

## Evaluation of skeletal and dental parameters in individuals with variations in depth of Curve of Spee

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### Abstract

**Aim:** The main aim of this study was to investigate the skeletal and dental relationships in individuals with various depth of curve of Spee in the vertical and horizontal plane.

**Material Methods:** Pre-treatment lateral cephalograms and dental cast of 300 patients were taken. The subjects were divided into three groups according to the depth of curve of Spee. Group A (N=100) = Flat curve of Spee i.e. < 2mm, Group B (N=100) = Normal curve of Spee i.e. between 2-4 mm, Group C (N=100) = Deep curve of Spee i.e. >5mm. Four angular and four linear measurements were performed on lateral cephalogram. The measurements of the depth of curve of Spee, overbite, overjet and molar relation were made on dental casts.

**Results:** In horizontal relationships Difference in overjet of the three groups was found to be statistically significant ( $p < 0.001$ ). Difference in molar relationship among Group A, Group B and Group C was found to be highly significant ( $p < 0.001$ ). SNA, SNB, ANB and Beta angle all were found not to be statistically different between the 3 groups. Difference in overbite of above three groups was found to be statistically significant ( $p < 0.001$ ). All the vertical skeletal parameters were found to be not statistically significant.

**Conclusion:** Increase in overjet, overbite and Class II Molar relation were seen in cases with deep curve of Spee (Group C). All horizontal and vertical skeletal parameters were not influenced by change in different depth of curve of Spee.

**Keywords:** Curve of Spee, Molar Relation, Overjet, Overbite.

### Introduction

The curve of Spee is a naturally occurring phenomenon in the human dentition. This normal occlusal curvature is required for an efficient masticatory system. Graf von Spee was the first to use skulls with abraded teeth to define a line of occlusion, first described the curve of Spee in 1890.<sup>(1)</sup> This line lies on a cylinder i.e. tangent to the anterior border of the condyle, following the occlusal surface of the second molar and the incisal edge of mandibular incisor. It has been suggested that the curve of Spee has a biochemical function during food processing by increasing the crushing strength between the posterior teeth and the efficiency of the occlusal force during mastication.<sup>(2)</sup> Most of Von Spee's predictions were made with view of skulls perpendicular to the mid-sagittal plane.

The understanding of how the curve of Spee develops is limited in literature. Some have suggested that its development probably results from a combination of many factors which include growth of orofacial structures, eruption of teeth, and development of the neuromuscular system.<sup>(3-4)</sup> It has been mentioned that the mandibular sagittal and vertical position relative to the cranium is related to the curve of Spee, which is present in various forms in mammals. In humans, an increased curve of Spee is often seen in brachycephalic facial patterns and associated with short mandibular bodies.<sup>(5)</sup>

Exaggerated curve of Spee is frequently observed in dental malocclusions with deep overbites. These excessive curve of Spee alters the muscle imbalance, ultimately leading to the improper functional occlusion. In a mechanical sense, the presence of a curve of Spee may make it possible for a dentition to resist the forces of occlusion during mastication.<sup>(6)</sup>

Several theories have been proposed to explain the presence of the curve of Spee in natural dentitions, its role in normal mandibular function has been questioned. It has been mentioned that an imbalance between the anterior, posterior components of occlusal force can lead to the eruption of lower incisors, infra-eruption of the premolars, mesial inclination of the lower molars. This altered condition requires specialized skills for the practitioner. Thorough knowledge would be useful of how and when this curve of Spee develops, so that it will help us in our treatment.<sup>(7-10)</sup> The curve of Spee is only influenced to a minor extent by craniofacial morphology.<sup>(11)</sup> The curve is greatly influenced by the horizontal position of the condyle and is weakly influenced by the vertical dento-skeletal dimension and by the position of the mandible with respect to the anterior cranial base.<sup>(12-15)</sup> The aim of this study was to evaluate if there are any different skeletal and dental relationships in individuals with different depths of curve of Spee.

## Methods

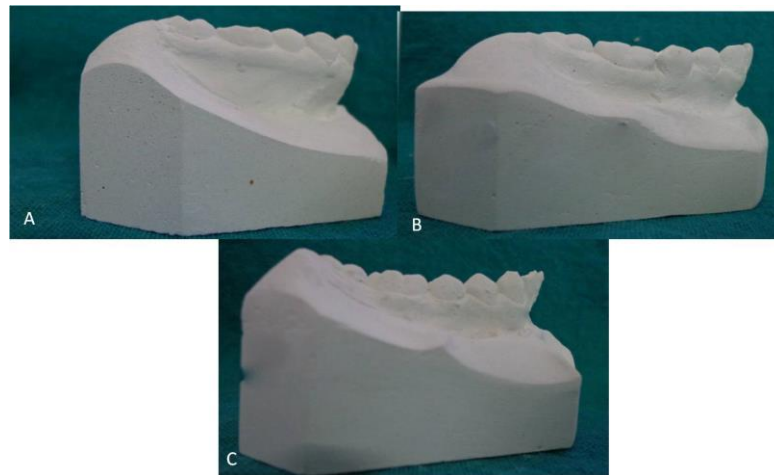
This study was approved by the Regional Ethical Committee of Research of Saraswati Dental College and Hospital Lucknow India (SDC/IHEC/2013/MDS-P/19). Pre-treatment lateral cephalograms and dental cast of 300 patients were taken who came in the OPD for treatment in the Department of Orthodontics and Dentofacial Orthopedics.

### Each subject met the following inclusion criteria:

- 1) No history of previous orthodontic treatment or functional jaw orthopedic treatment.
- 2) All the subjects had complete dentition.(Except third molars)
- 3) No history of facial trauma, severe cranio-facial disorders, such as cleft palate.

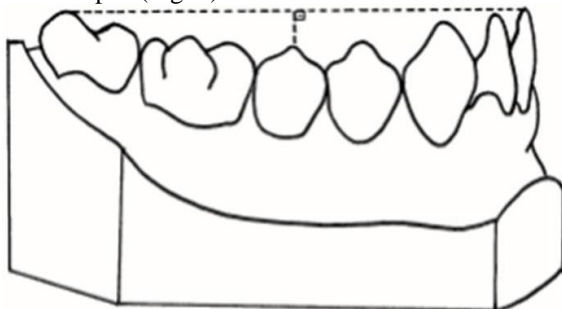
The subjects were divided into three groups according to the depth of curve of Spee. They are as follows (Fig. 1):

- 1) Group A= Flat curve of Spee i.e. < 2mm.
- 2) Group B = Normal curve of Spee i.e. 2-3 mm.
- 3) Group C = Deep curve of Spee i.e. >3mm



**Fig. 1: Different types of Curve of Spee, a) Flat curve of Spee, b) Normal curve of Spee, c) Deep curve of Spee**

The depth of curve of Spee was measured by measuring the perpendicular distance between the deepest cusp tip and a flat plane that was placed 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 lower. The measurement was made on the right and left side of the arch and the mean value of these two measurements was used as the depth of curve of Spee (Fig. 2).<sup>(16)</sup>



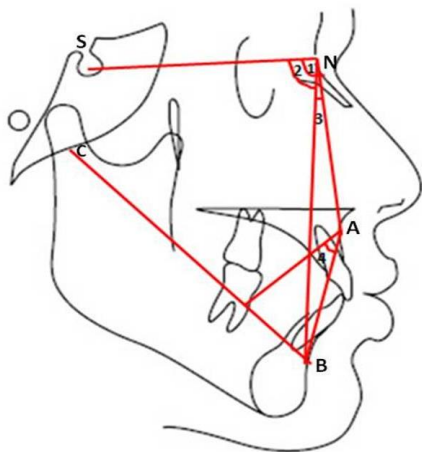
**Fig. 2: Measurement of Curve of Spee**

The cephalometric radiographs were taken using standard procedure. A single investigator performed the cephalometric tracings on tracing paper. Four angular and four linear measurements were performed on lateral cephalograms. The measurements of the depth of curve of Spee, Overjet, overbite (S.M. Freire et al.2007)<sup>(17)</sup> and molar relation were made on dental casts.

The following dental and skeletal parameters were taken (Table 1, Fig. 3, 4):

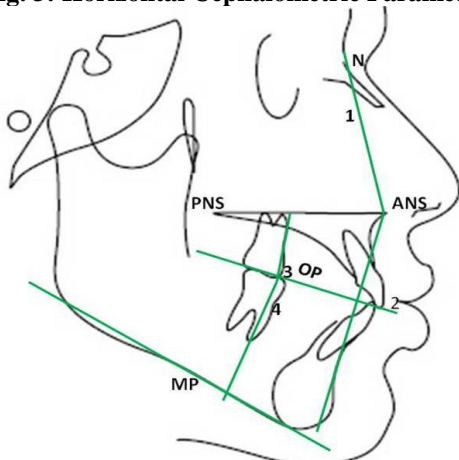
**Table 1: Skeletal and Dental Parameters**

Skeletal		
Horizontal parameters		
1	SNA	Angle between SN line and NA line
2	SNB	Angle between SN line and NB line
3	ANB	Difference between SNA angle and SNB angle
4	BETA ANGLE	Angle between the perpendicular line (dropped from point A to the C-B line) and AB line
Vertical parameters		
1	ANS-GN	Line joining ANS to Gnathion
2	N-ANS	Line joining Nasion to ANS
3	UPPER6-NF	Perpendicular drawn from mesiobuccal cusp of upper first molar to nasal floor
4	LOWER6-MP	Perpendicular drawn from mesiobuccal cusp of lower first molar to mandibular plane (Go-Gn) steiners
Dental		
Horizontal parameters		
1	Overjet	Horizontal overlap between upper and lower incisors
3	Molar relation	Angles molar relation
Vertical parameters		
2	Overbite	Vertical overlap between upper and lower incisors



The cephalometric landmarks and horizontal measurements used in the study are as follows :- 1)SNA 2)SNB 3)ANB 4)β Angle

**Fig. 3: Horizontal Cephalometric Parameters**



The cephalometric landmarks and vertical measurements used in the study are as follows 1)N-ANS 2)ANS-Gn 3)U6-NF 4)L6-MP

**Fig. 4: Vertical Cephalometric Parameters**

**Statistical Analysis**

A master file was created, and the data was analyzed statistically on a computer with Statistical Package for Social Sciences (SPSS) software (version 15). A data file was made under dBase and converted into a micro stat file. The data was subjected to descriptive analysis for mean, range, standard deviation and 95% confidence interval. Group differences were analyzed with one-way analysis of variance (ANOVA). Chi square test was also used. To identify errors due to radiographic measurements, 20 radiographs were selected randomly. Their tracings and measurements were repeated 6 weeks after the first measurements were taken. A paired sample t-test was applied to the first and second measurements, the differences between measurements were insignificant.

**Results**

Difference in overjet and overbite of the three groups was found to be statistically significant ( $p < 0.001$ ) (Table 2). Difference in molar relationship among the groups was found to be highly significant ( $p < 0.001$ ) (Table 3). The differences between SNA ( $p = 0.573$ ), SNB ( $p = 0.964$ ), ANB ( $p = 0.118$ ) and  $\beta$ -angle ( $p = 0.715$ ) were not found to be statistically significant (Table 4). The vertical measurements N-ANS ( $p = 0.846$ ), ANS-GN ( $p = 0.366$ ), U6-NF ( $p = 0.778$ ), L6-MP ( $p = 0.452$ ) showed no statistically significant difference (Table 5).

**Table 2: Comparison of measurement of Overjet (mm) of Study Population**

Group	No. of patients	Min.	Max.	Mean	S.D.
Group A	100	0	10	4.70	2.35
Group B	100	0	13	5.89	3.07

Group C	100	1	14	7.80	2.98
Total	300	0	14	6.07	3.07

F=12.732; p&lt;0.001 (ANOVA)

**Table 3: Comparison of Molar Relationship of Study Population**

Molar Relation	Group A (n=100)		Group B (n=100)		Group C (n=100)		Chi-square test	
	No.		No.		No.		$\chi^2$	P
I/I	60		55		43		22.447	<0.001
II/II	40		45		57			

**Table 4: Comparison of Horizontal Skeletal measurements (°) of Study Population**

Horizontal Skeletal measurements (°)	Group A (n=100)		Group B (n=100)		Group C (n=100)		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	F	P
SNA	82.61	5.65	83.58	5.19	83.56	4.14	0.560	0.573
SNB	78.70	5.59	78.97	5.36	78.95	5.06	0.036	0.964
ANB	4.45	2.67	4.65	2.77	5.66	3.30	2.166	0.118
β ANGLE	31.61	7.37	30.85	5.38	30.32	9.70	0.337	0.715

**Table 5: Comparison of Vertical Skeletal measurements**

Vertical Skeletal measurements (°)	Group A (n=100)		Group B (n=100)		Group C (n=100)		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	F	P
N- ANS	45.91	3.06	46.52	6.45	46.27	5.67	0.167	0.846
ANS- GN	57.98	5.17	56.75	7.22	56.00	6.59	1.011	0.366
U6- NF	20.20	2.14	19.80	4.89	20.39	5.28	0.252	0.778
L6-MP	27.64	3.66	28.08	6.79	29.15	5.49	0.799	0.452

## Discussion

Increased curve of Spee in the mandibular dentition is a common feature of patients undergoing orthodontic treatment. Orthodontists generally do not evaluate and consider the Curve of Spee in all cases, treatment planning should be a combination of cephalometric and dental discrepancies but consideration of the curve of Spee is an important factor in diagnosis.<sup>(19,20)</sup> The assessment of relationship of curve of Spee with the dento-skeletal morphology is essential to understand the influence of multiple factors that leads to variation in the depth of the curve of Spee.<sup>(21)</sup> Farella et al<sup>(14)</sup> has been suggested that the mandibular position (sagittal and vertical) relative to the cranium is related to the curve of Spee, which is present in various forms in mammals. In human, an increased curve of Spee is often seen in brachyo-cephalic facial pattern (Wyle and Bjork)<sup>(5,22)</sup> and associated with short mandibular bodies (Salem et al).<sup>(23)</sup> Marshall et al<sup>(24)</sup> measured the curve of Spee on 33 untreated subjects from the lower Facial Growth Study at seven different times spanning the time from the complete deciduous dentition through adulthood. Findings showed changes in the curve of Spee increase from 0.25 mm in the primary dentition to 1.32 mm when the permanent first molars and incisors erupt and increases further to 2.17 mm when the second molars erupt. A decrease of 2.0 mm was observed as a levelling off into adulthood occurred which has been shown to remain stable well into the sixth decade of life.<sup>(24)</sup> These averages can be used to help determine the type of curve

of Spee in a patient: flat, normal, or deep. This was also supported by Farella et al<sup>(14)</sup> who said that homogenous dental wear could be the reason for the maintenance of curve of Spee in adulthood.

The curve of Spee was universally linked to a part of a circle. In 1899, Bonwill<sup>(25)</sup> proposed 4 inches (101.6 mm) for the dimension of his "mandibular triangle." Traditionally curve of Spee measurements have been made on orthodontic casts using a ruler or electronic caliper. Some recent studies have utilized sophisticated tools such as the push dial indicator (L.S. Starrett, Athol, Mass), an engineering instrument capable of measuring to ten-thousandths of an inch (Shannon and Nanda, 2004),<sup>(26)</sup> or virtual 3D models supplemented by software programs dedicated to performing a wide array of measurements (Cheon et al).<sup>(27)</sup> Farella et al<sup>(14)</sup> investigated the relationship between the curve of Spee and craniofacial morphology, and concluded that the curve of Spee was influenced only to a minor extent by craniofacial morphology.

The finding suggested that the depth of curve of Spee was influenced by horizontal dental parameter Overjet, molar relation and vertical parameter overbite. Overjet of patients of Group A ranged from 0-10 mm while that of Group B ranged from 0-13 mm and of Group C ranged from 1-14 mm. Mean overjet of Group A (4.70±2.35 mm) and Group B (5.89±3.07 mm) were found to be lower than that of Group C (7.80±2.98 mm).

Difference in overjet of above three groups was found to be statistically significant (p<0.001) that is

overjet measurements in the deep Spee group were significantly larger than in the normal and flat Spee groups. The most pronounced differences for overjet were found between the flat and deep Spee groups. This was supported by finding of Shannon and Nanda.<sup>(25)</sup>

In this study curve of Spee also influenced by molar relationship (Table 3). Molar relationship of majority of patients of Group A (72.27%) and Group B (70.77%) was class I and of rest of the patients of above groups relationship was class II, on the contrary, majority of patients of Group C (68.29%) had molar relationship class II and rest of the patients (31.71%) had molar relationship class I. Difference in molar relationship among Group A, Group B and Group C was found to be highly significant ( $p < 0.001$ ). Means class II molar relation present in deep curve of Spee. Shannon and Nanda<sup>(26)</sup> found that Class II malocclusion had significantly deeper pre-treatment curve of Spee measurements than Class I malocclusions and same is the case in our study. Afzal et al,<sup>(28)</sup> also did a study to evaluate and compare the depth of curve of Spee in class I, class II div 1 class II div 2, class II subdivision and class III malocclusion and concluded that curve of Spee was deepest in class II div 2 malocclusion. Veli et al<sup>(29)</sup> found that maximum curve of Spee depth present in the Class II Division 1 subjects and a minimum depth in the Class III subjects.

This study results showed that Overbite of patients of Group A and Group B ranged from 1-10 mm while that of Group C ranged from 3-10 mm. Mean overbite of Group A ( $3.23 \pm 1.48$  mm) and Group B ( $3.60 \pm 1.70$  mm) were found to be lower than that of Group C ( $7.80 \pm 2.98$  mm). Difference in overbite of above three groups was found to be statistically significant ( $p < 0.001$ ). Increased overbite present in deep curve of Spee. Depth of curve of Spee significantly influenced by amounts of overbite and over jet the variation of the curve of Spee in the mandibular arch. The depth of the curve of Spee in the mandibular arch increases as there is increase in over jet and overbite.<sup>(27)</sup>

All the skeletal parameters which were taken for the study showed no statistically significant difference. This could be due no role of the curve of Spee which with skeletal structures. The curve has a direct effect on all the dento-alveolar structures. The skeletal structures were unaffected by the depth of the curve.

The results obtained from our study confirmed the above finding as depth of curve of Spee increases in both Class II (div 1 and 2) malocclusions in which there are increase overjet and overbite. Trauten et al<sup>(29)</sup> and Orthlieb<sup>(30)</sup> reported that there was a negative curve of Spee in open-bite cases, whereas a deep curve of Spee in deep-bite cases was found. Farella et al<sup>(14)</sup> found that the curve of Spee is more marked in short-face subjects and lesser marked in long-face subjects. We found that the curve of Spee is deepest in class II malocclusions that have deep overbite and short face heights (hypodivergent) than in the normal and flat Spee groups

and it was flat in Class III malocclusion that have high and low angle variants.

The positive correlation coefficient value also proved as the overbite increases depth of curve Spee also increases. These finding were supported by studies done by Alqubandi<sup>(31)</sup> and Lie F.<sup>(32)</sup> These finding showed that overbite measurements in the deep Spee group were significantly larger than in normal and flat Spee groups.<sup>(33,34)</sup> The most pronounced differences for overbite were found between the flat and deep Spee groups as supported by studies of Kuitert.<sup>(32)</sup> An excessive overbite can be an indication of excessive curve of Spee; in the same way, an exaggerated curve of Spee can be accompanied by an increased overbite.

This study is also supported by study done by Baydas et al,<sup>(2)</sup> where, the effect of the depth of the curve of Spee was compared with the bite depth, in sample of 137 untreated adolescent subjects. They were divided into 3 groups; normal, flat, and deep curves of Spee, and the groups were compared. The results showed statistically significant correlations between the depth of the curve of Spee and overjet and overbite. Many skeletal and dental parameters contributed to deep bite in horizontal growers. The highest contribution was of curve of spee which is similar to normal growers.<sup>(35)</sup> Shannon and Nanda<sup>(25)</sup> reported in their study that there is lack of correlation between the depth of curve of Spee and perpendicular distance of mandibular plane to the molar cusp tip same was found in this study.

## Conclusion

### Comparison of Horizontal Measurements

- In the present study, all horizontal skeletal parameters (SNA, SNB, ANB,  $\beta$ -angle) were not influenced by change in different depth of curve of Spee.
- Overjet of patients of Group A ranged from 0-10 mm while that of Group B ranged from 0-13 mm and of Group C ranged from 1-14 mm. Mean overjet of Group A ( $4.70 \pm 2.35$  mm) and Group B ( $5.89 \pm 3.07$  mm) were found to be lower than that of Group C ( $7.80 \pm 2.98$  mm). Difference in overjet of above three groups was found to be statistically significant, they showing that increased Overjet, in deep curve of Spee cases.
- Molar relationship of majority of patients of Group A (72.27%) and Group B (70.77%) was class I (left and right both side) and of rest of the patients of above groups relationship was class II, on the contrary, majority of patients of Group C (68.29%) had molar relationship class I and rest of the patients (31.71%) had molar relationship class I. Difference in molar relationship among Group A, Group B and Group C was found to be highly significant, means class II molar relationship present in deep curve of Spee cases.

### Comparison of Vertical Measurements

- Overbite of patients of Group A and Group B ranged from 1-10 mm while that of Group C ranged from 3-10 mm. Mean overbite of Group A ( $3.23 \pm 1.48$  mm) and Group B ( $3.60 \pm 1.70$  mm) were found to be lower than that of Group C ( $7.80 \pm 2.98$  mm). Difference in overbite of above three groups was found to be statistically significant, means increased Overbite present in deep curve of Spee in comparison to flat and normal curve of Spee.
- All Vertical skeletal parameters (N-ANS, ANS-GN, U6-NF, L6-MP) were not influenced by change in different depth of curve of Spee.

Overall, the findings of the present study suggested that horizontal dental parameters were influenced by the variation of the curve of Spee. The correlation obtained from the study confirmed these results.

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