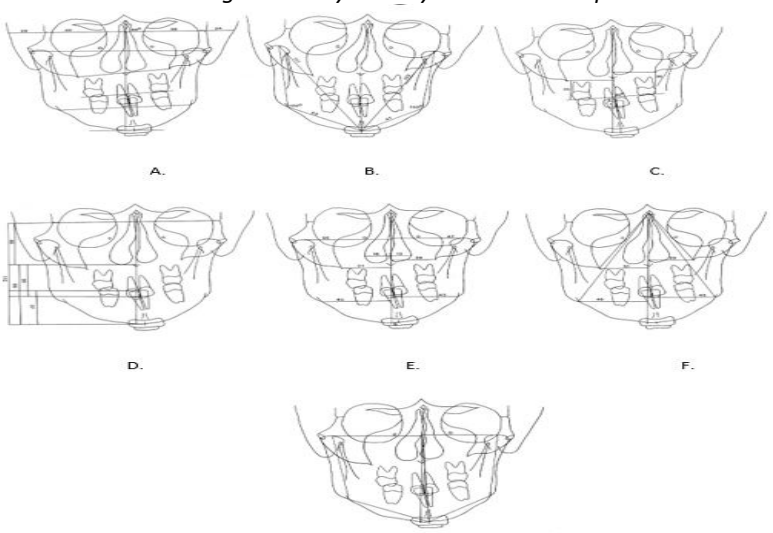


**Figure no. 10: Components of comprehensive frontal asymmetry analysis A. Horizontal planes B. Mandibular morphology C. Maxillo-mandibular relation D. Frontal vertical proportions E. Linear asymmetries F. Maxillo-mandibular comparison of asymmetry G. Volumetric comparison.**

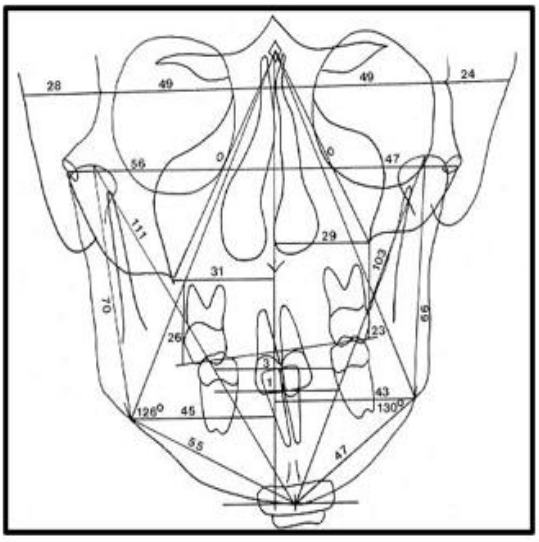


**Figure no. 11 Grummon's summary frontal asymmetry analysis**

**Submental Vertical Radiographs:** Another imaging technique for assessing asymmetry.

**Orthopantomograph (OPG):** Provides a panoramic view of the oral cavity, useful for diagnosing mandibular asymmetries and evaluating dental compensations, condylar hyperplasia, hemimandibular hypertrophy, and hemimandibular elongation (fig 12and 13).[57]

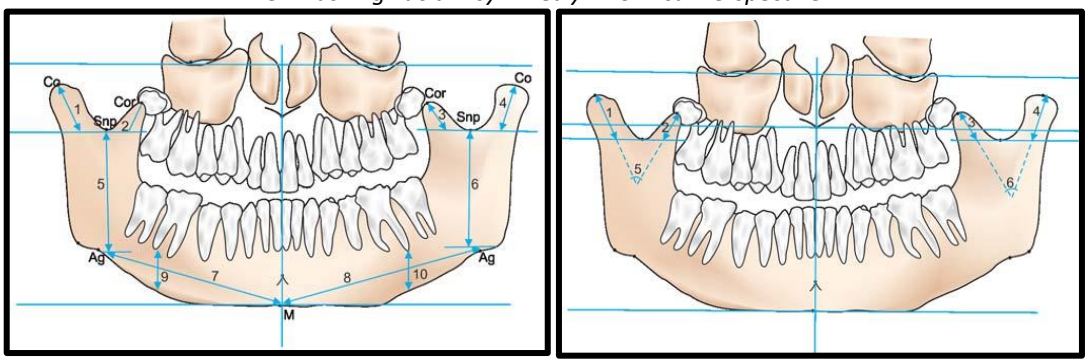


**Figure no. 12. OPG tracing showing linear and angular measurements of condyle and coronoid process**

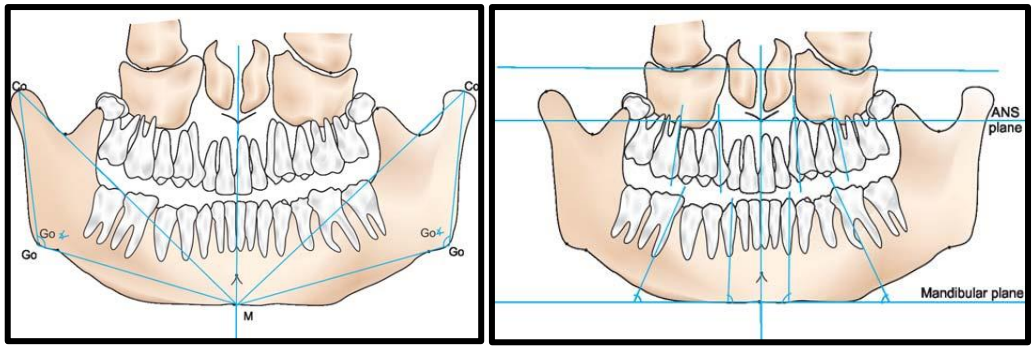


**Figure no. 13 Comparing right and left linear measurements and dentoalveolar angulations.**

**Three-Dimensional Techniques:** Clinicians use cone-beam computed tomography (CBCT) for 3D radiographic evaluation of asymmetry, creating three-dimensional virtual models. Non-radiographic 3D techniques include stereophotogrammetry, laser scanners, 3D optical sensors, and contact digitalization. Stereophotogrammetry reconstructs facial soft tissues using triangulation of images taken from different positions. CBCT is the principal 3D radiographic technique, allowing detailed visualization of hard and soft tissues and producing orthopanoramic-like and cephalogram-like images. It identifies craniofacial disproportions and evaluates asymmetry causes, including developmental abnormalities and modifications from external forces like orthodontics.[88]

**Table no. 3 Methods and their characteristics to quantify the asymmetry by two-dimensional techniques.**

| Two-Dimensional Techniques to Diagnose Facial Asymmetry | | | |
|---|---|---|---|
| **Types of Techniques** | **OPG** | **PA Cephalogram** | **Digital Photography** |
| **Advantages** | Panoramic vision of teeth and jaws; low dose of radiation. | First level exam in the diagnosis of facial asymmetry; low dose of radiation. | Useful for soft-tissue asymmetry analysis |
| **Disadvantages** | Distortion; magnification; diagnosis limited to condyle and mandibular ramus asymmetries; 2D vision of 3D structures. | Distortion; magnification; superimposition of anatomical structures; 2D vision of 3D structures. | 2D vision of 3D structures |
| **Methods to quantify the asymmetry** | Calculation of an asymmetry index; comparison between bilateral distances. | Calculation of an asymmetry index; comparison between bilateral distances and areas; performing of a cephalometric analysis; evaluation of the coincidence between two lines. | Calculation of an asymmetry index; comparison between bilateral distance,angles and areas; calculation of EDMA*; ratings of similarity between mirrored faces |

**Table 4. Methods and their characteristics to quantify the asymmetry by three-dimensional techniques.**

| Three-Dimensional Techniques to Diagnose Facial Asymmetry | | | | | |
|---|---|---|---|---|---|
| **Types of Techniques** | **CB-CT** | **Stereophotogrammetry** | **Laser Scanning** | **3D Optical Sensors (Computer-Aided Structured Light)** | **Contact Digitalization** |
| **Advantages** | 3D vision of structures; lack of superimposition; measurements accuracy. | Realistic and accurate rendering of the face surface easy to set up. | High resolution; medium photorealistic quality; acquisition of contour, topology and surface data; existence of low-cost scanner. | Photorealistic rendering of the face surface; very rapid capture. | Non-invasive. |
| **Disadvantages** | More expensive and higher dose of radiation than 2D radiographic methods; artefacts. | Initial training; suitable and expensive equipment; inaccurate rendering of some parts (like hairs); magnification errors; tedious work to map surfaces. | Remarkable duration (need of patient stillness); initial training; suitable equipment. | Variable resolution quality; sensitive to the technique. | Initial training; remarkable duration; suitable equipment; face recreation through points that outline the surface. |
| **Methods to quantify asymmetry** | Calculation of an asymmetry index; comparison between bilateral distances, angles and volumes; creation of a color-coded distance map; determination of the plane of symmetry; performing of a 3D cephalometric analysis. | Creation of a color-coded distance map; calculation of an asymmetry index; comparison between bilateral distances; comparison between the patient's original configuration and the symmetrical one. | Creation of a color-coded distance map; comparison between bilateral distances, angles, areas, volumes and contours; calculation of an asymmetry index or an asymmetry vector. | Determination of the plane of symmetry; comparison between bilateral distances, angles and volumes; creation of a color-coded distance map; calculation of an asymmetry index. | Calculation of an asymmetry index; comparison between bilateral distances and angles |

## CONCLUSION

Clinical examination is the initial step in diagnosing facial asymmetry, assessing sagittal, coronal, and vertical aspects through extra-oral and intra-oral evaluations. PA cephalogram quantifies asymmetry at a basic level, while OPG detects mandibular and/or condylar asymmetry. Digital photography enhances clinical evaluation accuracy.

Advanced 3D techniques like CBCT, stereophotogrammetry, laser scanning, 3D optical sensors, and contact digitization constitute the second-level examination. Comparing bilateral parameters and calculating asymmetry indices, especially with CBCT, is recommended. A color-coded distance map, requiring no reference points, is the most accurate method for stereophotogrammetry, laser scanning, and 3D optical sensors.

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