Original Article

A correlative study to evaluate the contributions of various dental and skeletal components in subjects with varying depth of Curve of Spee.

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ABSTRACT

Introduction: This occlusal curvature is a naturally occurring phenomenon in the human dentition, describedin the late 19th century, by Ferdinand Graf von Spee. It is an inveterate parameter in describing ideal occlusion.The phenomenon still needs an immense understanding of its determinants to unravel all the aspects of its existence and the role that it plays in governing the other dental and skeletal variables.

Materials and Methods: A total of 107 patient pre-treatment records were selected. The lateral cephalograms and study models of the selected sample were thoroughly evaluated based on various skeletal and dental cephalometric and cast parameters. For the precision in the measurement of the depth of curve of Spee and thereby precise grouping, a computer based photographic method was employed for which a standardized photographic set-up was advocated.

Results: Statistically significant correlations were found between the depth of curve of Spee and overjet, lower incisor–NPg mm, lower incisor–NPg^0, lower incisor–NB and Md-PABH measurements. Amongst these significant values Md-PABH, L1-NB, L1-MP, L1-NPg (^{0}) and L1-NPg (mm) were negatively correlated and overjet was positively correlated.

Conclusions: It was deduced that Curve of Spee is more influenced dentally and to a minor extent by facial morphology.

Keywords: Curve of Spee, Photographic Method, Irregularity Index, Cephalometric Parameters, Overbite.

INTRODUCTION

Curve of spee is not just a curve that can be viewed in the sagittal plane. It is an entity that has a multifactorial dependence and still has many unexplored horizons. It is not a chance occurrence but it holds a developmental as well as a biomechanical significance not only in the envelope of jaw movement but also in the orientation of dentition with respect to the craniofacial morphology.

This occlusal curvature is a naturally occurring phenomenon in the human dentition, described in the late 19th century, by Ferdinand Graf von Spee.[1] In the sagittal view, Spee connected the anterior surfaces of the mandibular condyles to the occlusal surfaces of the mandibular teeth with an arc of a circle, tangent to the surface of a cylinder lying perpendicular to the sagittal plane. The center of this cylinder was in the mid-orbital plane so that it had a radius of 6.5 to 7.0 cm.[1] He suggested that this geometric arrangement defined the most efficient pattern for maintaining maximum tooth contacts during chewing.

It is an inveterate parameter in describing ideal occlusion. Andrews[2] while describing the six characteristics of normal occlusion, found that the curve of Spee in subjects with good occlusion and intercuspation ranged from flat to mild. He proposed that flattening the occlusal plane should be the treatment goal in orthodontics.

The phenomenon still needs an immense understanding of its determinants to unravel all the aspects of its existence. Yet another consideration is the role that it plays in governing the other dental and skeletal variables. The aims and objectives of the following study were:

1. To evaluate cephalometrically the differences in the various dental and skeletal parameters in subjects with varying depth of curve of spee.
2. To examine the differences in the dental cast parameters in the same subjects with varying depth of curve of spee.

3. To determine, if any correlation exists between depth of curve of spee and any of these components.

To assess the actual contributions of these parameters in its development.

MATERIAL AND METHOD

SITE OF THE STUDY

The present retrospective, cross-sectional study was conducted in Department of Orthodontics and Dentofacial Orthopedics, D.A.V. (C) Dental College and Hospital, Yamuna Nagar, Haryana.

STUDY POPULATION

The subjects included in the study were of North Indian origin. The material for this present study comprised of initial pre-treatment orthodontic records (lateral cephalogram and orthodontic study models) of patients collected from the archives of the department as well as those who were undergoing comprehensive fixed orthodontic treatment in the department. All these subjects were then screened for fulfillment of the following inclusion criteria:

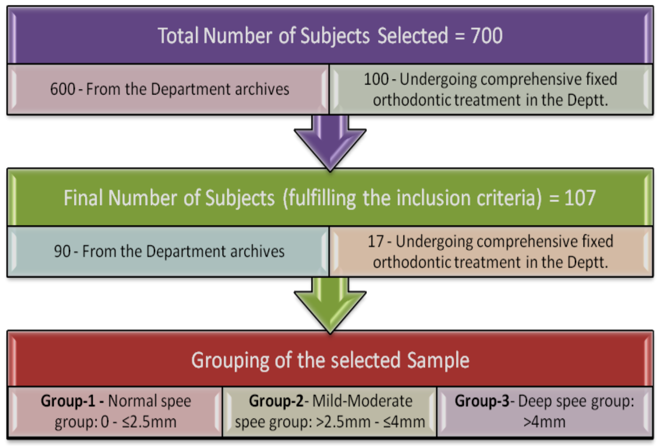
- Full complement of teeth were present till 2nd molar.
- No history of previous orthodontic treatment.
- No advanced carious lesions involving crowns, large restorations that might misinterpret the measurements.
- No cranio-facial anomalies, congenital anomalies (Cleft Lip & Palate) syndromes and developmental disturbances.
- No history of any facial trauma that deranges occlusion.
- No mutilated or periodontally compromised condition.
- There should be no pernicious habits
- Files of the subjects with poor quality records were excluded.
- Severe class-II and class-III malocclusions were not considered.

SAMPLE SIZE AND SUBJECT CHARACTERSTICS

A total of 700 patient pre-treatment records were selected. The lateral cephalograms and study models with bases of the selected sample were thoroughly evaluated to get the sample for the study to have a power of 80% and standard error of significance to be 0.05.[11] A total of 107 subjects fulfilling the 90% probability as calculated by power analysis using G Power 3.1.3 software were enrolled in the study. All these subjects aged from 14-20 years with the mean age of 16.58 years (SD ± 2.06). There were 50 males and 57 females in the total sample. (fig. 1)

SAMPLE SIZE AND GROUPING

(FIGURE 1)



GROUPING OF THE SAMPLE

The stratified randomly selected sample was grouped according to the depth of curve of spee. According to Andrews[2], a curve of spee is incorrect if it is less than 0 or more than 2.5mm. Therefore three spee groups were classified as follows:

Group-1- Normal spee group : 0 - ≤2.5mm

Group-2- Mild-Moderate spee group : >2.5mm - ≤4mm

Group-3- Deep spee group : >4mm

For the precision in the measurement of the depth of curve of spee and thereby precise grouping, a computer based photographic method was employed for which a standardized photographic set-up was advocated as shown in figure 2. For the uniformity of the photographs, DSLR Nikon D3000 camera was mounted on the set up to keep the constant camera to object distance of 25 cm. Each photograph was calibrated to obtain 1:1 magnification. These photographs were processed in Adobe Photoshop 7.0 software for life size output and measurement of curve of spee and irregularity index. This software enabled calibrations of photographs by defining the length of a standard ruler photographed with the dental cast. For each subject the right side and left side of the lower cast was captured in a plane perpendicular to the occlusal plane tangent to the buccal surface of 2nd molar, 1st molar, canine, and pre-molars and the mean value of these two measurements was used as the depth of curve of Spee. Following this, there were 50 subjects in Group-1, 38 subjects in Group-2 and 19 subjects in Group-3. All the cephalometric and photographic measurements were made (table 1 and 2) and (figures 3 – 13).

Standardized photographic set-up
(FIGURE 2)

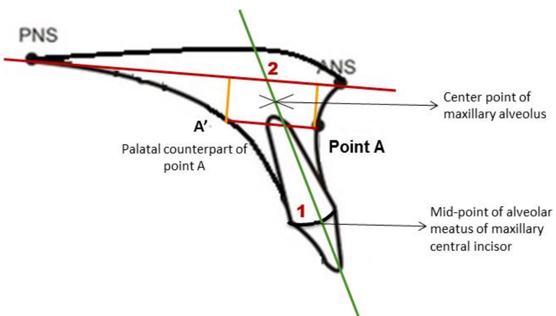


Fig. 3 Mx-AABH (mm), here, 1 - midpoint of the alveolar meatus of the maxillary central incisor and 2 - intersection point on the palatal plane.

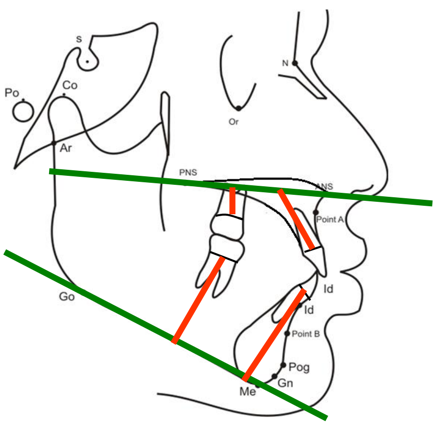


Fig. 4: 1– Mx-PABH; 2 – Md-PABH; 3 – Mx-AABH and 4 – Md-AABH

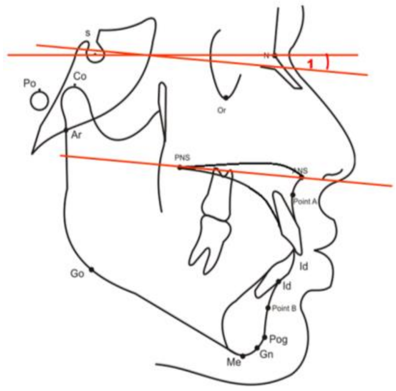


Fig. 5: SN-MxP, 0 (1)

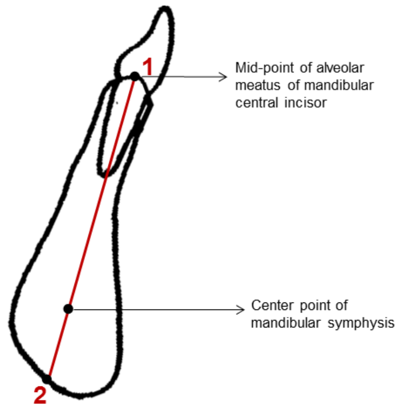


Fig. 6: Md-AABH (mm), here, 1 - midpoint of the alveolar meatus of the mandibular central incisor and 2 - intersection point on the mandibular symphysis. Distance from 1-2 is Md-AABH

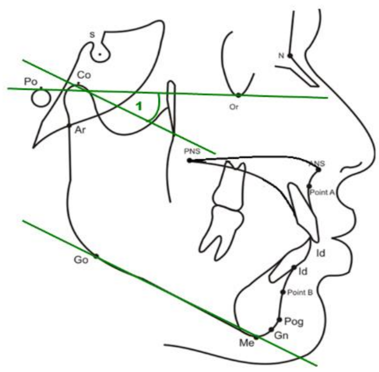


Fig. 7: 1. MndP-FH,0

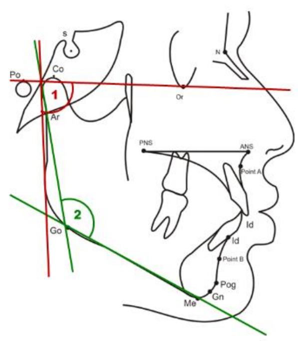


Fig. 8: 1. Ramus/FH, 0 2. Gonial

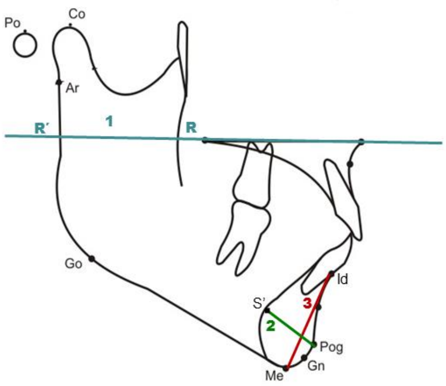


Fig. 9: 1 Ramus Width (mm) from R to R'; 2 – Symphysis Depth (mm) from S' to Pog and 3 – Symphysis Height from Id to Me (mm).

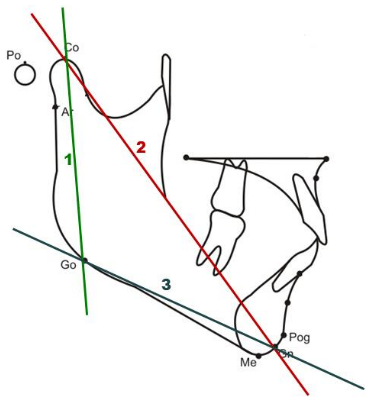


Fig. 10: 1–Condylion-Gonion (mm); 2–Condylion-Gnathion (mm) and 3–Gonion-Gnathion (mm).

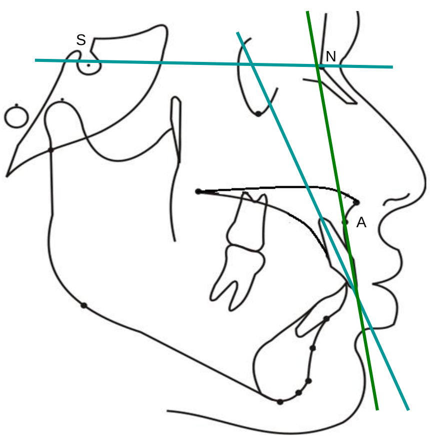


Fig. 11: 1 – U1-SN (0) and 2 – U1-NA (0)

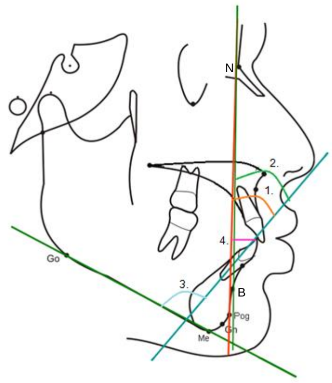


Fig. 12: 1 – L1-NPg(0), 2 – L1-NB(0) ; 3 – L1-MP(0); 4-L1-NPg(mm)

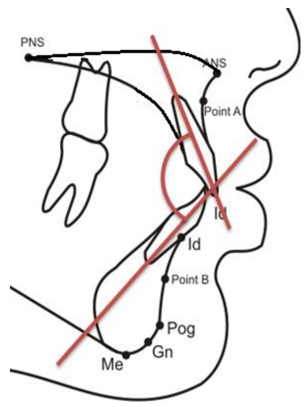


Fig. 13: Interincisal Angle (0)

ERROR STUDY[10]

To test the reliability of the measurements, 10 sets of cephalograms, study models and digital photographs were selected randomly and experimental procedure was repeated. Testing for method error for all measurements was done with Dahlberg's formula (table 3). The method error didn't exceed .40 for the angular measurements (range between .11-.40) and .46 for the linear measurements (range between .1-.46) Intra examiner reliability (table 4) and Inter examiner reliability (table 5) were quantified by using intra-class correlation (ICC) test and paired t test on 10 randomly selected sample at an interval of 4 weeks. Almost perfect intra and inter examiner reliabilities of .99 were determined and when paired t test was applied on the same data the p value was found to be more than .05 for all the variables.

RESULTS

All the analyses were performed with commercial statistical software SPSS Version 17.0. Descriptive statistics, including the mean and Standard Deviation (SD) values, were determined for each Spee group. The means and SDs of the chronological ages presented no statistically significant differences whereas the depth of curve of Spee for each group showed statistically

S.No.	Cephalometric Maxillary Skeletal parameters	
1.	illary anterior alveolar and basal heights **(Mx-AABH, mm)**	Distance between the midpoint of the alveolar meatus of the maxillary central incisor and the intersection point between the palatal plane and the long axis of the maxillary central incisor.
2.	Maxillary posterior alveolar and basal heights**(Mx-PABH, mm)**	Measured as the perpendicular distance between the midpoint of the alveolar meatus of the maxillary first molar and the palatal plane.
3.	Anterior nasal spine to posterior nasal spine**(ANS-PNS, mm)**	Distance between maxillary ANS to PNS points.
4.	Maxillary plane angle **{ SN-MXP,(^{0})}**	Angle formed between the maxillary plane and the sella- Nasion plane.
S.No	**Cepalometric Mandibular Skeletal Parameters**	
1.	Mandibular anterior alveolar and basal height **(Md-AABH, mm)**	distance between midpoint of alveolar meatus of mandibular central incisor and intersection between symphysial surface and mandibular alveolar axis forms the mandibular anterior alveolar and basal heights.
2.	Mandibular posterior alveolar and basal height **(Md-PABH, mm)**	measured as the perpendicular distance between the midpoint of the alveolar meatus of the mandibular first molar and the mandibular plane.
3.	Mandibular plane angle	formed between the mandibular plane and the Frankfort horizontal plane.
4.	Gonial angle	formed between the posterior border of the ramus and corpus line.
5.	Ramus/FH(^{0})	Angle formed between a tangent to the posterior border of the mandibular ramus and the Frankfort horizontal plane
6.	Ramus width	palatal plane extended posteriorly to intersect both the anterior and posterior borders of the ramus of mandible.The distance between the two intersection point measured as the ramus width.
7.	Symphysis height (SH, mm)	measured as the distance between infradentale and menton points.
8.	Symphysis depth (SD, mm)	measured as the distance between pogonion and the most posterior wall of the symphysis
9.	Condylion-gnathion (Cd-Gn)	distance between condylion and gnathion points.
10.	Gonion-gnathion (Go-Gn, mm)	distance between gonion and gnathion points.
11.	Condylion-gonion (Cd-Go)	measured as the distance between condylion and gonion points.
S.No	**Cepalometric Maxillary Dental Parameters**	
1.	Inclination of the upper incisor **(U1/SN^0)**	ween the extension of the long axis of the maxillary incisor and the sella - nasion plane.
2.	Upper incisor – NA (^{0})	between the long axis of the central incisor and N-A line.
S.No	**Cepalometric Mandibular Dental Parameters**	
1.	Inclination of mandibular incisors	Angle formed between the extension of the long axis of the mandibular incisor and mandibular plane
2.	Lower incisor –NB(^{0})	Angle formed between the long axis of the mandibular central incisor and N-B line.
3.	Lower incisor –NPg(^{0})	Angle between the long axis of the mandibular central incisor and N-Pg line.
4.	Lower incisor –NPg(mm)	Horizontal distance between the buccal surface of the mandibular central incisor and N-Pg line.
S.No	**Miscellaneous Cephlometric Parameters**	
1.	Overbite (mm)	Overbite is the distance between incisal tips of maxillary and mandibular central incisor perpendicular to occlusal plane.
2.	Overjet (mm)	rjet is the distance between incisal tips of maxillary and mandibular central incisor parallel to occlusal plane.
3.	Interincisal angle(^{0})	sured as the angle between long axis of maxillary and mandibular incisors.
S.No	**Photographic measurement**	
1.	Irregularity index	The linear displacement of the anatomic contact points of each mandibular incisor from the adjacent tooth anatomic contact point. The sum of these five displacements represent anterior lower crowding.

significant differences in Spee measurements (*P* <.001) (table 6).

The results of analysis of variance indicated that overbite, overjet, inclinations and positions of the lower incisors (lower incisor-MP, lower incisor-NB, lower incisor-NPg (°), lower incisor-NPg (mm)), gonial angle (Ar-Go-Me) and inter-incisal angle measurements were significantly different in three spee groups. Amongst these variables, overbite followed by lower incisor- NB and then lower incisor-NPg (mm) were highly significant (table 7).

Reliability with Dahlberg's formula (TABLE – 3)		
DAHLBERG VALUE FOR METHOD ERROR (Linear Measurements)		
Parameters	**Intraclass Error**	**Interclass Error**
Depth of Curve of Spee	0.24	0.17
Mx-AABH (mm)	0.15	0.17
Mx-PABH (mm)	0.15	0.22
ANS-PNS (mm)	0.46	0.24
Md-AABH (mm)	0.22	0.27
Md-PABH (mm)	0.27	0.15
RW (mm)	0.15	0.15
SH (mm)	0.41	0.27
SD (mm)	0.11	0.38
Cd-Go (mm)	0.22	0.4
Cd-Gn (mm)	0.38	0.4
Go-Gn (mm)	0.27	0.27
L1/NPg (mm)	0.11	0.33
Overjet (mm)	0.15	0.31
Overbite (mm)	0.1	0.15
Mx1 (mm)	0.31	0.46
Mx2 (mm)	0.38	0.48
Irregularity Index (mm)	0.46	0.43
DAHLBERG VALUE FOR METHOD ERROR (Angular Measurements)		
Parameters	**Intraclass Error**	**Interclass Error**
SN-MxP (degree)	0.22	0.15
MndP-FH (degree)	0.37	0.26
Ar-Go-Me (degree)	0.35	0.3
Ramus/FH (degree)	0.33	0.26
U1/SN (degree)	0.4	0.38
U1/NA (degree)	0.4	0.24
L1/MP (degree)	0.38	0.21
L1/NB (degree)	0.33	0.33
L1/NPg (degree)	0.31	0.32
I/I (degree)	0.38	0.39

The results of scheffe post hoc test for overbite measurement showed significant differences between group I and group II and group I and group III. The similar results were obtained for overjet, lower incisor-NPg (mm), lower incisor-NPg (^{0}) and lower incisor-NB (^{0}) measurements. The results obtained for lower incisor-MP (^{0}) showed significant differences between group I and group III and group II and group III. In contrast for interincisal angle measurement, significant differences were present between group I and group III only (table 8).

Pearson's correlation coefficients were calculated between the depth of curve of Spee and other variables. The largest correlation coefficient was present between the depth of curve of Spee and overbite. Amongst the significant values, Md-PABH, L1-NB, L1-MP, L1-NPg (^{0}) and L1-NPg (mm) were negatively correlated and overbite and overjet were positively correlated (Table 9).

Intra examiner reliability (table 4)		
Parameter	Intra-class correlation	paired t test
Depth of Curve of Spee	0.9999	0.2146
Mx-AABH (mm)	0.9995	0.3434
Mx-PABH (mm)	0.993	0.1088
ANS-PNS (mm)	0.9889	0.8113
SN-MxP (°)	0.9981	0.1521
Md-AABH (mm)	0.9957	0.7803
Md-PABH (mm)	0.9998	0.3434
MndP-FH (°)	0.998	0.7577
Ar-Go-Me (°)	0.9992	0.7263
Ramus/FH (°)	0.9954	0.0957
RW (mm)	0.9972	0.5910
SH (mm)	0.9972	0.7263
SD (mm)	0.9953	0.5910
Cd-Go (mm)	0.9994	1.000
Cd-Gn (mm)	0.9993	1.000
Go-Gn (mm)	0.9998	0.3434
U1/SN (°)	0.9964	0.0662
U1/NA (°)	0.9989	0.0811
L1/MP (°)	0.9984	0.4343
L1/NB (°)	0.9996	1.000
L1/NPg (°)	0.9999	0.5910
L1/NPg (mm)	0.9998	0.3434
I/I (°)	0.9996	0.3092
Overjet (mm)	0.997	0.5910
Overbite (mm)	0.9994	0.3434
Irregularity Index (mm)	0.9999	0.2058

Further the results of multiple regression analysis suggested that overbite alone explained 28.8% of the total variance of the curve of spee in the stepwise regression model. The inclination of lower incisor i.e. lower incisor-NB (^{0}) and inter-incisal angle (^{0}) also influenced the curve of spee by 6.9% and 8.2% respectively. In the enter regression model, overbite, overjet, inter-incisal angle and lower incisor position (i.e. lower incisor-MP (°), lower incisor-NB (^{0}), lower incisor-NPg (°), lower incisor-NPg (mm)) measurements explained 45.8% of the total variance of the curvature (table 10).

DISCUSSION

Although, levelling of the curve of spee is an everyday occurrence in orthodontic practice, little research has been done to examine the relationship of the curve of spee and the multiple factors causing variation in its depth, which may be useful to assess the feasibility of levelling the curve of spee by orthodontic treatment. The assessment of relationship of curve of spee with the dentoskeletal morphology is essential to understand the influence of multiple factors that lead to variations in the depth of the curve.

Inter examiner reliability (table 5)

Inter examiner reliability

Parameter	**Inter class correlation**	**Paired t test**
Depth of Curve of Spee	0.9999	0.2146
Mx-AABH (mm)	0.9995	0.3434
Mx-PABH (mm)	0.9914	0.1038
ANS-PNS (mm)	0.99	0.8113
SN-MxP (º)	0.9972	0.0621
Md-AABH (mm)	0.9961	0.7803
Md-PABH (mm)	0.9998	0.3434
MndP-FH (º)	0.9982	0.7577
Ar-Go-Me (º)	0.9993	0.7263
Ramus/FH (º)	0.9943	0.0957
RW (mm)	0.9974	0.5910
SH (mm)	0.9975	0.7263
SD (mm)	0.9956	0.5910
Cd-Go (mm)	0.9995	1.000
Cd-Gn (mm)	0.9994	1.000
Go-Gn (mm)	0.9998	0.3434
U1/SN (º)	0.9951	0.0662
U1/NA (º)	0.9986	0.0811
L1/MP (º)	0.9985	0.4343
L1/NB (º)	0.9996	1.000
L1/NPg (º)	0.9999	0.5910
L1/NPg (mm)	0.9998	0.3434
I/I (º)	0.9996	0.3092
Overjet (mm)	0.9972	0.5910
Overbite (mm)	0.9994	0.3434
Irregularity Index (mm)	0.9999	0.2058

Our study aimed at elucidating the various components responsible for varying depth of curve of spee, whether dental or skeletal. In addition to analyzing and assessing their specific contributions to the depth of curve of spee, it was determined, if any correlation exists between the depth of curve of spee and any of these variables.

The mean value for overbite increased from group I to group III in all the subjects. This was supported by findings of Shannon and Nanda[7] who in their study observed a close association between curve of spee and overbite in brachyfacial patterns.[3,4] They also stated that in the anterior segment of the arch, overbite and overjet positively correlated to deeper curves. This might suggest that when the anterior teeth have no vertical stop, their continued eruption will contribute to deepening the anterior aspect of the curve.

Sample description and F Values by analysis of variance (Table 6)

	Normal spee group GROUP I	**Mild-Moderate spee group GROUP II**	**Deep spee group GROUP III**	**F**
Number of subjects	**50**	**38**	**19**	
age				**1.36**
Mean	**16.24**	**16.86**	**16.94**	
SD	**1.9**	**2.0**	**2.2**	
Depth of curve of spee				**.0001**
Mean	**1.67**	**2.99**	**4.32**	
SD	**0.46**	**0.33**	**0.29**	

Further the results of the present study were supported by the findings of Al Qubandi and Lie F[8] who showed that the overbite measurement in the deep spee group were significantly larger than the moderate and flat spee groups. Batham and Tondon[12] studied curve of spee and its relationship with dentoskeletal morphology and found that the variation in the depth of curve of spee significantly influences the overbite, overjet and inclination of the mandibular first molar.

Results of one way ANOVA Test (table 7)

Significant Findings of ONE WAY ANOVA

S.NO.	**SIGNIFICANT VARIABLES**	**F value**	**SIGNIFICANCE**
1.	Overbite (mm)	20.1691	0.00000
2.	Overjet (mm)	5.7813	0.00416
3.	L1/NPg (mm)	9.3812	0.00017
4.	L1/NPg (º)	6.9535	0.00146
5.	L1/NB (º)	12.9459	0.00001
6.	L1/MP (º)	6.4414	0.00230
7.	I/I (º)	3.4519	0.03535

The results were also in agreement to the previously performed studies of Kuitert, Baydas et al, Cheon et al.[6] They found that most pronounced differences for overbite were recorded between the flat and deep spee groups. However, their study indicated that there were no significant differences in the positions and inclinations of the lower incisors among the subjects with different depths of curve of Spee.

In a study by Cheon et al[10], positive correlation values for both males and females for ODI and depth of curve of spee suggested that higher value of ODI in group III (deep curve of spee) signifies deep bite or tendency towards deep bite in deep curve of spee groups.

Significant Findings					
One way ANOVA				Pearson Correlation Values	
S.NO.	SIGNIFICANT VARIABLES	F value	p value	r value	p value
1.	Overbite (mm)	20.169	0.000	.537**	.000
2.	Overjet (mm)	5.781	0.004	.385**	.000
3.	L1/NPg (mm)	9.381	0.000	-.364**	.000
4.	L1/NPg (º)	6.953	0.001	-.311**	.001
5.	L1/NB (º)	12.945	0.000	-.452**	.000
6.	L1/MP (º)	6.441	0.002	-.315**	.001
7.	I/I (º)	3.451	0.035	-	-
8.	Md-PABH (mm)	-	-	-.260**	.007

Dusek and Celik[13] concluded in their study that there were significant correlations between the curve of Spee and the positions and inclinations of lower incisors. They also found that the more protrusively the lower incisors are positioned, the less marked is the depth of curve of Spee. Similar findings were obtained in the present study. Balridge[5] reported that decreasing the depth of curve of Spee leads to an increase in arch circumference and the lower incisors will be proclined in direct response to this increase.

Also, significant correlation was found for another variable MdPABH in this study. Similar results were obtained in a study conducted by Haskell[14] that showed correlation between the overbite and mandibular alveolar and basal area. He found that patients with open bite showed a smaller protruding chin area, i.e. a narrowed symphysis. This was also supported by the results of Ismail Ceylan[9] whose study showed that subjects with open bite generally had increased maxillary and mandibular dentoalveolar heights. The results of multiple regression analysis were in agreement to the study of Baydas et all[6] who found that overbite explained 17.3% of total variance of curve of spee, along with position and inclinations of lower incisors, that accounted for 5.3% of variance. In another study by Cheon et all[10] 25.2% of the variance of curve of spee was explained by overbite alone. Batham and Tondon[12] found strong relationship between curve of spee and ANB, overbite and mandibular arch length, whereas moderate significance for overjet. These parameters explained 66% of the total variation of the curve of spee. All these results were in concordance with the findings of the present study.

Curve of Spee has rightly been described as a compensatory curve as this arc truly defines the compensation in the alignment of dentition. The wide spectrum of its role and contributing factors has long been a focus of interest, yet the phenomenon remains partially explained. The more the topic is explored, the greater is scope for further research.

CONCLUSION

1. Overall, the findings of the present study suggested that the overbite; overjet; positions and inclinations of the lower incisors and inter-incisal angle were affected by the variation in the depth of curve of Spee.

Pearson Correlation Values
(curve of spee as dependent variable) (table 9)

L1/MP (º)	Pearson Correlation	-.315**
	Sig. (2-tailed)	.001
	N	107
L1/NB (º)	Pearson Correlation	-.452**
	Sig. (2-tailed)	.000
	N	107
L1/NPg (º)	Pearson Correlation	-.311**
	Sig. (2-tailed)	.001
	N	107
L1/NPg (mm)	Pearson Correlation	-.364**
	Sig. (2-tailed)	.000
	N	107
Md-PABH (mm)	Pearson Correlation	-.260**
	Sig. (2-tailed)	.007
	N	107
Overjet (mm)	Pearson Correlation	.385**
	Sig. (2-tailed)	.000
	N	107
Overbite (mm)	Pearson Correlation	.537**
	Sig. (2-tailed)	.000
	N	107

2. The overbite, overjet, lower incisor-NPg (mm), lower incisor-NPg (^{0}) and lower incisor-NB (^{0}) measurements in the deep Spee group were significantly larger than in the normal and mild-moderate Spee groups. The results obtained for lower incisor-MP (^{0}) showed significant differences between normal and deep spee group, and mild-moderate and deep spee groups. In contrast, for interincisal angle measurement, significant differences were present between normal and deep spee group only.

3. The correlation coefficients obtained from the study confirmed these results. The largest positive correlation was found between the depth of curve of Spee and overbite.

4. In addition, statistically significant correlations were found between the depth of curve of Spee and overjet, lower incisor–NPg mm, lower incisor–NPg^{0}, lower incisor–NB and Md-PABH measurements. Amongst these significant values Md-PABH, L1-NB, L1-MP, L1-NPg (^{0}) and L1-NPg (mm) were negatively correlated and overjet was positively correlated.

5. The results of multiple regression analysis suggested that overbite alone explained the variation of the depth of curve of spee to the largest extent by 28.8%.

MULTIPLE LINEAR REGRESSION ANALYSIS (table 10)

Method	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R^2
			B	Std. Error	Beta			
Method-I (Stepwise Regression)	1	**CONSTANT**	1.625	.172		9.433	.000	0.288379
		Overbite (mm)	.212	.033	.537	6.523	.000	
	2	**CONSTANT**	2.702	.361		7.485	.000	0.357693
		Overbite (mm)	.168	.034	.425	4.985	.000	
		L1/NB (º)	-.031	.009	-.286	-3.350	.001	
	3	**CONSTANT**	7.001	1.163		6.021	.000	0.439058
		Overbite (mm)	.192	.032	.485	5.944	.000	
		L1/NB (º)	-.065	.012	-.595	-5.256	.000	
		I/I (º)	-.030	.008	-.442	-3.865	.000	
Method-II (Enter)	4	**CONSTANT**	6.829	2.441		2.798	.006	0.457964
		Md-PABH (mm)	-.015	.018	-.071	-.841	.403	
		L1/MP (º)	-.014	.019	-.098	-.740	.461	
		L1/NB (º)	-.035	.026	-.318	-1.348	.181	
		L1/NPg (º)	-.006	.008	-.089	-.718	.475	
		L1/NPg (mm)	-.004	.041	-.017	-.104	.917	
		I/I (º)	-.021	.011	-.318	-1.867	.065	
		Overjet (mm)	.038	.035	.121	1.078	.284	
		Overbite (mm)	.183	.040	.464	4.549	.000	

Thus, it can be deduced that curve of spee is more influenced dentally and to a minor extent by facial morphology. These analyses investigating the dental and skeletal components contributing to the development of deep curve of spee, their significance, and correlations, helps to draw certain guidelines for the orthodontist that could help in more efficient treatment of these malocclusions. The clinician can focus on the main underlying component, design an individualized treatment plan, and tailor a mechanotherapy protocol suitable for each patient.

REFERENCES

1. Ferdinand Graf Spee. The gliding path of the mandible along the skull, prosector at the Anatomy Institute of Kiel. J Am Dent Assoc. 1980;100 (5):670-5.

Results of Scheffe post hoc Test (table 8)

Multiple Comparisons

Dependent Variable	(I) cosgrp	(J) cosgrp	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Overbite (mm)	1	2	-2.501*	.512	.000	-3.77	-1.23
		3	-3.487*	.637	.000	-5.07	-1.90
	2	1	2.501*	.512	.000	1.23	3.77
		3	-.986	.669	.342	-2.65	.68
	3	1	3.487*	.637	.000	1.90	5.07
		2	.986	.669	.342	-.68	2.65
Overjet (mm)	1	2	-2.039*	.727	.022	-3.84	-.23
		3	-2.492*	.904	.026	-4.74	-.25
	2	1	2.039*	.727	.022	.23	3.84
		3	-.453	.950	.893	-2.81	1.91
	3	1	2.492*	.904	.026	.25	4.74
		2	.453	.950	.893	-1.91	2.81
L1/MP (^{0})	1	2	1.742	1.593	.552	-2.21	5.70
		3	7.113*	1.983	.002	2.19	12.04
	2	1	-1.742	1.593	.552	-5.70	2.21
		3	5.371*	2.082	.040	.20	10.54
	3	1	-7.113*	1.983	.002	-12.04	-2.19
		2	-5.371*	2.082	.040	-10.54	-.20
L1/NB (^{0})	1	2	5.667*	1.947	.017	.83	10.50
		3	11.901*	2.423	.000	5.88	17.92
	2	1	-5.667*	1.947	.017	-10.50	-.83
		3	6.234	2.544	.054	-.08	12.55
	3	1	-11.901*	2.423	.000	-17.92	-5.88
		2	-6.234	2.544	.054	-12.55	.08
L1/NPg (^{0})	1	2	11.031*	3.334	.005	2.75	19.31
		3	11.356*	4.149	.027	1.05	21.66
	2	1	-11.031*	3.334	.005	-19.31	-2.75
		3	.325	4.357	.997	-10.50	11.15
	3	1	-11.356*	4.149	.027	-21.66	-1.05
		2	-.325	4.357	.997	-11.15	10.50
L1/NPg (mm)	1	2	2.375*	.907	.036	.12	4.63
		3	4.663*	1.128	.000	1.86	7.46
	2	1	-2.375*	.907	.036	-4.63	-.12
		3	2.287	1.185	.160	-.66	5.23
	3	1	-4.663*	1.128	.000	-7.46	-1.86
		2	-2.287	1.185	.160	-5.23	.66
I/I (^{0})	1	2	-4.383	3.420	.443	-12.88	4.11
		3	-11.033*	4.257	.039	-21.60	-.46
	2	1	4.383	3.420	.443	-4.11	12.88
		3	-6.649	4.470	.335	-17.75	4.45
	3	1	11.033*	4.257	.039	.46	21.60
		2	6.649	4.470	.335	-4.45	17.75

2. Andrews LF. The six keys to normal occlusion. Am J Orthod. 1972; 62 (3):296-309.

3. Wylie WL. Overbite and vertical facial dimensions in terms of muscle balance. Angle orthod 1944;19:13-7.

4. BjÖrk A. Variability and age changes in overjet and overbite. Am J Orthod 1953;39:779-801 .

5. Baldridge DW. Leveling the curve of Spee: its effect on mandibular arch length. JPO J Pract Orthod. 1969;3 (1):26-41.

6. Baydaş B, Yavuz I, Atasaral N, Ceylan I, Dağsuyu IM. Investigation of the changes in the positions of upper and lower incisors, overjet, overbite, and irregularity index in subjects with different depths of curve of Spee. Angle Orthod. 2004;74 (3):349-55.

7. Shannon KR, Nanda RS. Changes in the curve of Spee with treatment and at 2years post treatment. Am J Orthod Dentofacial Orthop. 2004;125 (5):589-96.

8. AlQabandi AK, Sadowsky C, BeGole EA. A comparison of the effects of rectangular and round arch wires in leveling the curve of Spee. Am J Orthod Dentofacial Orthop. 1999;116 (5):522-9.

9. Ceylan I, Eröz UB. The effects of overbite on the maxillary and mandibular morphology. Angle Orthod. 2001 Apr;71 (2):110-5.

10. Cheon SH, Park YH, Paik KS, Ahn SJ, Hayashi K, Yi WJ, Lee SP. Relationship between the curve of Spee and dentofacial morphology evaluated with a 3-dimensional reconstruction method in Korean adults. Am J Orthod Dentofacial Orthop.2008;133 (5):640-e7.

11. Meera. Power Analysis, Statistical Significance, & Effect Size.

12. Prerna Raje Batham, Pradeep Tandon, Vijay Prakesh Sharma, Alka Singh. Curve of spee and its relationship with dentoskeletal morphology. J Ind Orthod Soc 2013;47 (3):128-134.

13. Dusek MW. The Curve of Spee: A Search for Causation [master's thesis]. Memphis, Tenn: University of Tennessee; 2000.

14. Haskell BS. The human chin and its relationship to mandibular morphology. Angle Orthod. 1979 Jul;49 (3):153-66.