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Curve of spee and Its Relation with Dentoskeletal Morphology in Different Skeletal Growth pattern.

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Abstract: *Curve of spee is an antero-posterior anatomical curve established by the occlusal alignment of the teeth viewed in sagital plane. This occlusal curvature has clinical importance in orthodontics. The development of curve of Spee probably results from combination of factors including eruption of teeth, growth of orofacial structures, and development of neuromuscular system. The effect of variation in craniofacial morphology on the curve of spee has been evaluated, but these studies ignore the simultaneous contribution of multiple factors to the individual variation of the curve.*

Objective: *To evaluate the relationship between the curve of spee and dentoskeletal morphology in different skeletal growth patterns.*

Materials and Methods: *Pretreatment lateral cephalographs and Dental casts of 60 orthodontic patients (37 females, 23 males; 17-26 years old). Collected and divided in to three groups according to different skeletal growth patteren.*

Group A- Average (SN=28-32.5), Group B- Horizontal (SN<28), Group C- Vertical (SN>32.5) growth pattern. Cephalometric and study cast variables were measured and subjected to statistical analysis with curve of spee as dependent factor and others as independent variables.Four linear and four angular cephalometric measurements were done. Four study cast parameters were measured.

Pearson's correlation analysis was performed to determine correlation coefficients between the depth of curve of spee and other variables.

Results:

Overjet, Overbite, ANB angle, Molar relation are positively correlated with change in depth of curve of spee(P<0.05) i.e. just significant, SNB negatively correlated in each group i.e. not significant.

Conclusion: *We conclude that variation in the depth curve of spee is related with changes in dental parameters rather than skeletal parameters in all types of skeletal patterns.*

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I. Introduction

Curve of Spee is a naturally occurring phenomenon in the human dentition. This normal occlusal curvature required for an efficient masticatory system. Orthodontists eventually deal with the curve of Spee in virtually every patient they treat.[1]

Occlusion is defined a manner in which the upper and lower teeth intercuspate between each other in all mandibular positions and movements. It is a result of neuromuscular control of the components of the mastication systems namely: teeth, periodontal structures, maxilla and mandible, temporomandibular joints and their associated muscles and ligament.[2] Curve of Spee has been defined as an anatomic antero-posterior curve established by the occlusual alignment of the teeth. It was first described by F Graf Von Spee in 1890, which used skulls with abraded teeth to define a line of occlusion.

This line lies on a cylinder that is tangent to the anterior border of the condyle, the occlusal surface of the second molar, and the incisal edges of the mandibular incisors.Curve of Spee is located at the center of this cylinder in the mid-orbital plane.

Clinically in orthodontics today, the curve of Spee refers to the occlusal curvature of the mandibular dentition that runs tangent from the buccal cusp tips of the premolars and molars to the incisal edges of the anterior incisors when viewed in the sagittal plane.[1]

Andrews described the six characteristics of normal occlusion and found that the curve of Spee in subjects with good occlusion ranged from flat to mild, noting that the best intercuspation occurred when occlusal plane was relatively flat. He proposed that keeping occlusal plane flat should be the treatment goal in orthodontics.

The development of curve of Spee probably results from combination of factors including eruption of teeth, growth of orofacial structures, and development of neuromuscular system. 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 growth patterns and associated with short mandibular length.[3]

Exaggerated curve of spee is frequently observed in dental malocclusions with deep overbites. This 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.[4]

Several theories have been proposed to explain the presence of the curve of Spee in natural dentitions. It has been mentioned that an imbalance between the anterior, posterior components of occlusal force can lead to the supra-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 planning[5,6] .The curve of Spee is only influenced to a minor extent by craniofacial morphology[7.] 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.

The aim of this study was to evaluate relationship between variation in depth of curve of spee with different skeletal growth pattern, with the help of different skeletal and dental parameters.

II. Material And Methods

This is retrospective study consisting of pre-treatment lateral Cephalograms and dental casts of 60 patients reported to department of orthodontics and dentofacial orthopaedics. Subjects age ranged between (18-25) years. The cephalometric radiographs were taken using standard procedure. A single investigator performed the cephalometric tracings on lead acetate tracing sheet. High quality orthodontic impressions for diagnostic casts were taken.

Each subject met following inclusion criteria

- Full complement of teeth in occlusion up to the second molar.
- No history of previous orthodontic treatment.
- Mild crowding cases were acceptable.

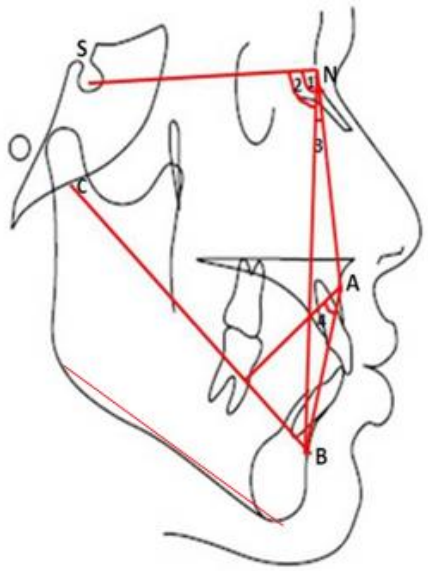
Each subject met following exclusion criteria

- Subjects with severe crowding.
- No cast restorations/coronal coverage.
- Anterior/lateral cross bite.
- Dental anomalies like - Supernumerary teeth, Microdontia, Macrodontia.

60 subjects were divided into three groups according to skeletal growth pattern,
Group A- Average (SN=28-32.5),
Group B- Horizontal (SN<28),
Group C- Vertical (SN>32.5) growth pattern.

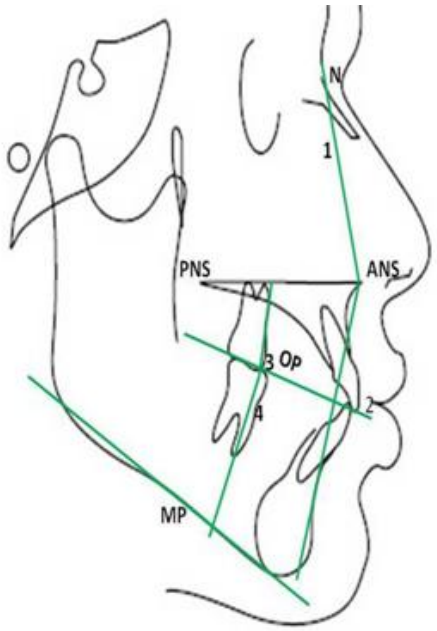
The groups were studied for following cephalometric parameters.(Figure 1),(Figure 2).
Anteroposterior parameters- SNA, SNB, ANB, B-ANGLE.
Vertical parameters- N-ANS, ANS-GN, upper first permanent molar to palatal plane (U6-NF), lower first permanent molar to mandibular plane (M6-Mp).

The groups were studied for following dental cast parameters.
Curve of spee(Figure 3),overjet,overbite, Molar Relation.



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

Fig:1

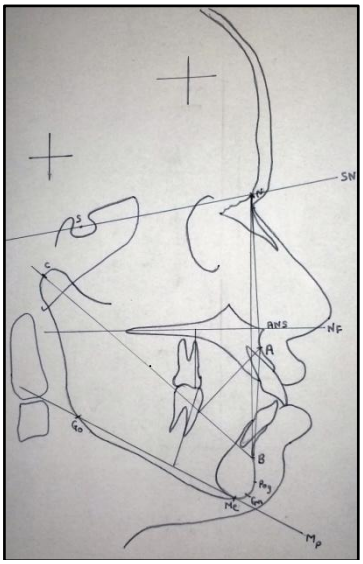


The cephalometric landmarks and vertical measurements used in the study are as follows 1)N-ANS 2)ANS-Gn 3)U6-NF 4)L6- MP

Fig:2

Table 1: Skeletal and Dental Parameters Skeletal

•	**Anteroposteror 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-Me)
•	**Dental**		
		curve of spee	
Horizontal parameters			
		Overjet	Horizontal overlap between upper and lower incisors
		Molar relation	Angles molar relation
Vertical parameter			
		Overbite	Vertical overlap between upper and lower incisors



Cephalometric measurements

measurements of overjet, overbite and molar relation

Measurement of curve of spee.

The depth of curve of Spee was measured by measuring the perpendicular distance between the deepest cusp tip of premolar 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 arch. The measurement was made on the right and left side of the arch and the mean value of these two measurements were used as the depth of curve of Spee.[8] (Right side + Left side/2).

The measurements of the depth of curve of Spee, Overjet, Overbite (S.M. Freire et al.2007)[8] and molar relation were made on dental casts.

Cephalometric and dental cast variables were measured and subjected to statistical analysis with curve of spee as dependent factor and other as independent variable.

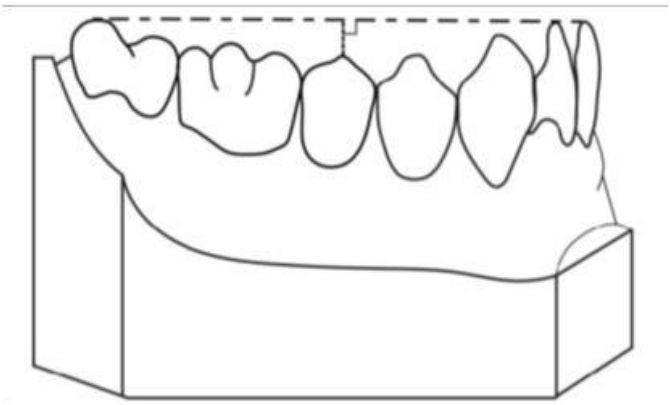


Fig:3.Measuring of curve of spee.

Statistical analysis

All measured parameters were subjected to following tests.

- Student t-test was used to determine the significant differences between mean and standard deviations of various parameters in each groups.
- Anova test was perform.
- The pearson's correlation coefficient was used to evaluate correlation between various measured parameters and curve of spee.

All statistical analysis was done by SPSS 16.0 software.

III. Result

The means, standard deviations, and percentages of contribution of the dental and skeletal components are given (Table 1).

The skeletal and dental parameters were correlated to change in the depth of curve of spee using the Pearson's correlation coefficient test (Table 2).

Comparison between molar relation and curve of spee was done (Table 3).

TABEL 1

VARIABLE	AVERAGE GROUP				HORIZONTAL GROUP				VERTICAL GROUP				AVONA
	MEAN	STANDERD DEVIATION	P VALUE	COEF. OF VARIATION	MEAN	STANDERD DEVIATION	P VALUE	COEF. OF VARIATION	MEAN	STANDERD DEVIATION	P VALUE	COEF. OF VARIATION	F / P
SNA	84.7	4.15	>0.05	3.5%	84	2.6	>0.05	2.5%	81.94	5.038	>0.05	2.6%	0.5/0.56
SNB	51.5	4.5	>0.05	3.9%	79	3.08	>0.05	3.6%	76.6	3.48	>0.05	4.6%	0.03/0.964
ANB	4.9	2.21	>0.05	12.6%	4.49	2.3	>0.05	10.2%	5.1	2.36	>0.05	11.3%	2.1/0.1
B ANGLE	30.2	4.91	>0.05	5.9%	28	8.4	>0.05	5.6%	29.1	4.069	>0.05	4.8%	0.3/0.71
N-ANS	51.5	4.5	>0.05	3.4%	51.0	3.6	>0.05	3.9%	49.9	4.44	>0.05	4.5%	0.1/0.8
ANS-GN	64.6	5.3	>0.05	4.5%	62.1	5.5	>0.05	2.5%	63.9	4.40	>0.05	3.8%	08.01/0.3
U6-NF	24.3	3.5	>0.05	3.6%	22.7	5.2	>0.05	2.5%	23.6	3.29	>0.05	2.8%	0.2/0.47
M6-MP	33.5	4.6	>0.05	2.6%	32.4	3.8	>0.05	3.3%	31.4	3.8	>0.05	1.2%	0.1/0.75
OVERJET	4.27	2.52	>0.05	6.5%	5.6	2.28	>0.05	3.1%	5.3	3.06	>0.05	6.15	11.25/0.001
OVERBITE	3.05	1.35	>0.05	9.6%	3.7	1.3	>0.05	6.3%	3.2	1.42	>0.05	10.2%	12.05/0.001
CURVE OF SPEE	1.625	0.65	>0.05	23.3%	2.8	0.9	>0.05	22.5%	1.66	0.793	>0.05	20.3%	8.1/0.5

TABLE 2-Pearson Correlation Test.

CORELATION WITH CURVE OF SPEE	AVERAGE		HORIZONTAL		VERTICAL	
	R VALUE	P VALUE	R VALUE	P VALUE	R VALUE	P VALUE
ANTERO POSTERIOR VARIABLE						
SNA	0.20	0.3	0.16	0.4	0.08	0.700
SNB	**-0.46**	**<0.001***	**-0.23**	**<0.001***	**-0.40**	**<0.001***
ANB	**0.46**	**<0.05***	**0.36**	**<0.05***	**0.45**	**<0.05***
B ANGEL	0.27	0.23	0.40	0.27	0.035	0.88
VERTICAL VARIABLE						
N-ANS	0.20	0.39	0.19	0.40	0.11	0.6
ANS-GN	0.05	0.82	0.25	0.45	0.55	0.11
U6-NF	0.22	0.33	0.21	0.35	0.29	0.20
M6-MP	0.003	0.98	0.30	0.18	0.18	0.44
DENTAL COMPONENTS						
OVERJET	**0.34**	**<0.05***	**0.36**	**<0.005***	**0.26**	**<0.05***
OVERBITE	**0.31**	**<0.05***	**0.55**	**<0.011***	**0.31**	**<0.05***

P value-*<0.05-just significant; *<0.001-highly significant

TABLE 3- comparison of molar relation of study population

MOLAR RELATION	AVERAGE N=20		MOLAR REALTION	HORIZONTAL N=20	MOLAR RELATION	VERTICAL N=20
	NO.	MEAN(CS)	NO.	MEAN(CS)	NO.	MEAN(CS)
CLASS I	13	1.4	10	2.75	10	1.6
CLASS II	7	**1.6**	10	**3.75**	10	**3.4**

- Table 1. Showed the descriptive statistics of each measured parameter in each group. Difference in overjet and overbite of the three groups were found to be statistically significant ($p<0.001$). The differences between SNA ($p=0.573$), SNB ($p=0.964$), ANB ($p=0.118$) and B-angle ($p=0.715$) were not found to be statistically significant. The vertical measurements N-ANS ($p=0.846$), ANS-GN ($p=0.366$), U6-NF ($p=0.478$), L6-MP ($p=0.752$) showed no statistically significant difference.
- Table 2. Showed correlation between different measured parameters with change in depth of curve of spee in each group. Pearson's correlation showed that in each group Overjet, Overbite, and ANB are positively correlated with change in depth of curve of spee ($p<0.05$) where as SNB was negatively correlated with curve of spee**,** other parameters like SNA, B-angel, N-ANS,ANS-GN, U6-NF,L6-MP showed weak correlation with curve of spee that was not statistically significant.
- Statistically high correlation was seen between overbite and depth of curve of spee for horizontal group.
- Table 3. Showed comparison between molar relation and curve of spee, in group A majority of patients were class I, but in group B and C There was equal distribution of class I and class II. Difference in molar relationship among Group A, Group B and Group C was found to be highly significant, within these groups subjects with class II malocclusion showed increasing depth of curve of spee.

IV. Discussion

Increased curve of Spee in the mandibular dentition is a common feature of patients undergoing orthodontic treatment. Orthodontists generally evaluate and consider the Curve of Spee in all cases. Treatment planning should be a combination of cephalometric and dental discrepancies so consideration of the curve of Spee is an important factor in diagnosis.[9,10,11] 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.[12] Farella et al[8] has been suggested that the mandibular position relative to the cranium is related to the curve of spee, which is present in various forms in mammals. Marshall et al[13] 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. 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.[13] 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[8] who said that homogenous dental wear could be the reason for the maintenance of curve of Spee in adulthood.

Although, levelling of the curve of spee is an everyday occurrence in orthodontic practices, 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.[11]

The measurement of curve of spee was done and the average of the distance on right and left side was taken as the depth of curve of spee (Nanda SK,[14] Dale J,[15] and Baydas et al)[16]. This method of assessment of curve of spee was easy to perform and lacked any magnificational and projectional errors. Other authors like Baldrige[17] used the perpendicular distances on both sides, Sondhi et al[9] used the sum of the perpendiculars, Bishra et al[18] used the average of the sum of the perpendicular distance to each cusp tip and Braun et al[19] and Braun and Schmidt[20] used the sum of the maximum depth on both sides.

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), or virtual 3D models supplemented by software programs dedicated to performing a wide array of measurements (Cheon et al).[21]

Farella et al[8] 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.

In this present study, the age group was in the range of 18-25 years to omit any effect of growth on the curve of spee. Eight cephalometric and four dental cast parameters were used of which cephalometric parameters were divided in to vertical and anteroposterior parameters. Since the curve of spee was significantly influenced by sagital and vertical craniofacial morphology as suggested by Farella et al. This study aimed at to evaluate relationship between different skeletal growth patterns with curve of spee. So subjects were divided

according to the different skeletal growth patterns and changes in curve of spee were assess by measuring skeletal and dental parameters.

The findings suggested that the change in depth of curve of spee was positively correlated with horizontal dental parameters like overjet, overbite, molar relation and vertical skeletal parameter that is ANB angel for each group. It was found that the subjects with higher maxilla-mandibular discrepancies tends to have deeper curve of spee. ANB was positively correlated with the depth of curve of spee, that is in subjects with less ANB angle depth of curve of spee was less. Same finding is supported by the study done by Cheon et al[21] and Orthlieb JD.[22]

In this study it was found that patients with horizontal growth pattern had increased depth of curve of spee as the highest contributing factor of deep bite,as pearson's correlation was highly statistically related with overbite and change in curve of spee. 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. This finding was supported by study done by Jhalani A.[23]

Overjet was also positively correlated with change in depth of curve of spee but for each group the correlation coefficient was same with change in depth of curve of spee.

In this study SNB angle was negatively co related with curve of spee, this finding suggested that the depth of curve of spee was influenced by the position of the mandible with respect to the anterior cranial base, this was seen in all three groups.

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 Class II malocclusions in which there is increase overjet and overbite**.** Trauten et al[24] and Orthlieb[22] 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[8] 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**.**

This study is also supported by study done by Baydas et al[16], 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. Shannon and Nanda[25] 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.

V. Conclusion

- The curve of spee was influenced by sagittal maxilomandibular discrepancies, for all three groups. Change in depth of curve of spee was correlated positively with ANB angle and negatively with SNB angle. Other skeletal parameters showed weak correlation with curve of spee but that was not statistically significant.
- Curve of spee was also positively correlated with dental parameters like overjet, overbite, Molar relation.
- Highly significant relation was seen between increasing depth of curve of spee in horizontally growing individuals, which was also positively correlated with increase in overbite.
- Within these groups subjects with class II malocclusion showed increasing depth of curve of spee.
- We conclude that variation in the curve of spee is related with changes in dental parameters rather than skeletal parameters in all types of skeletal patterns.

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