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Relationship of curve of Spee & dentofacial morphology in North Indian population – An in vitro study



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Sexual Dimorphism

ABSTRACT

Objective: The purpose of the study was to evaluate the relationship of curve of Spee with dentofacial morphology using multiple linear regression analysis and to determine sexual dimorphism in North Indian population.

Method: Two hundred subjects were selected and divided into two groups of 100 males and 100 females. Lateral Cephalogram and models of all the subjects were taken. After tracing the cephalograms various dentofacial & dental parameters were measured: Dentofacial parameters were SNA angle, SNB angle, ANB angle, APDI angle, ODI angle, FMA angle, Ar-Go-Me, Go-Me, Ar-Go, G-Sn-Pog', Cm-Sn-Ls, U to E-line, and L to E line. Dental parameters were Curve of Spee, Intercanine width, Intermolar width, Arch length and Dental arch form. Data thus obtained were subjected to statistical analysis.

Results: The results suggested that the curve of Spee is more influenced by the dental morphology as compared to the dentofacial morphology, but it is not affected by sexual dimorphism.

Conclusion: There is a significant correlation between mandibular curve of Spee and certain dental and dentofacial parameters.

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1. Introduction

The functional significance of curve of Spee was first described by F Graf Von Spee in 1890. He used skulls with abraded teeth to define the line of occlusion as the line on a cylinder tangent to the anterior border of the condyle, the occlusal surface of the second molar, and the incisal edges of the mandibular incisors.[1] The curve of Spee has a biomechanical function during food processing by increasing the crush-shear ratio between the posterior teeth and the efficiency of occlusal forces during mastication.[2] Spee located the center of the cylinder in the midorbital plane so that it measured 6.5–7.0 cm radius.[2]

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Baragar and Osborn[3] related the anatomy of the curve of Spee to mandibular morphology and biting force, concluding that in the sagittal plane, the long axes of mandibular molars are in the direction that most efficiently converts muscle force into work. Orthodontic correction of the overbite often involves leveling the curve of Spee by anterior intrusion, posterior extrusion, or a combination of these actions. The process of proclining the lower incisor has been used to decrease the relative vertical overlap of the lower incisors by the upper incisors.[4]

The deviation of the occlusal plane from a flat plane has practical consequences when considering the arch circumference requirements necessary to flatten the curve. Indisputably, a curved arch has a greater circumference than a flat arch. However, the amount of additional arch circumference required to flatten the curve is not as apparent. A popular theory is that 1 mm of arch circumference is needed to level each millimeter of the curve of Spee. Yet, Baldridge and Garcia[5] found that less than 1 mm of arch circumference is required to level each millimeter of the curve of Spee.

On the other hand, Andrews[6] stated that there is a natural tendency of the curve of Spee to deepen with time because downward and forward growth of the lower jaw is sometimes faster and continues longer than that of the upper jaw. This causes the lower anterior teeth, which are confined by the upper anterior teeth and lips, to be forced back and up, resulting in crowded lower anterior teeth and/or a deeper overbite and deeper curve of Spee.

The researches earlier evaluated the effect of curve of Spee on certain parameters like overbite and overjet as well on dentofacial structures of different racial populations, but very few studies have been conducted acknowledging the same subject in North Indian population. Hence, this study is designed to assess the relationship of curve of Spee and dentofacial morphology in North Indian population. Since, India is a subcontinent with a large number of racial subgroups and several religious and interracial mixtures, it was proposed, therefore, to study only the individuals from North India.

1.1. *Aim & objectives*

1. To evaluate the curve of Spee of mandibular arch in North Indian population.
2. To determine the sexual dimorphism for mandibular curve of Spee.
3. To evaluate the relationship of mandibular curve of Spee and dentofacial morphology in North Indian population with multiple regression analysis.

2. Materials & methods

The study was conducted in the Department of Orthodontics and Dentofacial Orthopedics at Kothiwal Dental College and Research Centre, Moradabad (U.P. India). Subjects ranged in the age group of 18–24 yrs, were taken for the study. The lateral cephalograms and study models of these subjects were taken from the previous records available in the Department of Orthodontics and Dentofacial Orthopedics. Before starting the study name, age and sex of each subject was recorded.

2.1. *Inclusion criteria*

- Subjects who were analyzed to be average growers as per the Frankfort mandibular plane angle (FMA-21°–29°) and Gonial angle (130° ± 7°)
- Dental Class I molar relationship bilaterally and clinically normal arch shapes
- Minimal dental crowding or spacing (≤2 mm)
- No anterior or lateral crossbite
- No history of previous orthodontic treatment
- No pathologic periodontal condition
- No history of temporomandibular disorders
- No history of orthognathic surgery and/or surgery for developmental disorders like cleft lip and palate
- No cast restorations or cuspal coverage

200 subjects were equally divided into two groups based on sex (i.e. 100 males and 100 females). All these subjects were from Uttar Pradesh, India and had a North Indian ancestory. Various dentofacial parameters and dental parameters were measured on cephalometric tracings and study models. The dentofacial parameters consisted of the hard and soft tissue cephalometric landmarks[7] (Fig. 1), planes[7,8] (Fig. 2),angular and linear measurements[7–12] (Figs. 3 and 4).

- The following dental measurements were recorded on study models:
  1. **Curve of Spee (COS)**[1]: Measured as the perpendicular distance between the deepest cusp tip and a flat plane that was laid on top of the mandibular dental cast, touching the incisal edges of the central incisors and the distal cusp tips of the most posterior teeth in the mandibular arch (Fig. 5).
  2. **Intercanine width (ICW)**[1]: Distance measured between the tips of the right and left canines (Fig. 6).
  3. **Intermolar width (IMW)**[1]: Distance measured between the tips of the right and left first molar mesiobuccal cusps (Fig. 6).

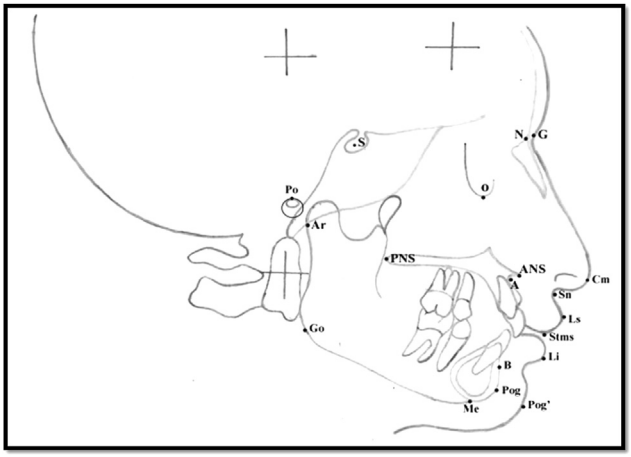


Fig. 1 – Showing cephalometric hard and soft tissue landmarks.

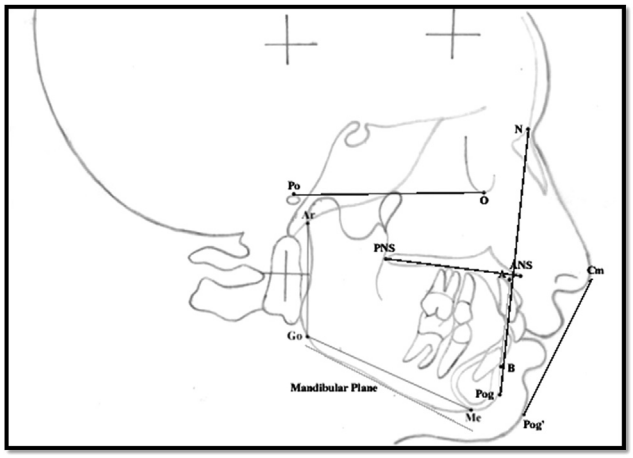


Fig. 2 – Showing cephalometric hard and soft tissue planes.

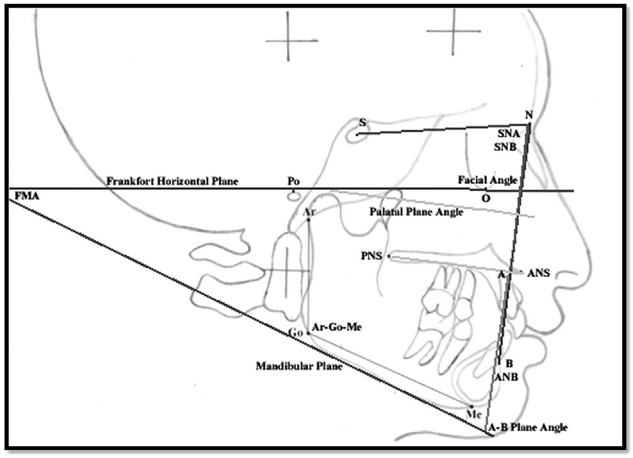


Fig. 3 – Showing cephalometric hard tissue angular and linear measurements.

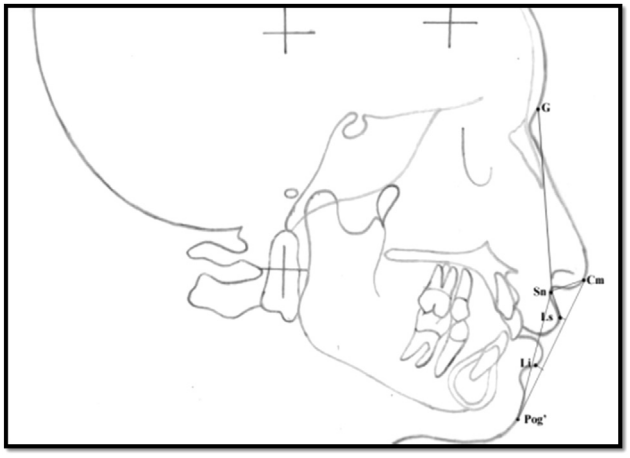


Fig. 4 – Showing cephalometric soft tissue angular & linear measurements.

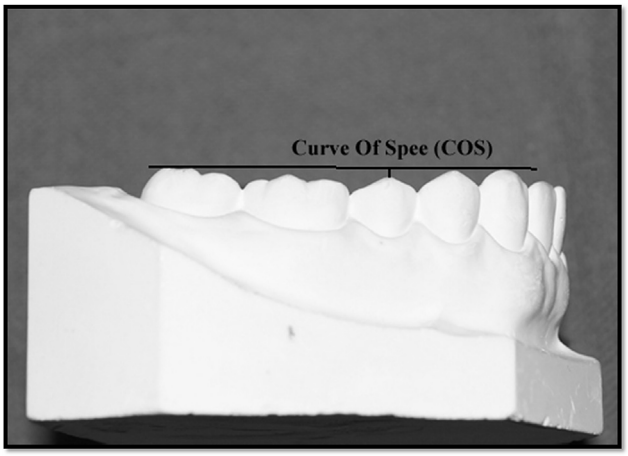


Fig. 5 – Showing Curve of Spee (COS) measurement on mandibular arch.

4. **Arch length (AL)**[1]: Distance measured from a line connecting the tips of the right and left second molar distobuccal cusps to the midpoint of the right and left central incisor edges (Fig. 6).
5. **Dental arch form**[1]: Symmetry of the dental arch evaluated by using the perpendicular distances from the midline of mandibular arch to the right and left canine cusp tip (RMn.C, LMn.C), the right and left second molar distobuccal cusp tip (RMn.M, LMn.M), and the distances from the midpoint of the right and left central incisors edge to the tips of the right and left second molar distobuccal cusp tip (RMn.2M, LMn.2M) (Fig. 7).

To check the intra-examiner reliability and accuracy in location of landmarks and in the linear and angular measurements, 15 cephalograms and their study models were randomly selected and the measurement obtained were compared with the first measurement to find out difference if any in the location of landmark, planes, and study models measurements. Data obtained from 1st and 2nd measurement were subjected to statistical evaluation to find out error in

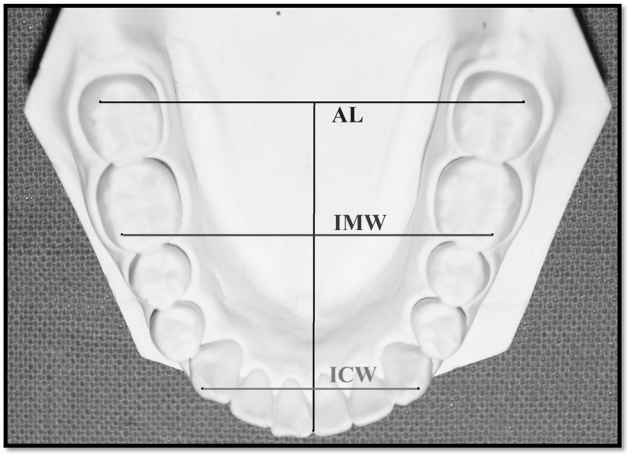


Fig. 6 – Showing intercanine width (ICW), Intermolar width (IMW) and Arch Length (AL) measurements on Mandibular arch.

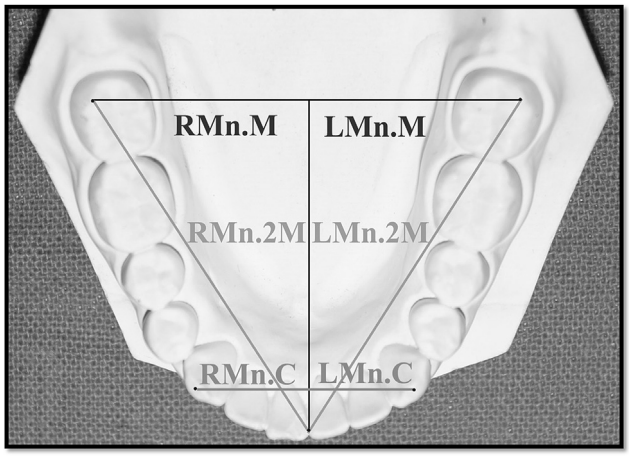


Fig. 7 – Showing dental arch form measurements on mandibular arch – Right & Left canine cusp tip distance from midline (RMn.C, LMn.C), Right & Left Second molar distobuccal cusp tip distance from midpoint (RMn.2M, LMn.2M), Right & Left Second molar distobuccal cusp tip distance from midline.

measurement. The results obtained were found to be statistically non-significant.

2.2. *Statistical analysis*

A series of parametric tests were conducted to analyze the data collected. The data were analyzed with a software program (SPSS version 16.0, Statistical Package for the Social Science for Windows). The Pearson correlation analysis was used to determine the correlation coefficients between the mandibular arch curve of Spee and other variables. Furthermore, a multiple regression analysis was performed to determine the relationship between the curve of Spee as the dependent variable and the other variables as the independent variables. The level of significance for all statistical tests was set at $p < 0.05$.

3. Results

The mean value of mandibular arch curve of Spee was found to be 1.85 with standard deviation 0.63 and standard error of mean 0.04 (Table 1) in North Indian population. There were statistically insignificant difference was found between the males and females mandibular arch curve of Spee with $p = 0.439$ (Table 2). Dentofacial parameters and their correlation to the mandibular arch curve of Spee in males showed that FMA had statistically significant negative correlation with mandibular arch curve of Spee with $p = -0.251^{**}$ (Table 3).

There was statistically insignificant correlation between dental measurements and mandibular arch curve of Spee in males (Table 4). On correlating, the dental arch form and dental arch symmetry with mandibular arch curve of Spee, mandibular canine region showed statistically significant negative correlation in males (Table 5).

There was statistically insignificant correlation between dentofacial parameters and mandibular arch curve of Spee in females (Table 6). Dental measurements and their correlation to the mandibular arch curve of Spee in females showed that mandibular intercanine width had statistically significant negative correlation with mandibular arch curve of Spee with $p = -0.221^{*}$ (Table 7).

The dental arch form and dental arch symmetry showed statistically insignificant correlation to the mandibular arch curve of Spee in females (Table 8). In the multiple linear regression analysis for mandibular arch curve of Spee, it was found that the curve of Spee in the mandibular arch is significantly influenced by FMA angle. The FMA angle explains about 6.3% of the total variance of the curve of Spee in regression model (Table 9).

Table 1 – Showing mean, standard deviation, and standard error mean for mandibular arch curve of Spee.

Curve of Spee (mm)	Mean	S. D.	S.E.M
Mand. COS	1.85	0.63	0.04

4. Discussion

The curve of Spee is an important characteristic of the mandibular dental arch.[13] The functional significance[14] of the curvature has not been completely understood. The human craniofacial skeleton[15] and its associated dental arches undergo visible alterations as they grow, adapt, and age. Relatively rapid changes occur during the transitional dentition, and once a functional permanent dentition is established, smaller changes continue to be observed. Although[16] there was literature found that indicated that there were significant changes occurring in the dentofacial complex into adulthood. These significant changes was observed by Harris (1997)[17] and Marcus et al (2008).[18] The sum of these studies is that the form, function, size, and shape of the components continue to reflect small, but often statistically significant changes. Among these studies, Harris and Marcus has attempted to describe dental arch changes as late as the sixth decade.

Table 2 – Showing sex differences for mandibular arch curve of Spee

Curve of Spee (mm)	Males			Females			(p-value)	Sig.
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M		
COS Mand.	1.89	0.68	0.07	1.82	0.58	0.06	0.439	N.S.

*Level of significance: 'p' is the probability level of significance of test – 'p' < 0.05 = significant (S) and 'p' > 0.05 is non significant (N.S).

Table 3 – Showing dentofacial parameters and their correlation to the mandibular arch curve of Spee in males.

Dentofacial parameters	Pearson correlation (r)	p-value	Sig.
SNA (deg.)	0.117	0.245	N.S.
SNB (deg.)	0.088	0.386	N.S.
ANB (deg.)	0.001	0.995	N.S.
FMA (deg.)	−0.251[a]	0.012	S
Ar-Go-Me (deg.)	−0.022	0.832	N.S.
APDI (deg.)	0.051	0.612	N.S.
ODI (deg.)	0.054	0.593	N.S.
G-Sn-Pog' (deg.)	0.077	0.449	N.S.
Cm-Sn-Ls (deg.)	−0.061	0.544	N.S.
Ar-Go (mm)	−0.038	0.711	N.S.
Go-Me (mm)	−0.019	0.854	N.S.
U-E line (mm)	0.021	0.836	N.S.
L-E line (mm)	0.012	0.908	N.S.

[a] Correlation is significant at 0.05.

Table 4 – Showing dental measurements and their correlation to the mandibular arch curve of Spee in males.

Dental measurements (mm)	Pearson correlation (r)	p-value	Sig.
ICW Mand.	−0.177	0.078	N.S.
IMW Mand.	−0.103	0.306	N.S.
Arch Len. Mand.	−0.135	0.181	N.S.

The subjects selected were of 18–24 years age since it was observed that dental arch dimensions and curve of Spee remains unchanged after 24 yrs of age, supported by the studies conducted by Michelotti et al (2002),[15] Carter et al (1998),[16] and it was also found that the arch dimensions and the curve of Spee were not influenced by gender, supported by Hui et al (2004)[13] and Virgilio et al (1999).[19]

The mean value of mandibular arch curve of Spee was found to be 1.85 mm in North Indian population (Table 1). These findings fall in the range of norm, i.e. 0–2.5 mm curve of Spee, as proposed by Lawrence F. Andrews.[6]

On conducting a comparison of males and females for mandibular arch curve of Spee statistically no significant difference was found (Table 2). This finding is strongly supported by previous studies[2,11,13,16] conducted in this regard. Hence, it is thereby suggested that the mandibular curve of Spee is independent of sexual dimorphism.

On establishing a correlation between mandibular arch curve of Spee and dentofacial parameters characteristic findings were revealed in males (Table 3). A statistically significant ($p < 0.05$) negative correlation ($r = -0.251$) was found between mandibular arch curve of Spee and the FMA angle in males. This significant negative correlation is in accordance with the study conducted by Shannon and Nanda (2004),[20] who found that patients with lower mandibular plane angles had deeper curves than those with high angles.

On establishing a correlation between mandibular arch curve of Spee and dental measurements in males, a statistically insignificant ($p > 0.05$) correlation was found (Table 4), which are in agreement with the study conducted by Cheon et al.[1]

While establishing a correlation of mandibular arch curve of Spee with dental arch form and dental arch symmetry in males, characteristic findings were found (Table 5). Statistically significant ($p < 0.05$) negative correlation ($r = -0.297^{**}$) was found between mandibular arch curve of Spee and the mandibular canine region. Hence, this suggests that as the mandibular arch curve of Spee increases, the mandibular

Table 5 – Showing dental arch form, symmetry of dental arch and their correlation to the mandibular arch curve of Spee in males.

Dental arch form (mm)	Pearson correlation (r)	p-value	Sig.
Mn.C	−0.297**	0.008	S
Mn.2M	0.125	0.088	N.S.
MnM	−0.041	0.298	N.S.

**Correlation is significant at 0.05.

Table 6 – Showing dentofacial parameters and their correlation to the mandibular arch curve of Spee in females.

Dentofacial parameters	Pearson correlation (r)	p-value	Sig.
SNA (deg.)	−0.177	0.078	N.S.
SNB (deg.)	−0.128	0.206	N.S.
ANB (deg.)	−0.047	0.645	N.S.
FMA (deg.)	0.073	0.472	N.S.
Ar-Go-Me (deg.)	0.079	0.435	N.S.
APDI (deg.)	0.181	0.072	N.S.
ODI (deg.)	−0.008	0.939	N.S.
G-Sn-Pog' (deg.)	−0.136	0.178	N.S.
Cm-Sn-Ls (deg.)	−0.094	0.355	N.S.
Ar-Go (mm)	−0.084	0.408	N.S.
Go-Me (mm)	0.071	0.482	N.S.
U-E line (mm)	0.05	0.619	N.S.
L-E line (mm)	0.026	0.8	N.S.

Table 7 – Showing dental measurements and their correlation to the mandibular arch curve of Spee in females.

Dental measurements (mm)	Pearson correlation (r)	p-value	Sig.
ICW Mand.	−0.221[a]	0.027	S
IMW Mand.	0.153	0.129	N.S.
Arch Len. Mand.	−0.029	0.772	N.S.

[a] Correlation is significant at 0.05.

Table 8 – Showing dental arch form, symmetry of dental arch and their correlation to the mandibular arch curve of Spee in females.

Dental arch form (mm)	Pearson correlation (r)	p-value	Sig.
Mn.C	0.068	0.502	N.S.
Mn.2M	−0.149	0.139	N.S.
MnM	−0.003	0.974	N.S.

Table 9 – Showing multiple linear regression analysis for mandibular arch curve of Spee.

Dependent variable (Sp)	Statistically significant independent variables	B	S.E	Beta	t-value	p-value	R^2 value
COS Mand.	FMA (deg.)	0.025	0.009	0.191	2.73	0.007*	0.063
	ICW Mand.	−0.003	0.002	−0.121	−1.716	0.088	
	Mand. Canine	−0.013	0.024	−0.039	−0.542	0.588	

Where Sp, mandibular curve of Spee; B, unstandardized regression coefficient; S.E, standard error of B; Beta, standardized regression coefficient.

canine region decreases. A possible explanation for the above interesting finding lies in the fact that as the mandibular arch curve of Spee deepens with time, the lower anterior teeth are forced back and up causing the intercanine width to decrease, as has been explained by Lawrence F. Andrews.[6] Whether or not the mandibular curve of Spee can be considered as a predictor of mandibular canine region is subject to further scientific verification in future research work.

On establishing a correlation between mandibular arch curve of Spee and dentofacial parameters in females, characteristic findings were revealed (Table 6). Statistically insignificant ($p > 0.05$) correlation was found between mandibular arch curve of Spee and dentofacial parameters.

On establishing a correlation between mandibular arch curve of Spee and dental measurements in females (Table 7), a statistically significant ($p < 0.05$) negative ($r = -0.221$*) correlation was found between mandibular intercanine width and mandibular arch curve of Spee. Hence this finding is suggestive of the fact that with the increase in the mandibular arch curve of Spee, the mandibular intercanine width decreases. This was supported by the study done by Lawrence F. Andrews.[6]

While establishing a correlation of mandibular arch curve of Spee with dental arch form and dental arch symmetry in females, statistically insignificant ($p > 0.05$) correlation was found (Table 8), which are in agreement with the study conducted by Cheon et al.[1]

Multiple Linear regression analysis suggests that the curve of Spee is more influenced by dental morphology as compared to dentofacial morphology. Only 6.3% of the variance of the curve of Spee could be explained by dentofacial morphology (Table 9). This finding was supported by the study done by Michelloti et al (2002),[15] who found that only one third of the variance of the curve could be explained by the dentofacial variables.

The literature states that most of the variation of the curvature remains unexplained by dentofacial morphology and could probably be explained better by other factors. This was supported by the study done by Baydas et al (2004).[2]

5. Conclusion

From the analysis of cephalograms, measurements of study models and results obtained, the following conclusions can be drawn:

1. The mean mandibular arch curve of Spee is 1.85 mm in North Indian population.
2. The curve of Spee is not influenced by sex.
3. The mandibular arch curve of Spee is significantly negatively correlated with FMA and mandibular canine region in males and mandibular intercanine width in females.
4. The mandibular arch curve of Spee has no correlation with dentofacial parameters in females.
5. Only 6.3% of the variance of curve of Spee could be explained by dentofacial morphology, as suggested by multiple linear regression analysis. Hence, only a minor part of the variance of curve of Spee can be explained by dentofacial variables and it is more influenced by the dental morphology.

Conflicts of interest

All authors have none to declare.

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