

Original Article

A novel approach for craniofacial symmetry evaluation: Using the midsagittal Reference line drawn from “Crista Gali” with NHP technique

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Abstract

Background & Objective: The purpose of this study was the determination of midsagittal reference line (MSL) for craniofacial asymmetry assessment by drawing a line from Crista gali parallel to the true vertical line in PA cephalometry, using Natural Head Position (NHP) technique.

Method and Materials: 60 Iranian subjects within the age range of 9-13 years old were selected for this prospective study. Patients referred for orthodontic treatment and had no supernumerary or missing teeth, no skeletal anomaly, or any history of orthodontic and jaw surgery with normal occlusion. Posteroanterior cephalometric radiographs (PA Ceph) were taken of all subjects with NHP technique. The midsagittal line was also traced parallel to the hanging chain from Crista gali. True horizontal line (THL) and true vertical line (TVL) were also traced from Crista gali (Cg). Using Cartesian system based upon Cg point (0~0), the craniofacial symmetry was assessed with linear, angular and proportional measurements in PA cephalogram, related to TVL and THL lines, for 10 bilateral (R&L) anatomical landmarks. The mean differences of the above measurements in left and right sides were analyzed by T- test.

Results: The proportional ratios for all left and right measurements were not statistically significant. This was true for both vertical and horizontal distances. The significant level for MSL drawn from Cg as referred to ANS (0 ± 0.255) and Me points (0.007 ± 0.527) was 0.002 and 0.004, respectively.

Conclusion: In posteroanterior cephalometry radiographs taken with NHP method, the MSL drawn from Crista gali is reproducible and reliable up to 96% of the times for facial symmetry diagnosis.

Keywords: Natural head position, Midsagittal line, Facial asymmetry, True horizontal line, True vertical line.

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Introduction

Different methods with versatile features are proposed for diagnosis of facial symmetry. By using these methods, clinician can identify location and the amount of skeletal deformities causative of asymmetries ¹⁻⁵. Conventional methods for assessment of asymmetry are based on intracranial landmarks. Researchers such

as: Betts ³, Grayson ⁵, and Mongini ⁶ used two intracranial landmarks introducing conventional midsagittal line as a reference for diagnosing facial symmetry. However, credibility of this reference line depends to the internal landmarks which can be affected by asymmetries ^{1, 7}. As such, validity and reliability of these reference lines is questionable. Due to controversies and differences in statistical methods

of previous studies, it became necessary to propose a technique with higher validity for PA cephalometric analysis. Recently, some researchers advocated 3-D techniques for facial symmetry analysis^{8,9}.

The aim of this study was to evaluate the validity of a midsagittal reference line drawn from “Crista gali” for assessment of maxillofacial asymmetry. This was accomplished by drawing the true vertical line parallel to hanging chain (near the patient’s face) passing through only an extra-cranial landmark, named “Crista gali”, while patient look into a mirror to his/her own eyes⁸. The advantage of using the above reference line is its independency from inconsistent intracranial structures¹¹.

Methods & Materials

60 orthodontic cases (30 males and 30 females) were selected with normal occlusion. Patients were 9-13 years old with no skeletal discrepancy, supernumerary, missing tooth, any past history of orthodontic treatment or jaw surgery. PA cephalometry radiographs were taken from all subjects with NHP technique (in standing position, while patients looking into a mirror to their eyes, and hanging chain was near the face), as a part of radiographic evaluations (Fig 1: A&B). Then, midsagittal line was traced parallel to the hanging chain, from Crista Gali (Fig 2). Tracings of PA cephalogram were done by one person using Canson 224×210 dimension tracing paper with a black pencil (diameter 0.5mm). Anatomical landmarks used in this research are shown in Fig. 3.



A. Posterior view.



B. lateral view

Fig 1. The film, chain and patient’s position is shown when taking PA cephalogram with NHP technique. (**A.** posterior view, **B.** lateral view)



Fig 2. A postero-anterior cephalogram taken with NHP technique

The midsagittal line as true vertical line is drawn from Crista Gali parallel to hanging chain. Then, by using conveyor at the point of Crista gali the true horizontal line was traced perpendicular to the midsagittal line (Fig 3&4). Also, the same true horizontal line at the

point of ANS was traced by using these three lines upper, middle and lower third of face in transverse view.

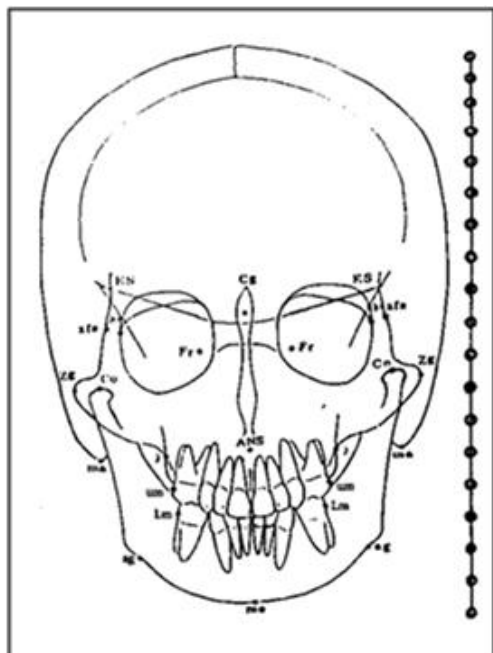


Fig. 3- Universal reference points in a P.A. cephalogram were used in this research for symmetry analysis, taken with NHP technique.

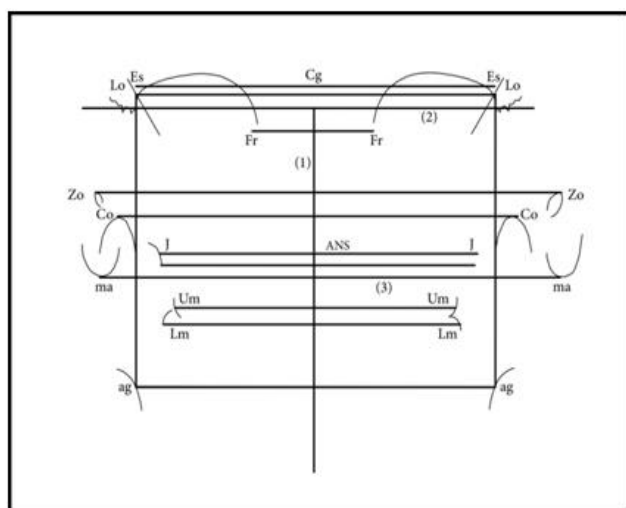


Fig. 4- Three important reference lines shown in this schematic view for the symmetry analysis: 1. midsagittal line drawn from Crista gali (T.V.L), 2. T.H.L (at Cg point), and 3. T.H.L (at ANS point)

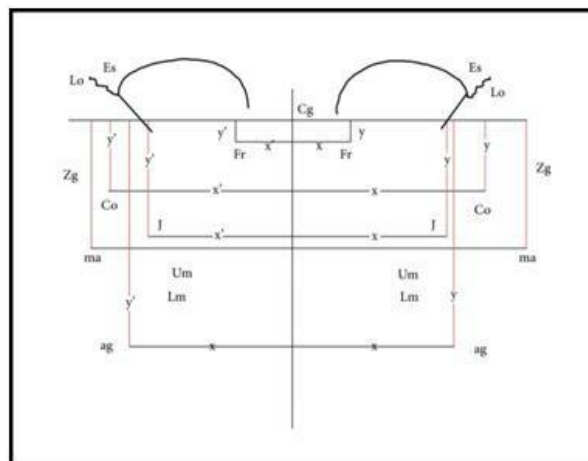


Fig. 5- The cranial landmarks were compared to the horizontal & vertical reference lines. The measurements are shown in Table 3.

Three determinant parts were initially considered for evaluating facial symmetry in this study: (**Fig. 4**)

A:Reference points in upper third of face which defines all landmarks superior to T.H.L

B:Reference points in middle third of face which are landmarks between T.H.L drawn at Cg. point and the other T.H.L drawing through A.N.S point.

C:Reference points in lower third of face which are inferior to the T.H.L drawn from A.N.S point.

Accordingly, the craniofacial symmetry was assessed on the basis of linear measurements as well as proportional ratios on both left and right sides. Finally, this technique was tested as to determine the standard transverse dimension for Iranian children. In order to increase the validity and reliability of the technique, after tracing all cephalograms, the detected “Cg” and other landmarks without considering the origin points were obtained two months later. In this stage, the new tracings were compared with the primary tracings. It was noted that the second tracing of 58 subjects out of 60 was similar to the initial ones; and “Cg” was completely corresponding to the first tracings. This was estimated at $58/60 \times 100 = \%96.66$ level of reliability for “Cg” points. The measurements are reported in Table 1- 5.

Furthermore, based upon the ratio of the distance of left and right anatomical landmarks from the midsagittal line in PA cephalograms, symmetry of the face was assessed according to true vertical and also horizontal lines. This was based upon the hypothesis

that “Cg” point of Cartesian axis with origin of coordinates (0~0), and in this way for any cephalometric point in P.A cephalometry we have two horizontal and vertical measurements (X~,Y~) in left and right sides. Each variable was measured independently and transverse ratios were prepared in all subjects. Then, their mean and S.D was calculated (Table 3) Finally, the proportional ratio of all distances of both right and left sides was separately measured from T.H.L (Table 3) and T.V.L (Table 4) and was statistically analyzed with the T-student test.

By using Cg. point, the validity of MSL can be described. Meaning that when discrepancy between right & left side is zero and proportional ratio is 1/1 the proposed MSL can be a valid axis for both symmetric analysis. At first we use proportional measurements and transverse ratio for eliminating errors due to magnification. For each similar landmark in left and right sides both X/X~ and Y/Y~ ratios were used and compared with 1/1 ratio for identifying Linear, transverse and proportional measurements. Then by the “T-student” test L&R sides were evaluated. Upon statistical findings for proving this technique we consider the hypothesis $H_0 : D = 0$. It means that there is no difference between means of all measurements in left & right sides of anatomical landmarks to MSL. In this manner the result of this equation should be $\bar{X}_1 - \bar{X}_2 = 0$. Since there are some minor differences, our hypothesis changes to $H_1: D \neq 0$. For this matter, “paired T-test” was performed to compare the two measurements in right & left sides. Using T-test, we actually compare the differences between means of two groups. In general, the larger the difference between two groups, the more likely it is for the T-test to be significant. The P-value in T-test is the correlation measurement for two groups. Finally, if the P-value is less than 0.05 (P-value <0.05) there is a good relation between these groups. If there is a little difference in statistical findings, it means as a “not significant” (NS). (Table 3, 4) As such, as it is presented in table 3 & 4 in all measurements, the P-value is less than 0.05. This implies that in all differences between right and left anatomical landmark measurements the statistical value is “not significant”. Consequently, this indicates that the introduced “MSL” is a good tool for symmetry evaluation.

Results

As was mentioned earlier, linear variables, transverse and proportional ratios were used for symmetric assessment of face. Among variable the Zg-Zg line has the greatest width so with SD=5.2 while Pt-Pt the minimum width 51.3 and SD= 6.2. Co-Co variable has the least SD=2.5 between all variables (Table 1).

Table 1: The mean and S.D. of dentofacial linear total measurement of right and left distance of the below 10 bilateral landmarks in 9-13 years old children.

*	Linear variable	Mean	S.D.
1	Lo-Lo	92.2	3.2
2	Pt-Pt	51.3	6.2
3	Es-Es	93.8	4
4	J-J	63.6	3.4
5	Zg-Zg	123.5	5.2
6	Ma-Ma	108.8	5.8
7	Um-Um	59.6	3.7
8	Ag-Ag	82	3.8
9	Lm-Lm	59.6	4
10	Co-Co	98	2.5

Lo = Latero-Orbital, Pt = Petrous, Es = Sphenoid, J = Jugale, Zg = Zygoma
 Ma = Mastoid, Um = Maxillary molar, Ag = Antegonion, Lm =Mandibular,
 Co = Condylion

According to these linear variables, transverse ratios (Fig 4) were assessed based upon the defined left and right of craniofacial landmarks. For example Um-Um/Lm-Lm has the proportional value of 1.01 with SD=0.04 which is compatible in normal anatomical face. The J-J/Lo-Lo has the minimum value of 0.69 with SD=0.04 (Table 2).

Table 2: Mean and S.D. of proportional dentofacial transverse ratios is measured for each bilateral landmark in 9-13 years Iranian children.

*	Transverse ratio variables	Mean	S.D.
1	J-J / Lo-Lo	0.69	0.04
2	Ag-Ag / Lo-Lo	0.89	0.04
3	J-J / Ag-Ag	0.78	0.04
4	Um-Um / J-J	0.92	0.03
5	Lm-Lm / Ag-Ag	0.72	0.06
6	Um-Um / Lm-Lm	1.01	0.04

In this way, by any proportional or linear measurements, there were no significant discrepancies between R&L landmarks. The mean and SD of these distances from MSL were calculated for all variables.

In many measurements, the proportion values were almost “1” which was indicative of no difference between R&L distance of anatomical landmarks to MSL (Fig 5). As it is shown in table 3, the value for Es/Es horizontal distance ratio was “1” with SD= zero. While, Ag/Ag showed the same distance ratio but with SD=0.046. The greatest value of the student t-test was for Zg /Zg with a value of 1.962 and the least value related to Pt/Pt ratio with -1.298 Student T-Test results. These values were not statistically significant (Table-3).

Table 3 –The proportional ratio (right to left measurements) in horizontal distances are shown to MSL, for nine variables. For all ratios, the measurements indicate that the high validity of the proposed MSL reference line.

Variable	\bar{X}	S.D	Student T-Test	P-value	Sig. level*
X_{Lo} / X'_{Lo}	0.995	0.028	-1.275	0.005	Ns
X_{Pt} / X'_{Pt}	1.004	0.017	-1.298	0.001	Ns
X_{Es} / X'_{Es}	1.000	0	0	0	0
X_{Fr} / X'_{Fr}	1.005	0.056	0.424	0.002	NS
X_{Zg} / X'_{Zg}	1.006	0.045	1.962	0.05	NS
X_{Co} / X'_{Co}	1.006	0.0517	0.447	0.02	NS
X_{Ma} / X'_{Ma}	1.020	0.072	0.915	0.004	NS
X_j / X'_j	1.004	0.037	0.676	0.01	NS
X_{Ag} / X'_{Ag}	1.000	0.0460	0	0	0

* Paired t-test was performed. P<0.05 indicate Not significant (NS). standard deviation(SD)

In vertical distance the mean proportion value for Es/Es was “1” with SD=zero. However, the same mean proportion value was calculated for Ag/Ag, the SD value was 0.018. As it is shown in table 4, the greatest value of student t-test related to Pt /Pt with the value of

0.387 and of the lowest value corresponded to Lo/Lo ratio with -1.360 Student T-Test results. These values were not statistically significant (Table 4).

Table 4–The proportional ratio (right to left measurements) in vertical distances to MSL, for ten variables. For all ratios the measurements indicates the high validity of the proposed MSL reference line.

Variable	X	S.D	Student T-Test	P-value	Sig. level*
y_{Lo} / y'_{Lo}	.980	.138	-1.360	0.03	NS
y_{Pt} / y'_{Pt}	1.091	0.155	0.387	0.06	NS
y_{Es} / y'_{Es}	1.000	0	0	0	0
y_{Fr} / y'_{Fr}	0.994	0.033	-1.588	0.003	NS
y_{Zg} / y'_{Zg}	0.996	0.014	-1.054	0.004	NS
y_{Co} / y'_{Co}	1.003	0.058	-0.329	0.005	NS
y_{Ma} / y'_{Ma}	1.004	0.047	-0.136	0.007	NS
y_j / y'_j	1.092	0.018	-0.430	0.003	NS
y_{Ag} / y'_{Ag}	1.000	0.018	0	0	0

* Paired t-test was performed. P<0.05 indicates “Not significant” (NS). Standard Deviation (SD)

For midsagittal line (MSL) validity assessment, in middle third, the ANS distance and in lower third, the Me (Meton) distance from symmetry line was measured. According to the result of this study, the ANS and Me distances to MSL were zero proving the accuracy and high validity of the introduced line. Then, the differences of mean values were analyzed by T-test. The P-value was 0.002 for ANS distance and 0.004 was for Me distance to MSL. All findings reveal the high validity and reliability of MSL drawn from Crista gali in this research (Table 5).

Table 5– The mean and standard deviation for the distance of ANS & Me landmarks to midsagittal line. The not significant level of both measurements indicates the high validity of MSL drawn from Crista gali in this study.

Variable	\bar{X}	S.D	Student T-Test	P-value	Sig. level *
MSL to ANS	0	0.255	0	0.002	NS
MSL to Me	- 0.007	0.527	0.095	0.004	NS

* Paired t-test was performed. P<0.05 indicates “Not significant” (NS). Standard deviation (SD)

Discussion

All previous studies ^{1, 5, 12} for symmetry assessment were based upon conventional PA cephalogram method with more than two or three intracranial landmarks for drawing MSL. These multiple

landmarks may increase technical errors. As such, many shortcomings of previous studies were carefully observed by taking P.A. cephalogram with NHP technique and selection of only one intracranial reference (Cg) for drawing. This was highly reproducible after the pilot evaluation (up to %96.66 level of reliability as was mentioned earlier).

The transverse proportions in this study proved the proposed MSL reference line to be highly efficient (Table 3&4). As opposed to this, the other intracranial anatomic landmarks have low predictability for symmetry analysis⁷. Additionally, personal errors, head movements and rotations were eliminated during preparing PA cephalogram procedures with NHP technique¹³.

As discussed previously, reference line for dentofacial landmark assessment is based upon two extra cranial lines (T.H.L and T.V.L) with only one intracranial point (Crista gali). Thus, difficulties and errors in conventional methods can be reduced significantly when using this method^{10, 14}.

Reported methods by other researchers can assess only dental and skeletal landmarks related to median axis of the face, except the computer-based method of Mongini which requires asophisticated computer software⁶. Furthermore, transverse ratio analysis used in this study eliminates any errors due to magnification. It should be mentioned that the method of the present study is comparable to Athanasiou et al. study where they used more than one intracranial landmarks for facial symmetry analysis¹².

In the NHP method, in addition to reproducibility of X-ray procedures using extra cranial landmarks, symmetry assessment is true and predictable up to 96%, which was similar to Madsen study⁷.

Conclusion

In posteroanteriorcephalometry radiographs with NHP method:

- 1- Crista Gali as an extracranial landmark (T.V.L) is reliable for assessment of facial symmetry, with minimum errors and maximum validity.
- 2- It is highly reproducible.

- 3- Up to 97% of times facial symmetries or asymmetries can be detectible.
- 4- MSL can be a reliable reference line for diagnosis of facial symmetry.

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