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Original Research

Hard Tissue Significance to Divine Proportion

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Abstract:

Background: Facial proportions are of interest in orthodontics. Leonardo Da Vinci had shown the relation between harmony and proportion when he discussed about "proportional beauties of an angelic face." The purpose of this study was to assess the influence of hard tissue on facial attractiveness on young attractive North Indian women.

Materials and Methods: Thirty attractive young women out of 102 were selected (of age group 18 to 26 years) representing the population of North India, by a panel of selectors from various different backgrounds. Divine proportions were evaluated by using Ricketts method of divine proportion analysis on lateral cephalogram.

Results: The subjects showed golden proportions on said parameters. The "*t*" test is significant at $t \leq 3.65$ very highly significant for linear facial height and the width ratios.

Conclusion: On hard tissue, the ratios were found to be very close to the divine proportion in vertical and transverse dimension. The soft tissue of attractive face also exhibits divine proportion.

Key Words: Attractiveness, divine proportion, lateral cephalogram, North India

Introduction

Leonardo Da Vinci had shown the interaction between proportion and harmony when he described "proportional beauties of an angelic face." The mathematician Luca Pacioli's (1509) Euclid' Elements renamed the golden proportion as the "divine proportion," because he thought the concept could not be rationalized. First known calculation of the golden proportion as a decimal was given by Maestlin. The number is 0.618 for the longer segment length of a line of length 1 when it is divided in the golden proportion. The ratio of the longer section to the whole line is equal to the ratio of the shorter section to the longer section of the line. The golden section (phi) is the point dividing the line.[1-3]

The correlation exists between the divine proportion/ Fibonacci series and the nature's beautiful art; like that in the sunflower' intersecting spirals or pine cones, the wings of a butterfly containing beautiful bands, the tree leaf with a symmetrical veins, the proportions of a peacock feather with exhilarating color or the snails with presence of logarithmic spirals (Nautilus).[4]

Harmony in a face has the morphologic accuracy in connection with an unquestionable charm. The identification of normality has concrete basis through the factor that causes the expression of harmony – "Proportion." Harmony in the face in orthodontics is established by the proportion of chin, nose and lips, and the morphologic relationships. The balance between these various anatomic structures can be affected or changed by both growth and the orthodontic treatment, thus it is important that the orthodontist should understand his role in marring or making of a facial beauty.[4] Ricketts put forward the concept of the magical divine proportion of "Phi (ϕ)" between the facial structures and also analyzed the proportion of different facial components.[4,5]

The study was designed to evaluate skeletofacial divine proportion in young attractive women's of North India using lateral cephalogram; on mathematical and geometric basis by means of various measurements (linear) on lateral cephalogram.

Materials and Methods

A group of 102 young females of 18-26 years of age group (unmarried) with comparatively pleasing faces consisted of the initial samples for this study. All the participants of this study had all the permanent teeth present with no previous history of orthodontic management.[7,8]

Ethical consent or permission is taken from the Ethical Committee before the start of the study. The selected participants of the study were healthy and had a proportionate balance and harmony of the dentofacial structures. Facial

photographs of all participants were captured using a digital camera. Photographs were captured with participant subjects in natural posture of head.[9,10]

Facial photographs of the subjects were analyzed by a panel of experts consisting of orthodontist, oral and maxillo-facial surgeon, prosthodontist, periodontist, beautician, and layman (all judges were of similar age group and experience in their respective field) with emphasis to emphasis on the balance in various facial structures disregarding individual features (such as beautiful hairs, and eyes).[11,12] A sheet for the marking of the scores was made and given to the individual judges.[13,14] Points were allotted to individual participants out of 10 by the judge. On scoring sheet provided by Orthodontics Department, points given to individual subject were then summed up and 30 scorers in the top were selected from the participant group and formed the database for further cephalometric analysis.

To evaluate divine proportion (Phi) in attractive young attractive North Indian women by using Ricketts divine proportion analysis on lateral cephalogram (Figure 1a and b).

Methods

Cephalometric landmarks used for skeletofacial analysis were as follows:

1. Nasion (N): The most anterior of the nasofrontal suture in the median plane.
2. Sella Turcica (S): Midpoint of maximum convexity between the nose and the forehead.
3. Basion (Ba): Lowermost point on the anterior margin of foramina magnum in the median plane.
4. Codylion (Co): Most superior point on head of the condyle.
5. Mandibular center (Xi): Centroid of the ramus of mandible derived by bisecting vertical height and horizontal depth of the ramus.
6. Porion (P): Point on the N-AR plane when a perpendicular point Ptm intersects it.
7. Articulare (Ar): Point of intersection of the posterior margin of ascending ramus and outer margin of cranial base.
8. Cranial center (CC): Point on the N-AR plane when a perpendicular Ptm intersects it.
9. Orbital (Or): Lowermost point on the orbital margin.
10. Subspinale/point A: The deepest midline point in the curved bony outline from base of the nose to ANS.
11. Menton (M): The lowermost point in the outline of symphysis.
12. Supra Mentale/point B: Most posterior point in the outer contour of mandibular alveolar process in midline.
13. Pogonion (Pog): Most anterior point of chin in midline.
14. Protuberance Menti (Pm): Point at which shape of symphysis changes from convex to concave.

All possible inter-measurement ratios between the transverse

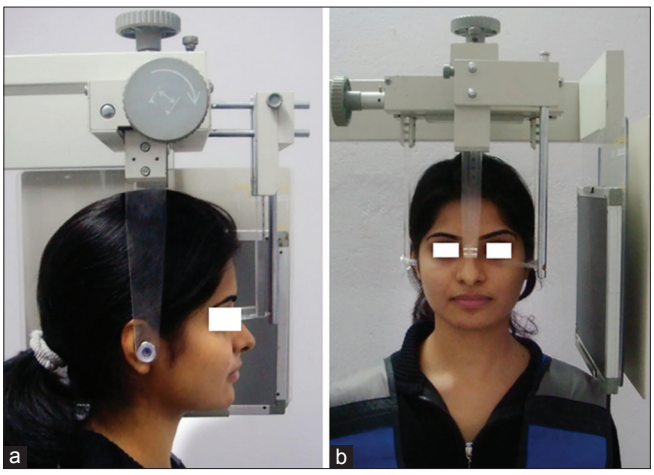


Figure 1: (a and b) Natural head position for cephalogram.

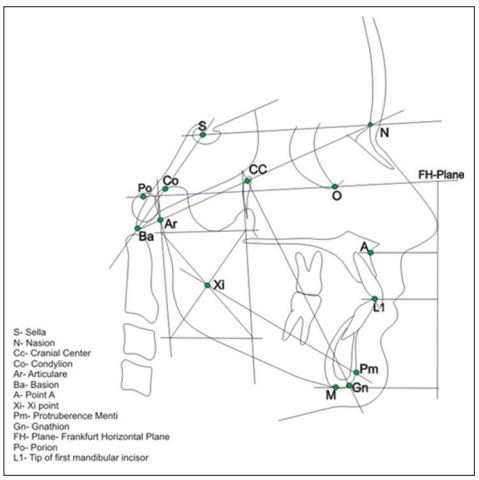


Figure 2: Model cephalometric tracing.

and vertical landmarks of the face were analyzed for the statistically significant ratio in comparison to the golden proportion constant 1.618 (divine proportion) (Figure 2).

Results

The data for analysis in this study were obtained for analysis of proportionality, for all the measurements of linear distance between various facial landmark utilizing lateral cephalogram (Table 1 and Graph 1; Table 2 and Graph 2a and b).

Statistical analysis

The analysis was performed using statistical analysis software Statistical Package for Social Sciences Version 17.0. The values were tabulated as number (%) and mean ± standard deviation. The following statistical formulas were used: One-sample "*t*" test, *t*-test critical value, and the level of significance.

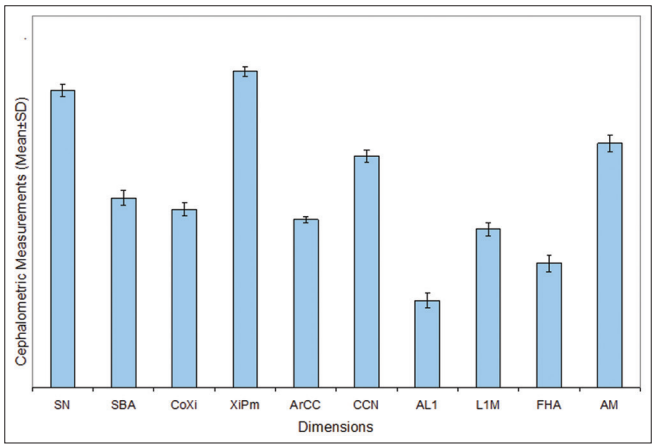
Discussion

Following show that study FH-A: Xi-CO (Frankfurt plane point A in maxilla is golden to condylar axis); 0.639, Xi-PM: Ar-CC (corpus axis of mandible is golden to Ar-cranial center);

Table 1: Cephalometric linear measurements.

S. No	SN	SBA	CoXi	XiPm	ArCC	CCN	AL1	L1M	FHA	AM
1	72	49	46	76	41	58	21	39	31	59
2	70	48	42	78	39	58	20	33	30	53
3	71	45	41	76	41	54	22	38	31	58
4	73	45	44	76	41	58	22	40	31	60
5	74	48	42	76	40	58	26	40	32	64
6	73	45	45	79	40	54	19	36	28	59
7	72	44	43	77	41	56	20	39	30	58
8	74	46	42	75	40	55	19	38	29	57
9	73	45	44	77	41	56	20	36	28	59
10	70	48	41	76	41	54	22	38	32	60
11	72	46	42	75	40	55	19	40	38	59
12	74	45	44	76	41	56	20	39	29	58
13	73	47	42	77	42	58	20	38	28	57
14	70	48	41	76	40	56	21	36	31	59
15	74	49	44	78	40	56	22	38	31	58
16	73	44	44	77	41	58	21	38	30	60
17	71	46	46	76	42	56	20	36	31	58
18	70	44	43	75	40	54	22	39	32	59
19	73	45	41	75	39	54	22	38	30	60
20	72	43	46	76	41	56	21	39	30	58
21	74	44	45	77	41	56	19	39	29	59
22	73	43	43	78	42	58	19	39	28	60
23	70	45	43	79	41	54	20	38	28	64
24	71	46	42	78	40	55	21	38	29	62
25	71	48	41	78	40	56	22	40	29	62
26	70	49	41	77	41	57	23	40	28	58
27	72	45	43	76	42	57	24	40	28	59
28	74	46	45	76	41	58	25	39	30	60
29	71	45	45	75	40	56	20	40	31	57
30	70	46	45	77	41	56	21	39	32	60
Mean	72.00	45.90	43.20	76.60	40.67	56.10	21.10	38.33	30.13	59.13
SD	1.49	1.77	1.67	1.16	0.80	1.45	1.75	1.60	2.03	2.11
COV (%)	2.06	3.85	3.86	1.52	1.97	2.58	8.29	4.19	6.74	3.57

SD: Standard deviation, COV: Coefficient of variation



Graph 1: Cephalometric linear measurements.

1.684, Xi-Pm: FH-A (corpus axis of mandible golden to Frankfurt plane point A); 2.553, S-N: S: Ba (anterior cranial fossa length is golden to posterior cranial fossa length); 1.571, S-N: Xi-Co (anterior cranial fossa length is golden to condylar axis of mandible); 1.669, S-Ba: Xi-Pm (posterior cranial fossa length is golden to corpus of mandible); 0.599, FH-A: S-Ba (vertical height, Frankfurt plane point A is golden is posterior cranial fossa length); 1.539, CO-Xi: CC-N (corpus axis of mandible is golden to cranial center and nasion); 0.620, CO-Xi: Xi-Pm (golden relationship between the corpus axis and condylar axis; (0.589), where $t \leq 3.65$ was very highly significant. Linear distances of Co-Xi and Xi-Pm measured were 43 mm and 76 mm, respectively, and ratio was 0.589.[6,20]

Similar results were reported by Ricketts who did a digitized cephalometric study on Peru population and found that, corpus axis was in golden/divine proportion to condylar axis (0.618), and inferred that it makes an excellent tool to determine mandibular dysplasia because of the relationship irrespective of age.[4,15]

The ratio S-N: S-Ba (anterior cranial fossa length is golden to posterior cranial fossa length) (1.571), which is in accordance with Ricketts who in a study on cover models found that the golden relation of S-N and S-Ba (1.618) which serves as a guide for analysis of nasopharynx and naso-oro airway and proportionality of anterior and posterior cranial base and protrusion of maxilla. This together with palatal length and nasopharyngeal depth in golden proportions, adds to

Table 2: Analysis of proportionality for cephalometric linear measurements.

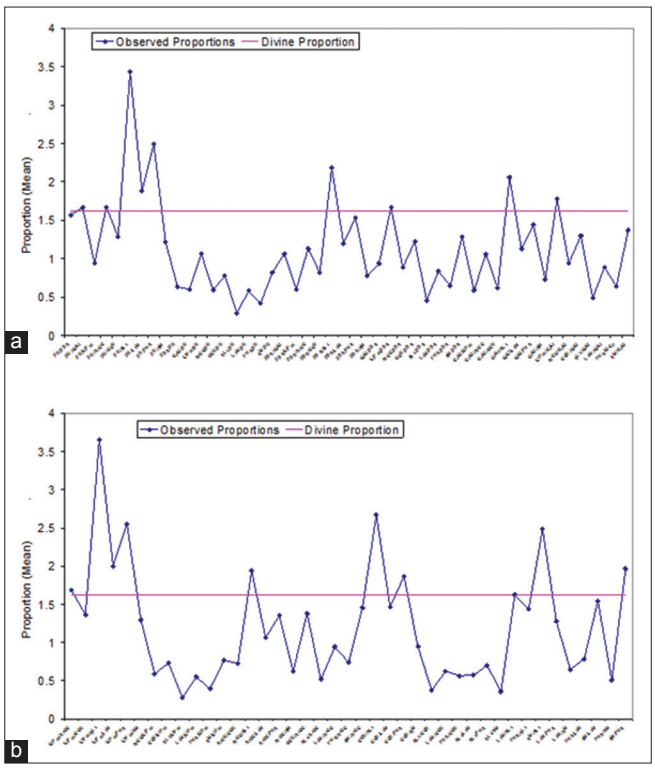
Cephalometric landmark interrelationship	*N*	Mean	SD	Standard error mean	*"t"*	Test for divine proportion
SN/SBA	30	1.571	0.074	0.013	−3.49	***
SN/CoXi	30	1.669	0.063	0.012	4.39	***
SN/XiPm	30	0.940	0.025	0.005	−149.19	*
SN/ArCC	30	1.671	0.048	0.009	17.30	*
SN/CCN	30	1.284	0.036	0.007	−51.36	*
SN/AL1	30	3.434	0.281	0.051	35.38	*
SN/L1M	30	1.881	0.084	0.015	17.10	*
SN/FHA	30	2.489	0.163	0.030	26.29	*
SN/AM	30	1.219	0.049	0.009	−44.77	*
SBA/SN	30	0.638	0.030	0.006	−176.78	*
CoXi/SN	30	0.600	0.023	0.004	−241.28	*
XiPm/SN	30	1.064	0.028	0.005	−106.91	*
ArCC/SN	30	0.595	0.015	0.003	−375.21	*
CCN/SN	30	0.779	0.022	0.004	−212.97	*
AL1/SN	30	0.293	0.025	0.004	−295.15	*
L1M/SN	30	0.583	0.023	0.004	−256.88	*
FHA/SN	30	0.419	0.031	0.006	−213.15	*
AM/SN	30	0.822	0.034	0.006	−130.14	*
SBA/CoXi	30	1.065	0.067	0.012	−45.00	*
SBA/XiPm	30	0.599	0.024	0.004	−232.44	***
SBA/ArCC	30	1.129	0.054	0.010	−49.60	*
SBA/CCN	30	0.819	0.034	0.006	−128.18	*
SBA/AL1	30	2.187	0.162	0.030	19.26	*
SBA/L1M	30	1.200	0.077	0.014	−29.89	*
SBA/FHA	30	1.539	0.102	0.019	−4.79	*
SBA/AM	30	0.777	0.043	0.008	−107.84	*
CoXi/SBA	30	0.943	0.059	0.011	−62.69	*
XiPm/SBA	30	1.671	0.067	0.012	4.34	*
ArCC/SBA	30	0.887	0.042	0.008	−95.01	*
CCN/SBA	30	1.224	0.052	0.009	−41.73	*
AL1/SBA	30	0.460	0.036	0.007	−176.13	*
L1M/SBA	30	0.837	0.050	0.009	−85.39	*
FHA/SBA	30	0.647	0.047	0.009	−111.86	***
AM/SBA	30	1.290	0.068	0.012	−26.41	*
CoXi/XiPm	30	0.589	0.023	0.004	−248.35	***
CoXi/ArCC	30	1.062	0.039	0.007	−77.75	***
CoXi/CCN	30	0.620	0.032	0.006	−147.04	*
CoXi/AL1	30	2.061	0.192	0.035	12.62	*
CoXi/L1M	30	1.129	0.065	0.012	−40.96	*
CoXi/FHA	30	1.439	0.104	0.019	−9.42	*
CoXi/AM	30	0.732	0.040	0.007	−121.47	*
XiPm/CoXi	30	1.776	0.072	0.013	11.93	*
ArCC/CoXi	30	0.942	0.035	0.006	−106.20	*
CCN/CoXi	30	1.300	0.053	0.010	−32.73	*
AL1/CoXi	30	0.489	0.048	0.009	−128.50	*
L1M/CoXi	30	0.889	0.050	0.009	−79.96	*
FHA/XiCo	30	0.639	0.056	0.010	−90.06	***
AM/CoXi	30	1.371	0.076	0.014	−17.79	*
XiPm/ArCC	30	1.684	0.046	0.008	32.05	***
XiPm/CCN	30	1.366	0.040	0.007	−34.49	*
XiPm/AL1	30	3.654	0.300	0.055	37.12	*
XiPm/L1M	30	2.002	0.104	0.019	20.16	*
XiPm/FHA	30	2.553	0.180	0.033	28.53	***
XiPm/AM	30	1.297	0.048	0.009	−36.66	*
ArCC/XiPm	30	0.591	0.013	0.002	−472.31	**
CCN/XiPm	30	0.733	0.021	0.004	−230.28	*
AL1/XiPm	30	0.276	0.024	0.004	−304.93	*
L1M/XiPm	30	0.551	0.024	0.004	−251.06	**
FHA/XiPm	30	0.394	0.030	0.006	−221.94	*
AM/XiPm	30	0.772	0.028	0.005	−167.88	*

Contd...

Table 2: Analysis of proportionality for cephalometric linear measurements.

Cephalometric landmark interrelationship	*N*	Mean	SD	Standard error mean	"*t*"	Test for divine proportion
ArCC/CCN	30	0.725	0.019	0.004	−251.90	*
ArCC/AL1	30	1.939	0.157	0.029	11.24	*
ArCC/L1M	30	1.063	0.046	0.008	−66.23	*
ArCC/FHA	30	1.355	0.095	0.017	−15.20	*
ArCC/AM	30	0.629	0.027	0.005	−189.93	*
CCN/ArCC	30	1.380	0.037	0.007	−34.88	*
AL1/ArCC	30	0.519	0.044	0.008	−135.41	*
L1M/ArCC	30	0.943	0.039	0.007	−93.66	*
FHA/ArCC	30	0.742	0.056	0.010	−85.57	*
AM/ArCC	30	1.455	0.058	0.011	−15.44	**
CCN/AL1	30	2.674	0.205	0.037	28.19	*
CCN/L1M	30	1.466	0.074	0.014	−11.22	**
CCN/FHA	30	1.870	0.129	0.024	10.65	*
CCN/AM	30	0.950	0.045	0.008	−81.03	*
AL1/CCN	30	0.376	0.030	0.005	−227.68	*
L1M/CCN	30	0.624	0.032	0.006	−161.87	*
FHA/CCN	30	0.568	0.041	0.007	−144.43	**
AL1/L1M	30	0.571	0.043	0.008	−137.29	**
AL1/FHA	30	0.703	0.068	0.012	−74.25	*
AL1/AM	30	0.357	0.027	0.005	−255.99	*
L1M/AL1	30	1.626	0.139	0.025	8.17	*
FHA/AL1	30	1.437	0.147	0.027	−6.74	*
AM/AL1	30	2.487	0.209	0.038	31.48	*
L1M/FHA	30	1.277	0.088	0.016	−21.18	*
L1M/AM	30	0.649	0.027	0.005	−197.75	*
FHA/L1M	30	0.787	0.057	0.010	−79.62	*
AM/L1M	30	1.544	0.065	0.012	−6.24	*
FHA/AM	30	0.510	0.039	0.007	−157.16	*
AM/FHA	30	1.970	0.141	0.026	13.70	*

*$t \leq 2.05$ Significant, *$t \leq 2.75$ highly significant, ***$t \leq 3.65$ very highly significant. Statistically all the ratios calculated for linear cephalometric measurements were significantly different from divine proportions



Graph 2: (a and b) Analysis of proportionality for cephalometric linear measurements. *Difference from divine proportion is statistically significant.

estimates of functional desirability and surgical planning of the palate.[4,16-18]

In North Indian females S-N, i.e., (Sella-Nasion distance) anterior cranial base length is 72 mm, However, this is a much lower value than the study done by Dibbets and Nolte.[3] They compared the linear measurement of anterior cranial base length of different groups of population (Ann Arbor - 78 m, Nashville - 75 mm, Cleveland - 72 mm, and Philadelphia - 72 mm) and concluded that the anterior cranial base length (S-N) in Ann Arbor population was clearly longer than other three.[19,20]

Our study concludes that more beautiful faces show less deviation from that of golden proportions and little variable in young attractive faces of North Indian.

In this study, we dealt with only one group of population, i.e., North Indian among Asian racial group, whereas Richardson *et al.* who investigated on various groups of population among whites, i.e., Nashville, Americans of African descent, concluded that racial differences with in one group is always greater than the differences in among different groups. It showed the limitation in our study, which could be further elaborated by comparing North Indian faces with South Indians, Maharashtrian population, and so on.[21-23]

Conclusion

On hard tissue examination, the ratios were found to be very close to divine proportion. Therefore, it shows that the underlying hard tissue structures have a significant proportionate relationship with the facial attractiveness. However, one must take account of the number of available measurements that can be made in a particular anatomical area as complicated as human skull and also further study, including this mathematical relationship is essential before ascertaining its use as an important parameter for production of esthetic harmony.

In future, above study will help in digital simulation of attractive human face in North Indian ethnic origin and so rest; it will help even more for orthognathic surgical diagnosis and treatment planning.

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