Review of literature

1.1 Dental midline and facial midline

The facial midline and dental midline play an important role in facial esthetics, cosmetic dentistry, facial plastic surgery, and anthropologic studies **(Bhuvaneswaran, 2010; Chen et al., 1992).**

1.1.1 The dental midline

is an imaginary vertical line that runs between the two upper and lower front teeth **(central incisors)**.

- Ideally, this line should align with the center of the face, creating a symmetrical and aesthetically pleasing smile.
- Proper alignment of the dental midline is crucial for both functional and cosmetic reasons.

This condition can cause esthetic concerns and functional problems, impacting your child's self-esteem and oral health **(Redford and Burke, 2024).**

1.1.2 The facial midline

which divides the face into a right half and left half, was taken as the line passing the glabella, nose tip, the midpoint of the philtrum, and middle of the chin **(Daskalogiannakis, 2000).**

Various facial landmarks in the middle third of the face, such as the midpoint between the pupils, the nasion point, the tip of the nose, the philtrum tip, and the chin, are used to determine the facial and dental midlines. Some studies prefer the use of intraoral points such as the incisive papilla to determine the maxillary dental midline. The alignment of the dental midline with either the facial midline or the mouth midline has been debated in other studies **(Farahani et al., 2019).**

Facial and dental midlines can be located and examined clinically in patients or in 2D photographs **(Jayalakshmi et al., 2013; Miller et al., 1979).** Fig. 1: Evaluation

of the perfect or accepted coincidence **(deviation to either side of up to 2 mm)** between the dental and facial midline **(Cardash et al., 2003; Jayalakshmi et al., 2013; Parrini et al., 2016).**

***(*Figure 1)** Evaluation of the perfect or accepted coincidence **(deviation to either side of up to 2 mm)** between the dental and facial midline **(Cardash et al., 2003; Jayalakshmi et al., 2013; Parrini et al., 2016).**

Dental midline shifting is evaluated by comparing the positions of the maxillary and mandibular dental midlines to the face midline, with the philtrum serving as a reference point.

In many previous studies, the philtrum or vermilion border was used to provide facial form, and due to its results and its position, it could be a reliable landmark for midline analysis **(Beyer and Lindauer, 1998; Cardash et al., 2003; Johnston et al., 1999; Latta, 1988; Miller et al., 1979).**

However, in a pleasant smile, almost all maxillary teeth are displayed, and coordination of the maxillary central incisors' midline with the facial midline is more important than the mandibular incisors.

Nevertheless, coordination of the upper and lower arch dental midlines is necessary to achieve beauty and a proper occlusion, and in addition, it can increase the duration and complexity of orthodontic treatment cases **(Bishara et al., 1994).**

Dental midline deviations greater than 2 mm are typically regarded as a cause for concern because they are more noticeable and less likely to enhance facial attractiveness than shifts between 1 and 2 mm or less **(Cardash et al., 2003; Kharbanda, 2019).**

1.2 Prevalence of midline deviations

Dental midline deviation was more common in patients with Class I **(73.6%)** and Class II, Division 1 **(13%)** malocclusions than in those with Class III malocclusions **(10.5%)**. Similarly, **Anistoroaei *et al.* (Miller et al., 1979)** found that dental midline deviation was most common in patients with Class I **(11.20%)** and Class II, Division 1 **(6.25%)** malocclusions. Another study found that dental midline deviations occurred in 26.28% of patients with Class I malocclusion, 18.18% with Class II malocclusion, and 4.94% with Class III malocclusion **(Khan and Kazmi, 2019)**. These findings are consistent with ours. The findings underscore that discrepancies between the maxillary/mandibular dental midline and the mandibular dental midline deviation from the facial midline were more prevalent than maxillary midline deviation from the facial midline **(Qurban et al., 2024).**

The deviation of the dental midline changed with age; the prevalence of midline deviation increased after age 12 years with statistically significant correlations. This may be related to the fact that after the age of 12 years, dental anomalies of the number, shape, dental size, position, dental crowding, spacing, and the

consequences of premature loss of primary teeth cause the establishment of deviation of the maxillary and mandibular dental midlines **(Anistoroaei et al., 2018). Jain *et al.*** observed that 77.0% of patients exhibited midline deviations during routine clinical examination, of which 21% affected the maxillary arch and 43% affected the mandibular arch, nearly double the frequency of the maxillary arch.

a study that found midline deviation in 12.2% of females and 8.3% of males **(Anistoroaei et al., 2018).**

1.3 Evaluation of dental midline

Dental midline shifting is evaluated by comparing the positions of the maxillary and mandibular dental midlines to the face midline, with the philtrum serving as a reference point. In many previous studies, the philtrum or vermilion border was used to provide facial form, and due to its results and its position, it could be a reliable landmark for midline analysis **(Beyer and Lindauer, 1998; Cardash et al., 2003; Johnston et al., 1999; Latta, 1988; Miller et al., 1979).**

Dental midline deviations greater than 2 mm are typically regarded as a cause for concern because they are more noticeable and less likely to enhance facial attractiveness than shifts between 1 and 2 mm or less **(Cardash et al., 2003; Kharbanda, 2019).**

Historically various numbers of facial landmarks present in the middle third of the face, such as the bisector of the pupil, nasion, tip of the nose, tip of the philtrum, and chin, were used to define the facial and dental midline. Some authors prefer the use of intraoral landmarks, such as the incisive papilla, for defining the maxillary dental midline. Modifications in genetic structure can lead to misalignment of these landmarks, such as chin position and the cartilaginous structure of the nose, while the philtrum of the lip is considered to be one of the most accurate of these anatomical guideposts, as it is always in the center of the

face. The exceptions are cases in which there is deviation as a result of accident or congenital abnormalities such as cleft lip, palate, etc. **(Singh et al., 2016).**

From an esthetical point of view, the maxillary dental midline should be coincident with the midline of the face, then the mandibular midline. This may be due to the dominant attribution of the maxillary anterior teeth while smiling and functioning **(Eskelsen et al., 2009).**

Mid-sagittal reference **(MSR)** plane:

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 of 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 **(Anison et al., 2015)**.

1.4 Etiology of the midline deviation

Midline deviation can arise from a single factor or a combination of factors. Dental and skeletal issues can significantly impact facial symmetry and oral health. Problems such as teeth missing from birth, premature loss of primary teeth, tooth rotation, crowding, and habits like thumb sucking or mouth breathing can all contribute to asymmetry. Skeletal asymmetry, which involves discrepancies in size or alignment between the upper and lower jaws, can also contribute since it can affect various facial structures, as seen in conditions such as hemifacial macrosomia, cleft lip, and cleft palate **(Jain et al., 2015).**

Midline deviation can also be caused by dental interferences that hinder proper tooth contact in the centric position. These interferences can cause the mandible to

shift functionally to one side during closure, typically toward the side with the interference. Once these interferences are addressed, the mandible generally returns to its original position, resolving the deviation **(Fu et al., 2003).**

1.4.1 Dental factors

Dental asymmetry Early loss of deciduous teeth, a congenital missing tooth or teeth, and habits such as thumb sucking. Tooth asymmetry generally does not involve the entire arch. On the other hand, teeth in the same morphologic class tend to have the same directional 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) (Garn et al., 1966).**

Several dental factors can cause asymmetry of the dental arches and midline shift, including:

A-side differences in the pattern of exfoliation: A midline shift in the mandible is often seen with the premature shedding of the deciduous canine, leading to shifting of the midline to the same side as shown in **(Figure 2)**. Also, unbalanced loss of the 1st molar and possibly the deciduous 2nd molar can cause midline shift; however, the more anterior the tooth loss, the greater the effect on the extent of midline shift **[Kharbanda, 2019].**

(Figure 2) A midline shift in the mandiblular arch **(Kharbanda, 2019)**

B-Supernumerary tooth: Position and orientation of the developing successor tooth buds in the eruptive phase. Eruption pathways can be disturbed due to the physical obstruction such as a presence of a supernumerary tooth, **(Figure 3)**.

(Figure 3) Supernumerary tooth **(Kharbanda, 2019)**

C- Differences in the site of tooth emergence: The sequence of eruption and position of the antagonist. A premature extraction of the deciduous molar leading to drift of permanent molar teeth compromising arch length leading to dental arch asymmetry including midline shift **(Kharbanda, 2019).**

D- Tooth rotations: Occur consequently to lack of space in the arch or due to the physical obstruction caused by root stumps of the deciduous teeth, retained deciduous teeth or in association with supernumerary teeth **(Kharbanda, 2019).**

E- Crowding: If anterior crowding results in an infra-position of canine or a palatally positioned lateral incisor on one side, this leads to an upper midline shift towards the crowded side **(Kharbanda, 2019)** as shown in **(figure 4)**.

(Figure 4) Midline shift with crowding [my clinical cases]

F- Ankylosis and retained primary teeth: As in cases of unilateral retained primary incisor, canine or molar [Kharbanda, 2019].

G- Congenitally missing teeth/ partial hypodontia: As the missing maxillary lateral incisors/missing second premolars cause midline sift toward missing side as shown in**(figure 5) [Kharbanda, 2019].**

(Figure 5) Missing lateral incisor **[Kharbanda, 2019].**

H- The tooth-size discrepancy: Unusually large teeth, such as macrodontia or microdontic teeth leading to migration of adjacent teeth as in situation of microdontic laterals, as shown in **(figure 6) (Kharbanda, 2019).**

(Figure 6) Peg lateral incisors **(Kharbanda, 2019)**

I- Transverse problems in the dental arch or its bases: Leading to crowding of the anterior segment are associated with midline shift **(Kharbanda, 2019)**as shown in **(figure7)**.

(Figure 7) Unilateral posterior cross bite **(William R. Proffit et al.,2o18)**.

10- Habits: Deleterious oral habits, influencing facial morphology, such as thumb sucking, tongue thrusting, pacifier use, mouth breathing.

1.4.2 Skeletal factors

Skeletal asymmetry may involve one bone such as the maxilla or mandible, or it may affect a number of skeletal structures on one side of the face, as in hemifacial microsomia. When one side of osseous development is 9 affected, the contralateral side will most inevitably be influenced resulting in compensational or distorted growth **(Bart and Kopf, 1978).**

Early unilateral condylar fracture leading to deficient growth on the affected side.condylar fractures in children are especially important due to the risk of a

mandibular growth center in the cartilage of the condylar head. It can also retard growth and/or cause facial asymmetry **(Farronato et al., 2009; Hackett and Sleeman, 2001; Zachariades et al., 2006).**

1- Rheumatoid arthritis of TMJ.

RA-induced asymmetric condylar destruction causes shifting of the lower dental midline toward the damaged side. TMJ Dysfunction in Rheumatoid Arthritis. Annals of the Rheumatic Diseases **(Voog et al., 2003).**

2- Hemifacial microsomia:

HFM is one of the congenital disabilities responsible for facial asymmetry. Asymmetry of the mandibles could involve the ramus, the condyle, the body, and the symphysis, which may result in size, volume, or position changes. Skeletal deviation equal to or greater than 4 mm is considered asymmetry noticeable in an individual's face, while a skeletal deviation less than 4 mm is identified as mild and unnoticeable **(Lee et al., 2014; Silva et al., 2011).**

3- Neurofibromatosis

Because NF1 can cause unilateral **(one-sided)** facial enlargement due to plexiform neurofibromas, the dental midline may shift **(Friedman, 2025).**

This leads to:

• Misalignment of upper or lower dental midline.

• Malocclusion **(e.g., crossbite or asymmetrical occlusion)**.

4- Pathological state in the form of cysts and tumors.

Facial tumors usually present as unilateral asymmetries, with occasional bilateral occurrences **(Cohen, 1995).**

5- Cleft lip and cleft palate, especially unilateral clefts:

Unilateral clefts impair normal maxillary development **(Fudalej et al., 2009).**

• The cleft side often shows reduced horizontal and vertical growth.

• This produces midfacial asymmetry, shifting the perceived facial midline toward the non-cleft side.

6- Facial Trauma

According to the National Trauma Bank Data, facial trauma takes up a quarter of all forms of injuries yearly. Particularly, these traumatic events that occur at a young age usually interrupt the process of growth in the facial regions. This leads to detrimental influences on the development of the craniofacial skeleton, resulting in asymmetric changes of the face and causing long-term aesthetic, physical, and psychological distress **(Morris et al., 2012).**

1.4.3 Functional factors

Functional asymmetry may result from the mandible being deflected laterally if occlusal interferences prevent proper intercuspation in the centric position. These functional deviations may be caused by a constricted maxillary arch or a local factor such as a malpositioned tooth. In some cases, temporomandibular joint derangement, such as an anteriorly displaced disc, may result in a midline shift during mouth opening caused by interference in mandibular translation on the affected side **(Reyneke et al., 1997).**

1.5 Diagnosis of midline deviation

Clinical examination and radiography are necessary for diagnosis of dentofacial asymmetry. These tools are used to determine the extent of the soft tissue, skeletal, dental, and functional participation **(Manosudprasit et al., 2017).**

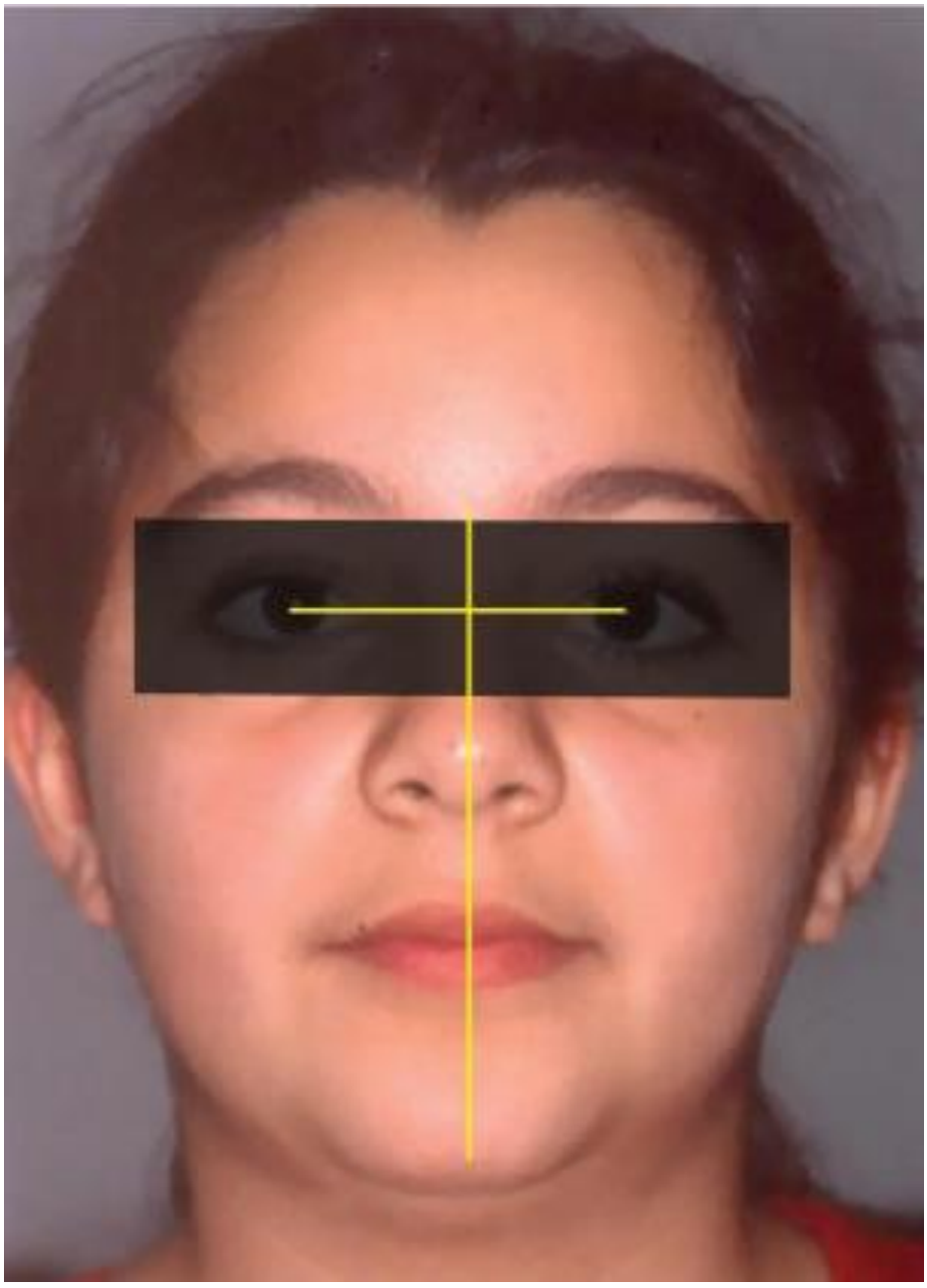
1.5.1 Patient history

Following the patient's chief complaint and evaluation of their medical and dental history helps clinicians identify the precise cause of the asymmetry. Childhood traumas or infections related to the craniofacial area and records of dental history, such as abnormal eruption or premature loss of the dentition, should also be taken into account **(Maheshwari et al., 2015).**

1.5.2 Extra-oral and intra-oral clinical examination

Evaluation of dental midline in the following positions: mouth open; in centric relation; at initial contact; in centric occlusion. True asymmetry exhibits similar midline discrepancies in centric relation **(CR)** and centric occlusion **(CO)**. On the other hand, asymmetry due to occlusal interferences may result in a mandibular functional shift following initial contact. The lower dental midline and chin point should be compared to the facial skeletal, dental, and soft tissue midline **(Manosudprasit et al., 2017).**

The extraoral clinical examination of asymmetry is performed with the patient in the natural head position and involves utilizing some specific facial planes and landmarks, i.e., the interpupillary line and a vertical line through the glabella perpendicular to the interpupillary line, tip of the nose, and center of the philtrum and chin **(Figure 2)**. The clinical examination for asymmetry can be performed by looking from a frontal view. In addition, looking from an inferior view of the mandible can aid in determining the extent of deviation **(Cheney 1961) (Figure 3)**. Alternatively, a straight instrument or piece of floss placed in line with the facial midline can aid in visualization of asymmetry **(Figure 4)**.

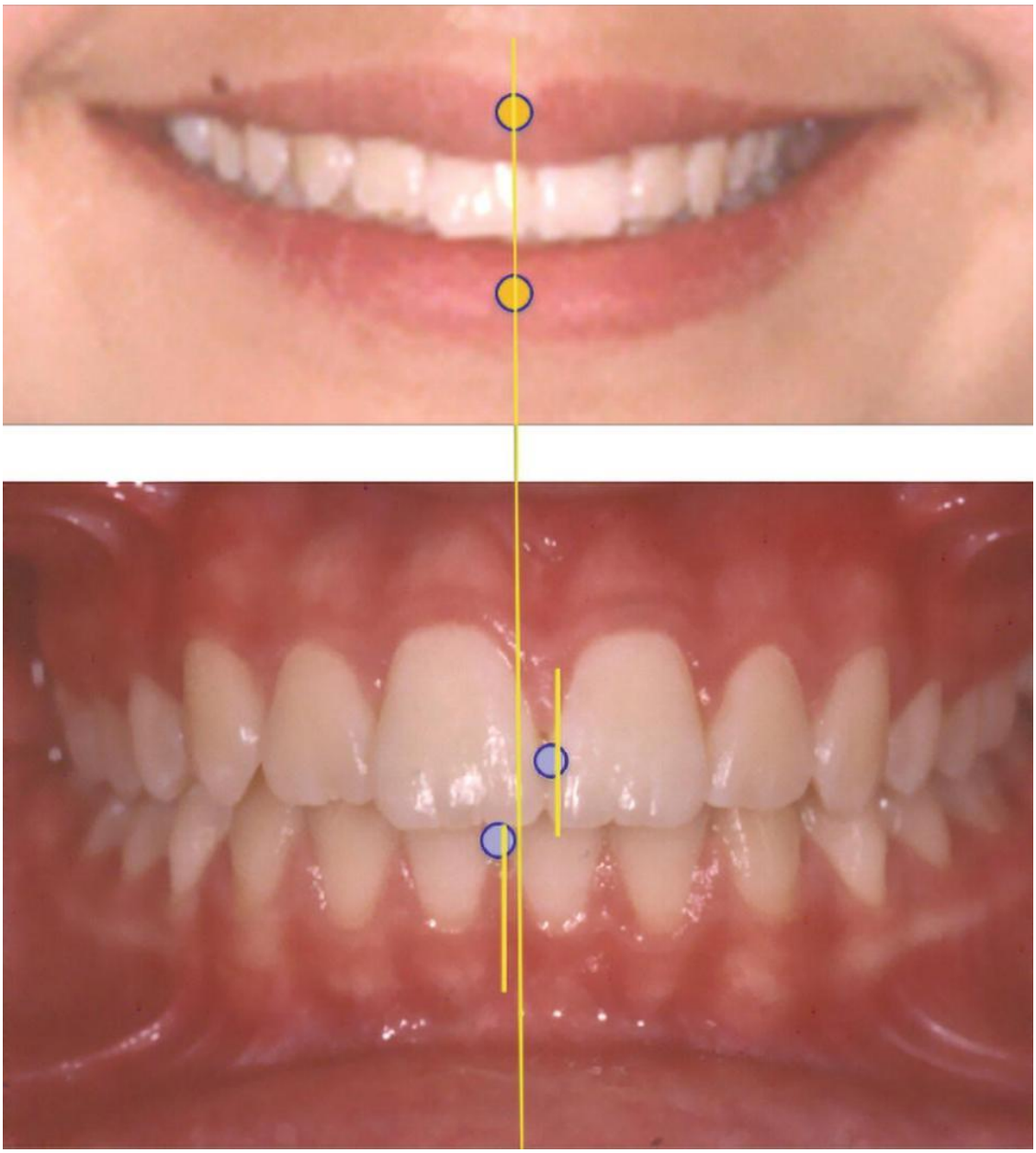


(Figure 8) An extra-oral clinical examination utilizing the interpupillary line, and a vertical line through the glabella perpendicular to the interpupillary line **(Bouserhal et al., 2021)**.

(Figure 9) A clinical examination can be performed by looking from inferior view of the mandible **(Bouserhal et al., 2021)**.

(Figure 10)A straight instrument or piece of floss placed in line with the facial midline can aid in visualization of asymmetry**(Bouserhal et al., 2021)**.

Moving intra-orally, the facial midline is coincident with the upper lip philtrum and the midpalatal suture, and these landmarks should be used when measuring the upper dental midline deviation. In both the upper and lower arches, the labial or lingual frenum should not be used as a reference landmark, due to their alveolar insertion which adapts and alters based on tooth position **(Figure 4)**.



(Figure 11) Examination of dental midline asymmetry **(Bouserhal et al., 2021)**.

1.5.3 Intra and extra oral photographs or video

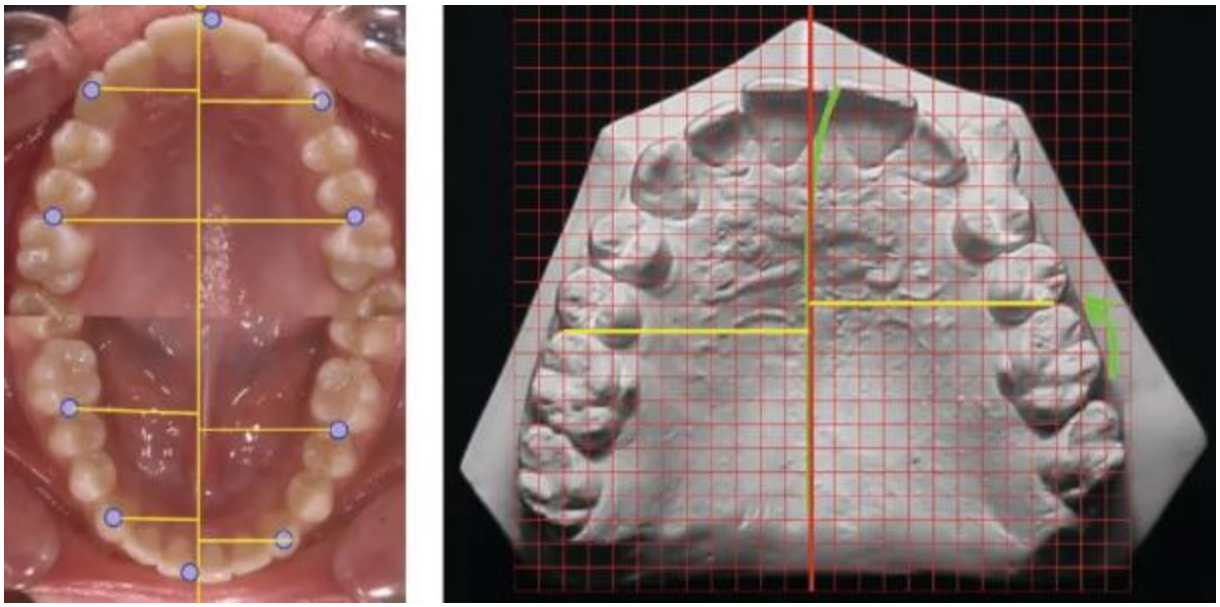
General principles of facial photography, head position, camera position and lightning were used as reviewed by Lewis et al. **(1990)**. Anthony **(1984)** used photographs of smiling subjects to analyze various esthetic factors in smile **(Tjan and Miller, 1984)**. Eskelsen et al. **(2009)** and Jayalakshmi et al. **(2013)** also used photographs of smiling subjects to visualize deviation of midlines in comparison to known soft tissue landmarks **(Lewis et al., 1990)**.

studies done by Mavroskoufis et al. **(1981)**, Jacob and Gazit **(1975)** and Grave **(1987)** proving that incisive papilla lies in between two central incisors and remains constant even after extraction. Study done by Harper on incisive papilla concludes the presence of incisive papilla in center of two maxillary central incisors in dentate patients and in center of ridge in edentulous patients **(Peng and Cocke, 1999)**. Lau **(1993)** had done similar study in Chinese population and proved the position of incisive papilla in relation to central incisors **(Singh et al., 2016)**.

As we have already defined dental midline as an imaginary line passing through two central incisors in vertical direction, so the relation of incisive papilla with dental midline and other facial landmarks can be drawn on imaginary horizontal line with vertical dental midline **(Singh et al., 2016)**.

1.5.4 Dental models trimmed to centric relation occlusion

The dental cast can also be investigated for asymmetry via an occlusogram, which involves the use of a grid to aid in measurement of dental arch asymmetries.This allows for discrete measurements of the left and right differences and asymmetries in different planes **(Bouserhal et al., 2021)**.



(Figure 12) Asymmetry of dental arches evaluation **(Bouserhal et al., 2021)**.

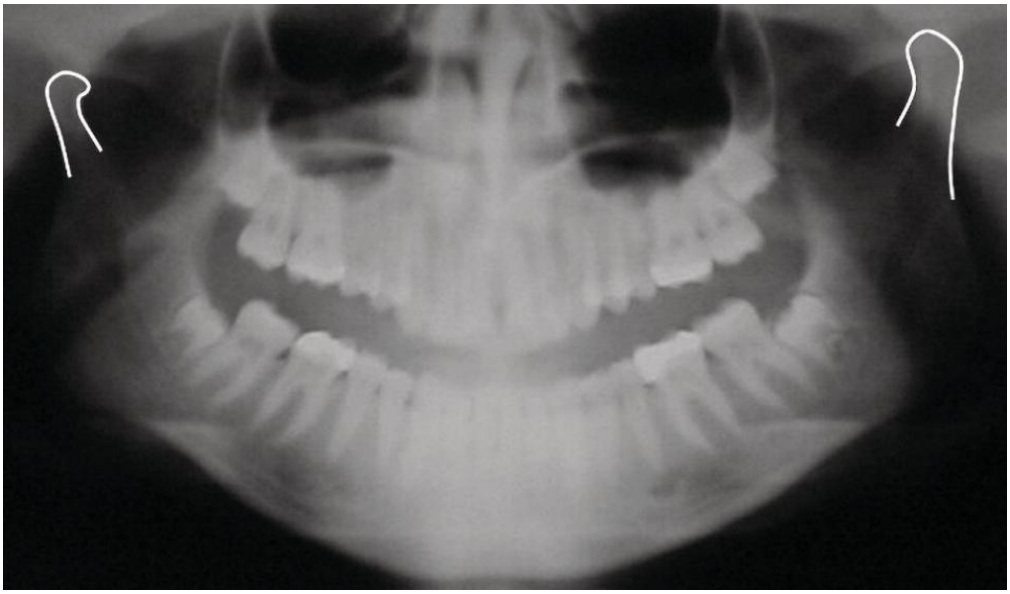
1.5.6 Radiographs

The radiographic examination for asymmetry should start with conventional panoramic and cephalometric radiographs.

1- The panoramic radiograph enables the clinician to view the condyles for size and shape discrepancies, as well as irregular cortical borders **(Figure 7)**. While the condylar length and ramus length may be measured as well, positioning errors of the patient tends to make these measurements unreliable and is better evaluated using CBCT. **(Bouserhal et al., 2021)**

2-A lateral cephalometric radiograph can be used to identify mandibular asymmetry by observing the two borders of the mandible **(Figure 8)**. This also has some reliability issues, however, as the patient's head positioning may lead to small discrepancies between the borders of the mandible **(Bishara et al. 1994)**. Hence only gross and obvious asymmetry can be reliably identified. Frontal and submental cephalometry has been the traditional go-to method for evaluating skeletal asymmetry due to the right and left structures being equidistant from the film and X-ray source. Hence, landmarks on either side of the midline can be

measured and contrasted with greater accuracy **(Bouserhal et al., 2021) (Figure 9)**



(Figure 13) Panoramic radiographic examination. **(Bouserhal et al., 2021)**

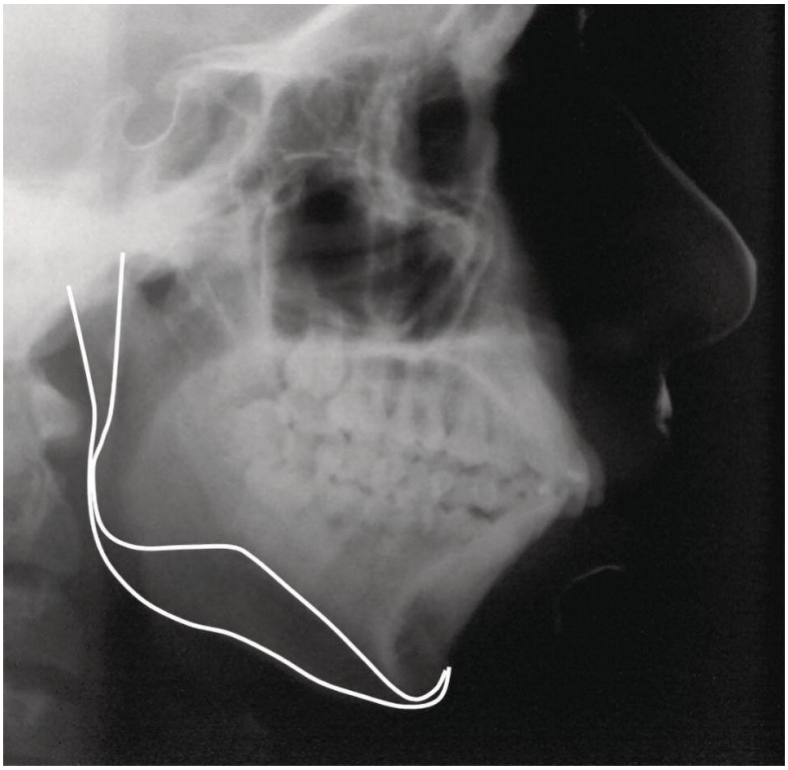
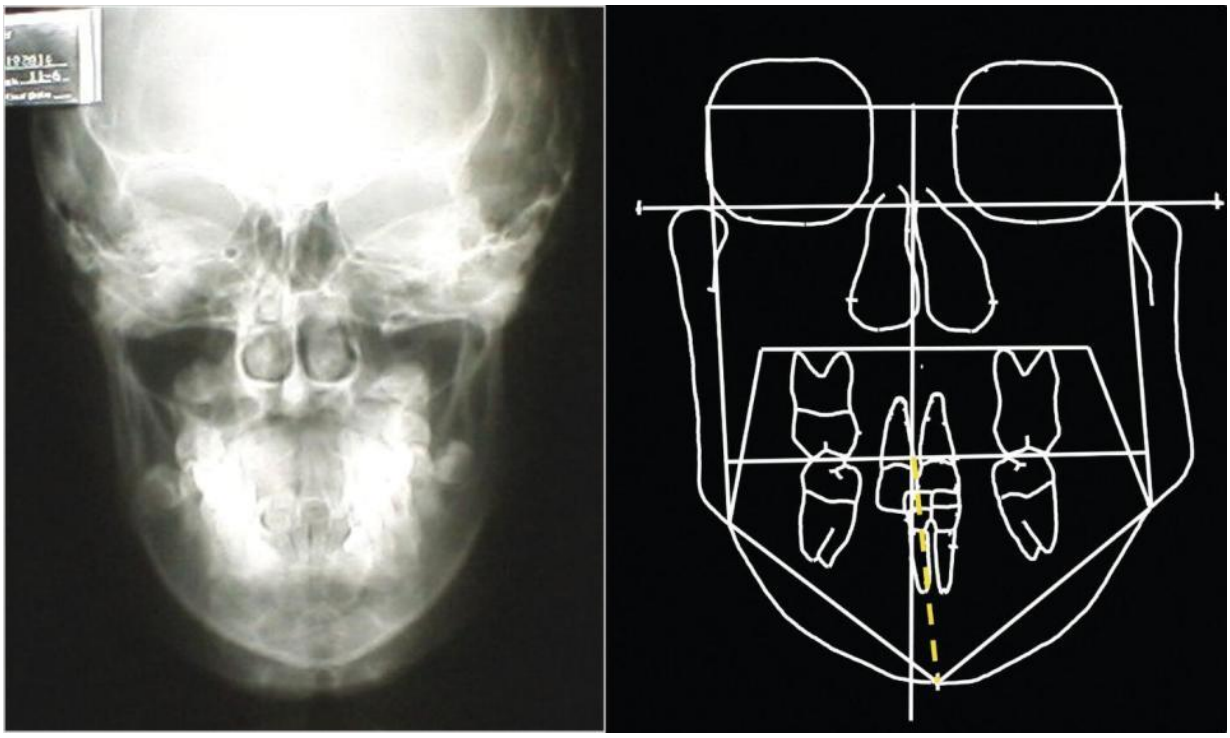


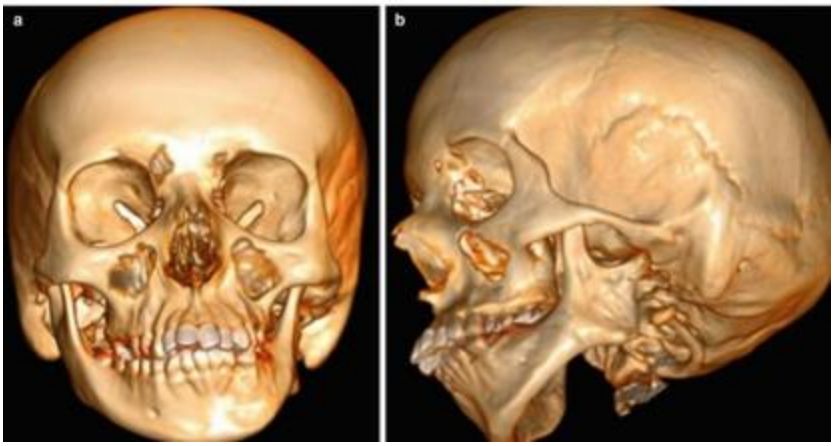
Figure 14 Identification of mandibular asymmetry on a lateral cephalometric radiograph **(Bouserhal et al., 2021)**.



(Figure 15) Frontal cephalometric evaluation. **(Bouserhal et al., 2021)**

Computed tomography/Cone Beam CT with 3D Reconstruction

The main advantage of the 3D CT scan is that it helps in visualization and treatment planning of complex facial asymmetry in cases like hemifacial microsomia **(Fig 10)**, temporomandibular ankylosis, and unilateral condylar hyperplasia . Unlike cephalometric and panoramic radiographs, there is no superimposition of structures, the absolute position of anatomical landmarks can be defined, and viewing is possible from any angle. It is also an excellent tool for patient education. The disadvantage of the CT scan is the exposure to a high radiation dose; with the introduction of the CBCT, the amount of radiation exposure has been greatly reduced **(Andrade et al., 2021)**.



(Figure 16) CT scan of patient with Hemifacial microsomia disorder **(Andrade et al., 2021)**.

The most accurate method that can be used to determine the size of the bony structures is cone beam computed tomography **(CBCT) (Venkatesh and Elluru, 2017)**. This procedure is not absolutely risk-free, meaning it should not be performed on healthy individuals **(Lindfors et al., 2024)**. The indication for CBCT for other reasons, such as certain types of TMDs, allows for measurements of the SS, specifically to assess the dental midline shift.

1.6 Association of midline discrepancy with tempromandibular joint disorder

Any shift in the midline can disturb the seating of condyle in the glenoid fossa or apply unequal functional forces which can lead to disorders of the temporomandibular joint. Hence is it important to evaluate the predisposition of midline discrepancy in causing potential damage to the TMJ i.e. the temporo-mandibular disorders **(Jain et al., 2018)**.

(Sonneson 1998, Almasan 2011, Pradhan 2002, Celic 2002, Ballanti 2013 and Padala 2012) had moderate grade of evidence and one study **(Pullinger 1993)** had strong grade of evidence. In all the articles, midline was a part of the occlusal or malocclusion traits studied.

Of the total seven studies discussed in this article, four studies showed a significant correlation between the presence of midline shift and TMDs and the remaining three had non-significant correlation.The scientific evidence is insufficient and contradictory for this study evaluating the association between midline and TMDs. Clear and sound evidence cannot be verified, and there is still a need for further long-term studies **(Jain et al., 2018)**.

1.7 Management of dental midline shifts

Dental midline asymmetries demand specific consideration in rehabilitation **(orthodontic or prosthetic procedures)** during diagnosis and treatment planning, since they represent one of the most challenging, frequent, and enduring issues that dentists deal with **(Ciavarella et al., 2023; Jain et al., 2018)**. Dental and functional asymmetries may be treated orthodontically, but significant structural facial asymmetries may require orthopedic correction during the growth period and/or surgical management at a later point **(Manosudprasit et al., 2017)**. Midline deviation treatment mechanics: **(Iris, 2024)**

1- Combination of elastics and jig spring,

1.7.1.Asymmetric Mechanics for correction of midline shift

A.Temporary Anchorage Devices (TADs)

TADs are small titanium screws or mini-implants that are temporarily fixed into the bone of the mouth. They serve as stable anchor points to facilitate the movement of teeth with greater precision and control **(OrthoSynetics, 2024)**.

Use of miniscrews might help to correct a severely deviated midline without the use of intermaxillary elastics that require the patient's cooperation. The greatest advantage of this technique is that there is no need for patient cooperation. In order to correct midline deviation, the screws might be placed either unilaterally or

bilaterally, in one or both of the arches, depending on the side where the midline deviation exists **(Camcı et al., 2017)**.

Mini screw anchorage for the correction of midline discrepancies can allow seemingly impossible midline discrepancies to be easily corrected without the use of compliance-dependent intermaxillary elastics or adverse side effects. The mini screws can be implanted either unilaterally or bilaterally, in one or both of the arches, depending on the midline deviation **(Chung et al., 2009; Feng et al., 2014)**.

B. Asymmetric elastics

The use of elastics with a continuous wire is often the most popular method to place asymmetric forces to correct the midlines. This method is satisfactory for minor midline problems restricted to tipped teeth **(Shroff and Siegel, 1998)**. Elastics are commonly used in orthodontic treatment to help correct both sagittal **(front-to-back)** and vertical discrepancies. When combined with good patient compliance, elastics can significantly aid in achieving correct occlusion. They play key roles in intermaxillary **(between jaws)** and intramaxillary **(within the same jaw)** treatments, helping to correct maxillary and mandibular occlusions, address crossbites, align midlines, and finalize occlusion during the finishing stages **(Singh et al., 2012)**.

Sant'Anna et al. **(2015)** addressed a 3 mm lower midline deviation using Class III 5/16 intermaxillary elastics on one side, finishing with a mild midline deviation.

Sabuncuoglu **(2011)** managed both upper and lower midline shifts using Class II and Class III elastics, along with oblique elastics in the anterior area, achieving correct midline positions.

Tripathi et al. **(2020)** used Class II elastics on the right side and Class III elastics on the left to correct the midline.

Tripathi et al. **(2020)** reported a 4.5 mm lower midline shift, using Class II and Class III elastics **(5/16 inch, 3.5 ounces)** to correct the midline, completing treatment in 1 year with a slight shift remaining.

This suggests that while elastics can effectively promote midline correction, complete resolution may not always be achievable, potentially due to individual variations or compliance issues **(Iris, 2024)**.

C.Asymmetric extractions

The asymmetric extractions allowed to correct midline deviation and anterior crowding favoring unilateral movement of the posterior teeth without using intermaxillary elastics **(Lewis, 1976)**, obtain occlusal stability and a good response on patient profile **(Ciavarella et al., 2023; Gianelly et al., 1986; Janson et al., 2007)**.

D.Asymmetric archwire bend

asymmetric reciprocal torque represented a treatment option for midline corrections of approximately 2-4 mm and improvement in the chin position without mesiodistal tooth movement or extraction.

E. Asymmetric Interproximal Reduction **(IPR)**

Performed only on one side to create space for shifting teeth.

1.7.2.Correction of functional midline deviation

Correction of functional midline deviation: The functional midline shift can be corrected by **(Narmada et al., 2015)**:

1- Unlocking the mandible.
2- Removal of the occlusal prematurities.
3- Expansion of the upper arch.
4- Functional appliances.
5- Interarchelastics.

1.7.3. Surgical options

Skeletal asymmetry in adults cannot be managed orthodontically and the only question is the type of surgical intervention. The major treatment planning decision is the extent to which surgery will be used to correct the deformity at its point of origin, as opposed to compensating for deformity and camouflaging its existence.

An asymmetric mandible can be approached by surgery in the ramus, correcting the unequal ramus length, or it can be managed by inferior border osteotomy. This technique is applied to slide the chin sideways, correct the obvious asymmetry inferiorly and leave the gonial angles as they were. Another successful surgical approach for asymmetric mandible is bilateral sagittal split ramus osteotomy associated with a basilar osteotomy in the form of an "L" on the affected side**(41)**.

41. Avelar RL, Becker OE, Dolzan AN, Goelzer JG, Haas OL, Jr., de Oliveira RB. Correction of facial asymmetry resulting from hemimandibular hyperplasia: surgical steps to the esthetic result. J Craniofac Surg 2012; 23: 1898-900. 4

An asymmetric maxilla can be approached via rotating, inferior positioning or camouflaged by asymmetric onlay grafts.

When an asymmetry of the jaws develops, the nose may deviate in the same direction as the chin. Hence, rhinoplasty is recommended to correct the nose in addition to jaw surgery.

http://www.jmatonline.com/PDF/S50-S60-PB-100-S6.pdf

1.7.4. Clear aligner

Clear aligners are increasingly being used to correct mild to moderate midline discrepancies. The ability of aligners to apply gentle, controlled forces has shown favorable results in moving teeth and aligning the midline, especially in cases where discrepancies are caused by dental misalignment rather than skeletal discrepancies. According to a 2024 study by Dr. Melanie Carter**,** clear aligners showed success rates of 70-85% in correcting midline discrepancies when the underlying cause was dental and treatment was planned with precision.

Digital Treatment Planning: One key factor in the success of clear aligners for midline correction is digital treatment planning. Using advanced software, orthodontists can accurately map out tooth movements, ensuring the necessary forces are applied to shift the midline. A 2024 paper published in the Journal of Clinical Orthodontics highlighted that custom treatment plans generated through artificial intelligence improved the predictability of midline correction by 25%.

Patient-Specific Factors: Research from early 2024 also shows that patient-specific factors, such as the extent of the discrepancy and compliance with wearing aligners, significantly impact treatment outcomes. The flexibility of aligners to adapt to individual needs offers a customizable approach, making them effective in a wider range of cases. Challenges in Treating Midline Discrepancies with Clear Aligners While clear aligners present various advantages, their limitations must be acknowledged, especially in more complex cases of midline discrepancies.

1.8. Midline correction in the finishing stage

The techniques used to correct midline problems during the finishing phase mainly rely on the use of anterior cross elastics. In some instances a combination of Class II elastics on one side and Class III elastics on the other side can be used. This method seems easy but can result in serious side effects if used indiscriminately **(Uribe et al., 2015)**.

1.9. Digital treatment planning

Primarily, digital technology was used foremost to improve diagnosis accuracy; as a result, work- flow became more streamlined.

The next wave of technological advances will focus on improving treatment results and shortening chair-side time as well as treatment time **(Vaid, 2018)**.

The first step is collecting all necessary digital records: **(AlMortadi et al., 2020)**

- Intraoral 3D scan **(STL files)** to capture dental arches.
- Facial photographs or 3D facial scan for soft-tissue evaluation.
- CBCT scan **(if skeletal asymmetry is suspected)**.
- Digital bite registration.

These data are imported into planning software such as:

3Shape Ortho Analyzer, ClinCheck, Dolphin Imaging, OrthoInsight, or Archform.

2. Digital Model Analysis

The software automatically aligns the upper and lower arches and allows clinicians to:

- Measure **upper and lower dental midline deviation** relative to:
- Facial midline
- Opposing arch
- Assess arch symmetry, tooth angulation, rotations, and crowding.
- Determine if the deviation is **dental vs. skeletal**.

3. Virtual Setup (Digital Treatment Simulation)

A **virtual setup** is created by digitally moving teeth to their ideal positions.

This provides:

• Predicted final midline position
• Required tooth movements **(mesialization, distalization, rotation, expansion)**
• Required space distribution **(IPR or extraction if needed)**
• Time and number of aligners/brackets stages

This simulation is the core of modern digital orthodontic planning.
4.Planning Tooth Movement for Midline Correction

Based on the digital simulation,
Appliance Design

5.Depending on the chosen appliance, the digital platform generates:
• **Clear aligner stages** with precise midline movement goals
• **Bracket positioning maps** for indirect bonding
• **Custom archwires (e.g., Insignia, Suresmile)**
• **3D-printed transfer trays**

This step converts the virtual plan into a physical orthodontic device.
6. Monitoring Progress Digitally

During treatment:
• Periodic 3D scans are compared with the digital plan
• Deviations from planned movement are detected early
• Refinement stages are created digitally if needed

Digital monitoring increases accuracy of midline correction.

7. Post-Treatment Evaluation

Using digital post-treatment scans, clinicians evaluate:

- Final midline alignment **(upper-to-facial, upper-to-lower)**
- Tooth positions
- Arch symmetry
- Retainers are digitally designed **(Vivera, 3D-printed retainers)**

Conclusion

Dental deviations should be treated as far as possible with intra-arch mechanics, functional deviations with inter-arch mechanics, and skeletal deviations with orthognathic surgery. While some degree of asymmetry is definitely part of natural appearance, symmetry is the ideal that we should treat toward **(Pinho et al. 2007)**.

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