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Original Research

Assessment of facial asymmetry on photographs and correlate them with posteroanterior cephalogram in harmonious faces

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ABSTRACT:

Background: Facial harmony plays a vital role in orthodontic diagnosis and treatment planning. Mild skeletal asymmetries are often masked by soft tissues and may go unnoticed in otherwise harmonious faces. True frontal photographs, along with posteroanterior cephalograms, can be valuable tools in the identification of skeletal asymmetries, as they can influence occlusal outcome, treatment mechanics and long-term stability. This study aims to assess facial asymmetry on photographs and correlate them with posteroanterior cephalograms in harmonious faces. **Materials and Methods:** A study was conducted on 100 subjects (aged 18-30 years) with clinically harmonious faces and no history of trauma or congenital anomalies. True frontal photographs and PA cephalograms were taken in standardized conditions. Soft tissue asymmetry was assessed by photographic analysis and skeletal asymmetry was evaluated using Grummon'sanalyses.Landmarks were identified and measurements performed using AutoCAD 2025 software.Statistical analysis was performed using independent t-tests, One-way ANOVA. **Results:** Photographic analysis showed statistically significant right-sided dominance in outer canthal, inner canthal, and gonial widths.Grummon's analysis also showed right side dominance thusindicating a strong correlation with photographic analysis for posteroanterior cephalometric landmarks such as gonial and zygomatic widths. **Conclusion:** Mild asymmetries in harmonious faces are often masked by soft tissues. Right-sidedominance was observed on both photographic and postero-cephalometric analysis. Grummon's analysis showedstrong correlation with photographic findings,depicting clinical usefulness in orthodontic diagnosis and treatment planning.

Key Words: Facial Asymmetry, PA Cephalogram, Frontal Photography, Grummon's Analysis, Harmonious Faces.

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INTRODUCTION

Facial symmetry is an important component in the evaluation of facial harmony and esthetics. In orthodontics, symmetry plays a critical role in achieving pleasing aesthetic outcomes and in diagnosing underlying skeletal and dental discrepancies. A certain degree of asymmetry is considered within the limits of normal anatomical variation. It may go unnoticed unless it affects facial balance or function.[1]

This paradigm shift from skeletal to soft tissue analysis has enhanced the importance of photographs in orthodontics. However, Postero-anterior cephalograms still remain a valuable method for evaluating skeletal asymmetries.[2] Soft tissue analysis using frontal photographs allows clinicians to assess asymmetries in proportion, discrepancies in both transverse and vertical directions. The photographic records, such as frontal photographs provide useful information about soft tissue asymmetries and facial divergence. However, they are limited by their inability to visualize underlying skeletal structures. Postero-anterior cephalogram can be utilized to visualize these underlying skeletal structures.[3]

The posteroanterior cephalogram, introduced by Broadbent and Hofrath in 1931, enables us to visualize structures such as the zygomatic arches, maxilla, mandible, and nasal cavity, and provides key landmarks for identifying discrepancies between the right and left. Various authors gave various analyses

for assessing and evaluating facial asymmetry at the skeletal level.[4],[5]

Studies have shown that when both photographic and PA cephalometric analyses are used together, the reliability of asymmetry detection is enhanced, although facial asymmetries are often associated with skeletal discrepancies.

Bishara et al. [6], Padwa et al. [7] emphasized that asymmetry is often observed more in the lower third of the face, and a mild degree of skeletal asymmetry may remain unnoticed in individuals with otherwise harmonious facial features. However, identifying and documenting such asymmetries is still important, as they may influence the occlusal outcome, treatment mechanics, and long-term stability.[8]

Thus, this study aims to assess the facial asymmetry using standardized frontal facial photographs and to correlate these findings with posteroanterior cephalometric measurements in individuals with esthetically harmonious faces.

MATERIALAND METHODS

This study was carried out in Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, Ahmedabad, following approval from the Institutional Ethics Committee.

The study included 100 individuals (18–30 years) with harmonious and clinically acceptable faces, excluding patients with mandibular deviation, maxillofacial pathology, trauma, orthognathic surgery, congenital anomalies.

True frontal photographs of 100 subjects were taken after approval from three orthodontists. Photographs were taken with a Canon 80D digital camera and a 100mm lens (ISO: 100, Shutter Speed: 125, Focal length: 7.1). True-size photographs were obtained. An assembly of two rulers, one horizontal and one vertical, was kept. Subjects were made to sit 1m from the tripod stand, such that Frankfort horizontal plane was parallel to the ground.

Reference points

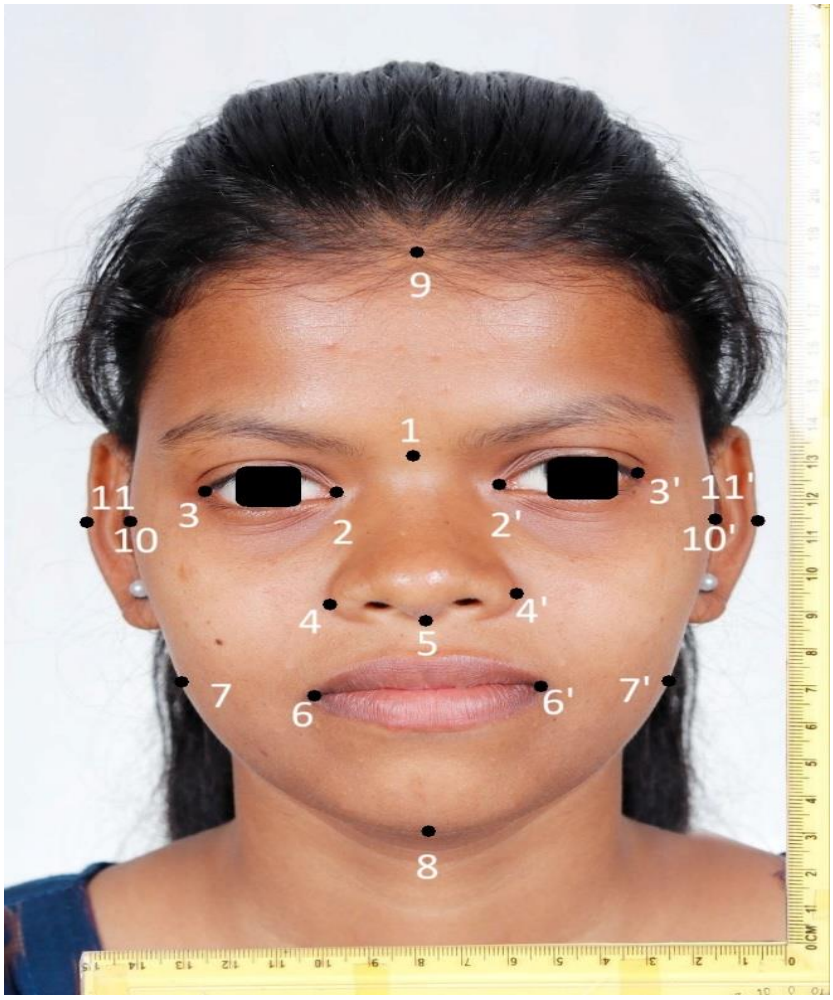

Figure1: Photographic Landmarks

Photographic Landmarks: (Figure 1)

1: G' (Glabella Soft Tissue): Most prominent point in the midline of the forehead between the eyebrows.

2 & 2': En & En' (Endocanthion): The right/left medial (inner) commissure of the eyelids.

3 & 3': Ex & Ex' (Exocanthion): The right/left lateral (outer) commissure of the eyelids.

4 & 4': Al & Al' (Alare): The most lateral point on the alar curvature of the nose, right/left (outermost part of the nostrils) side.
5: Sn' (Subnasale): The point where the columella of the nose merges with the upper lip in the midline.
6 & 6': Ch & Ch' (Cheilion): The right/left lateral commissure (corner) of the mouth.
7 & 7': Go & Go' (Gonion Soft Tissue): The right/left most lateral and inferior point on the soft tissue angle of the mandible (jaw angle).
8: Me' (Menton Soft Tissue): The most inferior point on the soft tissue contour of the chin in the midline.
9: Tr' (Trichion): Midpoint of natural hairline.
10 & 10': z & z' (Zygion point): Right/left most lateral point on the zygomatic arch.
11 & 11': er & er' (lateral ear): Right/left most lateral point of the ear.

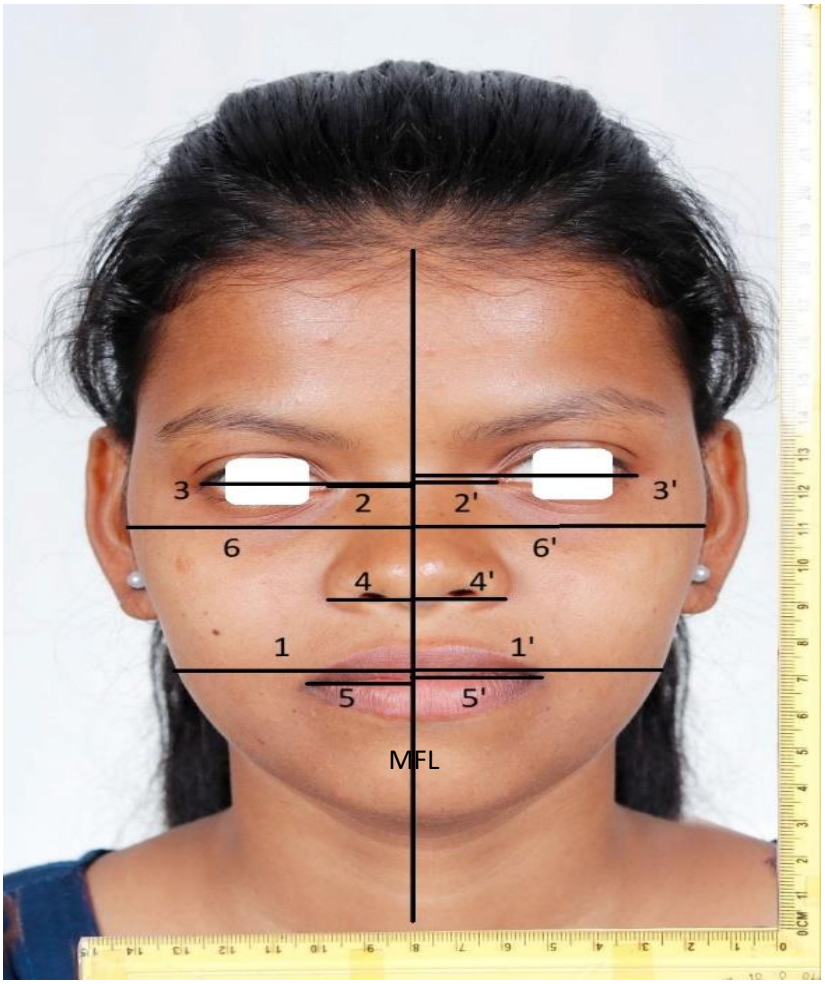

Figure2: Linear Measurements

Linear Measurements: (Figure2)

- Facial Widths on the right and left sides are measured.

1 & 1': Gonial Width (Go/Go' to MFL): Distance between right/left gonion and mid facial line.
2 & 2': Inner-canthal Width (En/En' to MFL): Distance between right/left inner corner of the eye and mid facial line.
3 & 3': Outer canthal Width (Ex/Ex' to MFL): Distance between right/left outer corners of the eye and mid facial line.
4 & 4': Alar Width (Al/Al' to MFL): Distance between the nose at its widest point on the right/left side and mid facial line.
5 & 5': Cheilion Width (Ch/Ch' to MFL): Distance between right/left cheilion and mid facial line.
6 & 6': Zygomatic width (z/z' TO MFL): Distance between the most lateral point on the zygomatic arch on the right/left side and midfacial line.

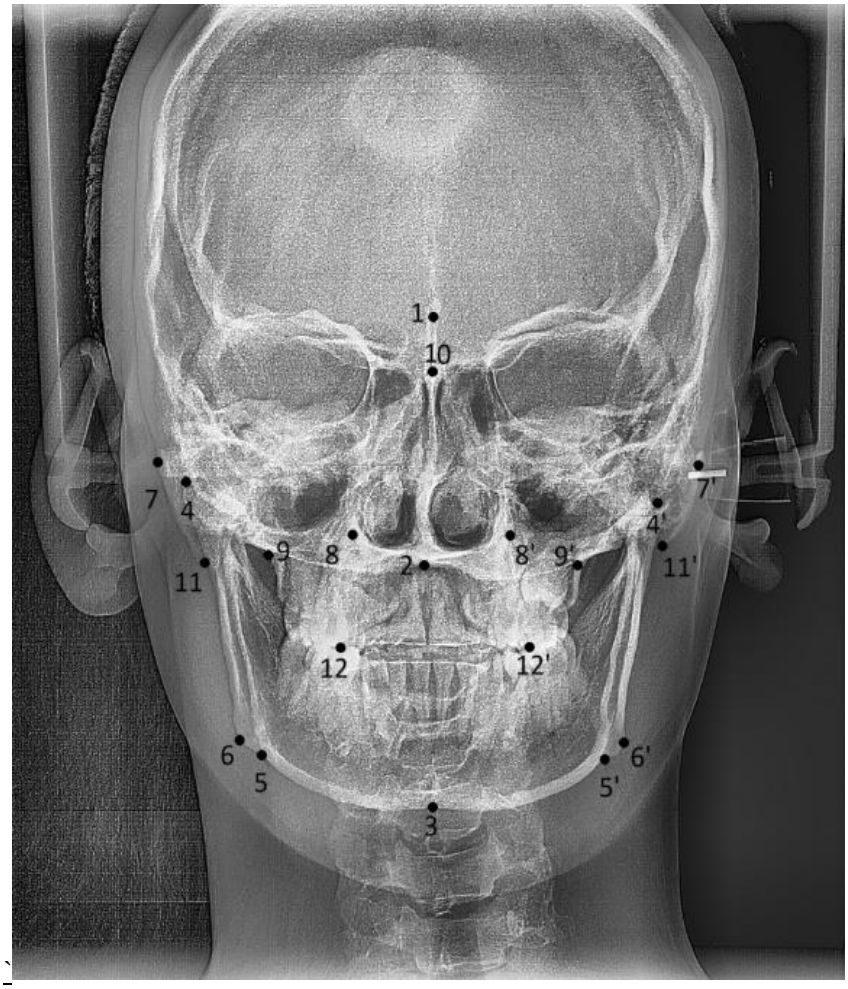

Figure3: PA Cephalogram Landmarks

Postero-anterior cephalogram landmarks: (Figure 3)

1: Crista Galli (Cg): Most superior and anterior point on median ridge of bone projecting upward from ethmoid bone

2: Anterior Nasal Spine (ANS): Tip of anterior nasal spine, representing most anterior point of the nasal floor.

3: Menton (Me): Most inferior point on the mandibular symphysis.

4 & 4': Condylion (Co & Co'): Most superior aspect of the condyle of the mandible on the right and left side.

5 & 5': Antegonial Notch (Ag & Ag'): Deepest point on the curvature of the antegonial notch on the inferior border of the mandible on the right and left side.

6 & 6': Gonion (Go & Go'): Most posterior-inferior point on the angle of the mandible. Often constructed by bisecting the angle formed by the mandibular plane and the ramus on the right and left side.

7 & 7': Zygomatic Arch (Za & Za'): Most lateral aspect of the zygomatic arch on the right and left side.

8 & 8': Nasal cavity (NC & NC'): Lateral wall of the bony nasal cavity on the right and left side.

9 & 9': Jugal Point (J & J'): Intersection points of the maxillary tuberosity and the zygomatic buttress on each side, on the right and left side.

10: Sella (S): Midpoint of the sella turcica.

11 & 11': Mastoidale (Ma & Ma'): The right/left most inferior and lateral point on the outline of the mastoid process of the temporal bone.

12 & 12': Upper molar point (U6 & U6'): The buccal cusp of the maxillary first molar on the right/left side.

The points and planes used for Grummon's analysis include the following.

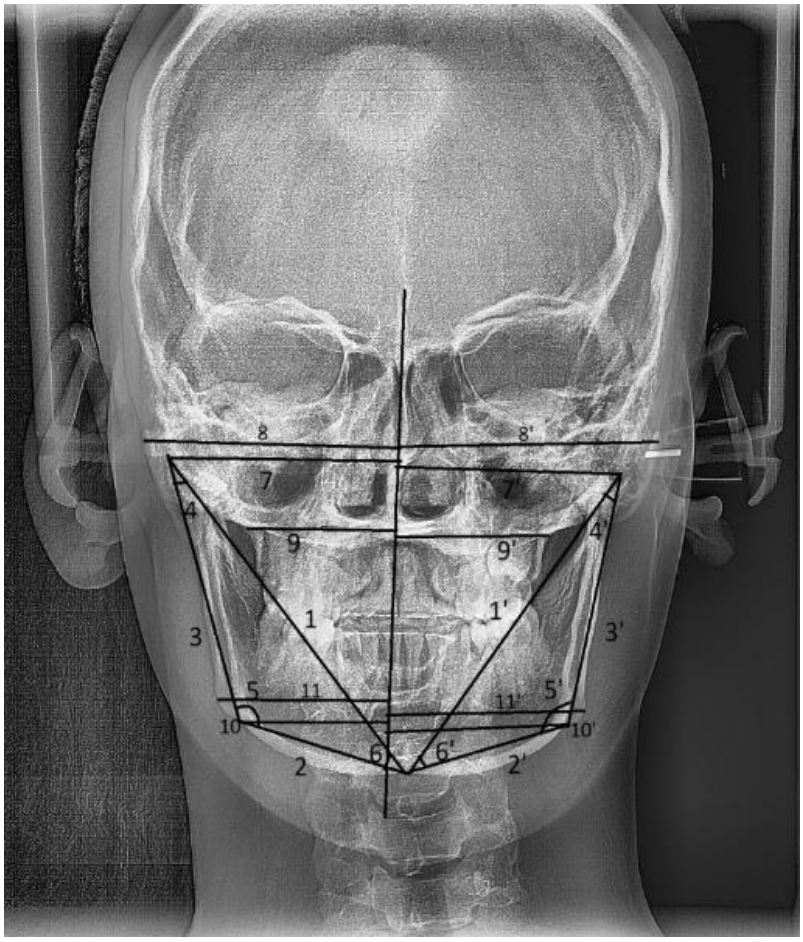

Figure 4: Grummon's analysis

Midsagittal Reference Line: Drawn from Crista Galli (Cg) through Anterior Nasal Spine (ANS).

- Measurements from Mandibular Triangles:

1 & 1': Condylion-Menton distance on right/left side (Co/Co' to Me).
2 & 2': Antegonion-Menton distance on right/left side (Ag/Ag' to Me).
3 & 3': Condylion-Antegonion distance (Co-Ag & Co'-Ag') on right/left side.
4 & 4': Angle at Condylion in the (ΔAg-Co-Me/Ag'-Co'-Me) on right/left side.
5 & 5': Angle at Antegonion in the (ΔCo-Ag-Me/Co'-Ag'-Me) on right/left side.
6 & 6': Angle at Menton in the(ΔCo-Me-Ag/Co'-Me-Ag') on right/left side.

- Linear Asymmetry Assessment:

7 & 7' (Co/Co'-MSR): Linear distances from on right/left Condylion to the MSR.
8 & 8' (Za/Za'-MSR): Linear distances from on right/left Zygomatic arch to the MSR.
9 & 9' (J/J'-MSR): Linear distances from on right/left Jugal point to the MSR.
10 & 10' (Ag/Ag'-MSR): Linear distances from right/left Antegonion to the MSR.
11 & 11' (Go/Go'-MSR): Linear distances from right/left Gonion to the MSR.
Differences in the dimension of these bilateral landmarks to the MSR were calculated.

In this study, we used AUTOCAD 2025 software (by AUTODESK Software, United States) to accurately measure linear and angular values in postero-anterior cephalometric images and frontal photographs. All the cephalometric landmarks were traced and measured. Data was analysed by SPSS 26.0. Statistical analysis was performed using independent t-tests, One-way ANOVA.

RESULTS

The study analyzed 100 subjects with harmonious faces, yielding the following comparisons

Table I shows linear photographic measurements. Significant asymmetry was found in the outer canthal width (p=0.049) and inner canthal width (p=0.018), with the right side consistently larger. Similarly, gonial width was significantly greater on the right compared to the left (p=0.04).

Cephalometric Analysis

- Grummon's Analysis (Table II): Significant vertical asymmetry was identified. The distance from Condylion to Menton was significantly larger on the right. Antegonion-Menton distance showed a similar significant increase on the right (p=0.0001). Angular measurements at the Condylion also favored the right side (p=0.0001). In transverse linear measurements, the Zygomatic

arch-MSR (p=0.01) and Condylion-MSR (p=0.003) distances were significantly greater on the right.

Correlation between Methods (Table III) compares soft tissue and skeletal measurements.

- Alar vs. Nasal Width: A highly significant discrepancy (p=0.0001) was found between the mean difference in photographic alar width (0.22±0.15 mm) and cephalometric nasal cavity width (1.00±0.32 mm), indicating poor correlation in the nasal region.
- Gonial Width: The difference in gonial width measured via photographs (1.10 mm) versus Grummon's analysis (0.98 mm) was not statistically significant (p=0.082), suggesting a strong correlation in the mandibular angle region.

Using both true frontal photographs and postero-anterior cephalograms gives a more accurate evaluation of facial asymmetry. Grummon'sanalysis showed close correlation with photographic analysis. Therefore, both soft-tissue and skeletal components is essential for proper orthodontic diagnosis, treatment planning, and long-term stability.

DISCUSSION

The present study evaluated subclinical facial asymmetry in 100 individuals with harmonious facial profiles and examined the relationship between soft tissue measurements obtained from frontal photographs and skeletal measurements derived from postero-anterior (PA) cephalograms.

Table I present the mean values and standard deviations of linear facial parameters measured from frontal photographs. Analysis of these measurements revealed slight differences between the right and left sides in several facial regions.

The mean right outer canthal width (Ex–MFL) was 47.74 ± 3.25 mm, while the left (Ex'–MFL) measured 47.20 ± 3.52 mm. Similarly, the right inner canthal width (En–MFL) averaged 16.67 ± 4.04 mm compared to 15.72 ± 1.80 mm on the left. Both parameters showed statistically significant asymmetry (p = 0.049 and p = 0.018, respectively), with a marginal right-side dominance. These findings align with Farkas et al. (1981) [16], who reported that asymmetry is most pronounced in the upper facial third and often favors the right side.

The mean right alar width (Al–MFL) was 14.87 ± 3.58 mm and the left (Al'–MFL) was 15.09 ± 3.98 mm. Although the left side showed a slight increase, the difference was not statistically significant (p = 0.320). This observation is consistent with the findings of Simmons et al. (2004) [17], who also reported insignificant left-side dominance in alar width.

Cheilion width measurements revealed near symmetry, with mean values of 25.81 ± 2.82 mm on the right and 26.02 ± 2.90 mm on the left.

In contrast, gonial width showed significant asymmetry. The mean right gonial width (Go–MFL) was 60.28 ± 8.85 mm, compared to 59.02 ± 8.47 mm on the left, with a statistically significant difference (p = 0.04). These results support the findings of Mishra et al. (2014) [11], who also observed greater right-side gonial width in the Indian population.

Zygomatic width measurements were nearly symmetrical, with mean values of 67.55 ± 2.38 mm on the right and 67.24 ± 2.27 mm on the left.

Previous studies show varying patterns of facial dominance. Reddy et al. (2017) [14] reported right-side facial dominance in 81% of healthy individuals, whereas Naheeda et al. (2022) [15]observed greater left hemifacial dimensions. These differences may reflect ethnic variation, genetic influences, or differences in measurement techniques.

Table II summarize measurements obtained using Grummon's frontal analysis. The right Condylion–Menton (Co–Me) distance was significantly greater (92.89 ± 6.51 mm) than the left (90.88 ± 6.84 mm), with a highly significant difference (p = 0.0001). This suggests vertical elongation or downward positioning of the right mandibular component. Similar trends were reported by Goel et al. (2003) [9], Mishra et al. (2014) [11], Reddy et al. (2016) [14], and Rajpara et al. (2014) [12].

Antegonion–Menton (Ag–Me) distance also showed significant right-side dominance (p = 0.0001), indicating asymmetry along the lower mandibular border. This is consistent with Mishra et al. (2014) [11], while Naheeda et al. (2022) [15] reported a non-significant difference.

Condylion–Antegonion (Co–Ag) distance demonstrated no significant bilateral difference (p = 0.787), suggesting symmetry in ramal height. This finding corresponds with earlier reports by Mishra et al. (2014) [11] and Naheeda et al. (2022) [15].

Angular measurements revealed mixed results. The angle at Condylion (Ag–Co–Me) was significantly greater on the right side (p = 0.0001), whereas the angle at Antegonion (Co–Ag–Me) was significantly greater on the left (p = 0.013). These angular deviations support previous findings by Mishra et al. (2014) [11] and Azevedo et al. (2006) [10], indicating their usefulness in identifying facial asymmetry.

Linear distances from skeletal landmarks to the mid-sagittal reference line showed minimal asymmetry. Jugal and Antegonion distances did not differ significantly between sides, consistent with earlier studies [11,15]. However, Condylion–MSR and Zygomatic Arch–MSR distances showed statistically significant right-side dominance (p = 0.003 and p = 0.01), supporting findings by Rajpara et al. (2014) [12] and Mishra et al. (2014) [11].

Tables III compared soft tissue measurements from photographs with corresponding skeletal measurements from PA cephalograms. Alar width differences showed poor correlation with skeletal nasal cavity width, with a significant discrepancy (p = 0.0001). This may be due to the flexibility and mobility of nasal soft tissues.

In contrast, gonial and zygomatic width measurements showed strong agreement between photographic and cephalometric analyses, with no statistically significant differences (p = 0.082 and p = 0.064). These findings confirm that bony landmarks such as the gonion and zygomatic arch are reliably reflected in soft tissue profiles, as previously noted by Grummon's.

Table I – Photographic Analysis (Left vs Right comparison)

	Group	N	Mean	Std. Deviation	Std. Error Mean	*p*Value (t test)
Outer canthal width	Right	100	47.7479	3.25756	.32414	**0.049***
	Left	100	47.2021	3.51814	.35007	
Inner canthal width	Right	100	16.6770	4.04780	.40277	**0.018***
	Left	100	15.7278	1.80520	.17962	
Alar width	Right	100	14.8743	3.58978	.35720	0.320
	Left	100	15.0986	3.98039	.39606	
Chelion width	Right	100	25.8106	2.90325	.28888	0.537
	Left	100	26.0207	2.82364	.28096	
Gonial width	Right	100	60.2893	8.85235	.88084	**0.04***
	Left	100	59.0224	8.47379	.84317	
Zygomatic width	Right	100	67.5553	2.38453	.23845	0.37
	Left	100	67.2404	2.27035	.22703	

***p*<0.05 is statistically significant**

Table II –Grummons analysis (Left vs Right comparison)

	Group	N	Mean	Std. Deviation	Std. Error Mean	*p*Value (t test)
Condylion-menton	Right	100	92.8889	6.51507	.64827	**.0001***
	Left	100	90.8816	6.84209	.68081	
Antegonion-Menton	Right	100	44.9816	2.68983	.26765	**.0001***
	Left	100	42.7004	3.22796	.32119	
Condylion-Antegonion	Right	100	62.3130	7.43959	.74027	.787
	Left	100	62.2456	6.68390	.66507	
Angle at Condylion in ∆Ag-Co-Me	Right	100	31.6920	9.60229	.95546	**.0001***
	Left	100	30.6712	10.60835	1.05557	
Angle at Antegonion in ∆Co-Ag-Me	Right	100	116.9320	5.15375	.51282	**.013***
	Left	100	117.7860	5.62011	.55922	
Angle at Menton in ∆Co-Me-Ag	Right	100	36.2450	6.17620	.61456	.4
	Left	100	36.880	7.0889	.76013	
Jugal process-MSR	Right	100	32.0696	1.97620	.19664	.676
	Left	100	32.0176	2.40874	.23968	
Antegonion-MSR	Right	100	41.2041	2.95484	.26317	.552
	Left	100	40.9051	2.99050	.28164	
Condylion-MSR	Right	100	51.9580	5.97967	.59500	**.003***
	Left	100	51.1504	5.78431	.57556	
Zygomatic arch-MSR	Right	100	62.8195	3.85064	.38506	**0.01***
	Left	100	61.4993	3.37610	.33761	
Gonion-MSR	Right	100	46.4452	2.40667	.24067	0.13
	Left	100	45.8727	2.67983	.26798	

***p*<0.05 is statistically significant**

Table III- Comparison of mean difference between photographic analysis measurement& postero-anterior cephalogram measurements

	Mean	Std. Deviation	Std. Error Mean	*p* Value (T test)
Gonial width (Photographic analysis)	1.105	0.964	0.7932	0.082
Gonial width (Grummons Analysis)	0.980	0.893	0.7912	
Zygomatic width (Photographic analysis)	0.315	0.264	0.2431	0.064
Zygomatic width (Grummons Analysis)	0.375	0.294	0.235	

***p*<0.05 is statistically significant**

CONCLUSION

Combining photographic and cephalometric analyses provides a more complete and accurate assessment of facial asymmetry. Right-side dominance was consistently observed in both skeletal and soft tissue parameters, particularly in mandibular and maxillary regions. Grummon's analysis showed the strong correlation with photographic measurements and is therefore a valuable tool for evaluating transverse skeletal asymmetry. Ethnic and demographic differences may influence asymmetry patterns, highlighting the need for population-specific norms. A comprehensive evaluation of both skeletal and soft tissue components is essential for orthodontic diagnosis and surgical planning.

Limitations

This study is limited by the use of two-dimensional imaging techniques, which cannot fully represent the three-dimensional complexity of facial structures. Future studies using 3D imaging modalities and larger sample sizes may provide more precise and conclusive insights into facial asymmetry.

Abbreviations

1. Ag – Antegonion
2. Ag' – Left Antegonion
3. Al – Alare
4. Al' – Left Alare
5. ANS – Anterior Nasal Spine
6. Cg – Crista Galli
7. Ch – Cheilion
8. Ch' – Left Cheilion
9. Co – Condylion
10. Co' – Left Condylion
11. En – Endocanthion
12. En' – Left Endocanthion
13. Ex – Exocanthion
14. Ex' – Left Exocanthion
15. Go – Gonion
16. Go' – Left Gonion
17. J – Jugal Point
18. J' – Left Jugal Point
19. Ma – Mastoidale
20. Ma' – Left Mastoidale
21. Me – Menton
22. Me' – Soft Tissue Menton
23. MFL – Mid Facial Line
24. MSR – Mid Sagittal Reference Line
25. NC – Nasal Cavity
26. NC' – Left Nasal Cavity
27. PA – Postero-Anterior
28. Sn' – Soft Tissue Subnasale
29. SPSS – Statistical Package for the Social Sciences
30. Tr' – Trichion
31. U6 – Maxillary First Molar (Right)
32. U6' – Maxillary First Molar (Left)
33. Za – Zygomatic Arch
34. Za' – Left Zygomatic Arch
35. z – Zygion
36. z' – Left Zygion

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