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Variability in depth of curve of Spee and its associated skeletal and dental implications in population of Pakistan: A cross sectional study

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***Abstract*---**Background and Aim: The curve of Spee (COS) is a physiological entity in human dentition. A functional masticatory system necessitates an appropriate occlusal curvature. The primary objective of this investigation was to assess the skeletal and dental parameters in individuals with variation in the depth of curve of Spee. Materials and Methods: A total of 276 patients with pre-treatment lateral cephalograms and dental cast models were investigated in the Orthodontics and Dentofacial Orthopedics Unit of a Tertiary Care

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Hospital of Mardan, Pakistan from January 2021 to December 2022. Patients with no prior history of orthopedic treatment for functional jaw, prosthodontic treatment, no prior history of cleft lip and palate and cranio-facial disorders were enrolled. Ethical approval was obtained and all the patients were categorized into three groups based on the depth of curve of Spee (COS): Group-I (flat curvature < 2 mm), Group-II (normal curvature 2-3 mm), and Group-III (deep curvature > 3 mm). Lateral cephalometric analysiswas done to measure the four angular and four linear parameters. Molar relation, overbite, COS depth, and overjet were measured based on the occlusal classification. SPSS version 27 was used for data analysis. Results: The overall mean measurement of overjet (in millimeters, mm) in Group-I, II, and III was 4.68±2.42 mm, 5.92±3.12 mm, and 7.78±2.99 mm respectively. The horizontal skeletal angular measurements (degrees ^{o}) such as SNA, SNB, ANB, and β-angle in Group-I were (81.74±5.72, 77.68±5.62, 4.52±2.72, and 31.58±7.42), in Group-II were (82.64±5.21, 78.96±5.42, 4.72±2.84, and 30.92±5.46), and in Group-III were (82.66±4.22, 78.94±5.12, 5.72±3.29, and 30.42±9.78). Vertical skeletal measurements such as N-ANS, ANS-GN, U6-NF, and L-6 MP in Group-I were (44.89±3.12, 56.94±5.24, 20.18±2.12, and 26.78±3.74), in Group-II were (45.64±6.52, 56.82±7.18, 19.76±4.92, and 28.12±6.82), and in Group-III were (46.32±5.72, 56.02±6.62, 20.42±5.32, and 29.21±5.52). There were statistically significant differences in horizontal measurement parameters in terms of overjet in three groups (*p*-value <0.001) whereas no such association was found regarding vertical skeletal measurements in the study groups. Conclusion: The present study found that the depth of curve of Spee (COS) was associated with increased overjet, molar relation, and overbite. Additionally, horizontal and vertical skeletal parameters had an association with the variations in COS depth. Peculiarly, all horizontal skeletal metrics (SNA, SNB, ANB, and β-angle) were affected by changes in COS depth.

***Keywords*---**overjet, curve Spee depth, dental parameters, skeletal parameters, overbite.

Introduction

Curve of Spee is a naturally existing feature in the human dentition. A functional masticatory system necessitates appropriate occlusal curvature. Ferdinand Graf von Spee was a German human anatomy scientist and was the first to utilize skulls with abraded teeth to create a line of occlusion and initially defined the curve of Spee (COS) in the late 19th century [1]. During mastication, the occlusal force and posterior teeth's crushing strength is increased for food processing and is suggested as a biochemical function of COS [2]. The Spee's curve is an occlusal curve that can be measured from the anterior tooth's incisal margins to the distal marginal ridge of the most posterior tooth in the lower arch as defined in clinical orthodontics [3]. Exaggerated COS affects muscular balance during occlusion thus resulting in an inappropriate functional occlusion. COS leveling has to be corrected by malocclusion treatment involving posterior tooth extrusion, anterior tooth intrusion, and/or a combination of both. [4, 5]. Nayar et al., defined proper occlusion as Class-I molar relation, crown angulation and inclination, absence of tooth rotations, close interproximal contacts, and curve of Spee having a depth of no more than 1.5 mm [6]. There is also a substantial relationship between COS curve and overjet, overbite, and irregularity index [7]. In class I, II, and III malocclusions, a deep COS is frequently encountered in conjunction with a deep overbite [8, 9].

The orofacial structural development, tooth eruption patterns, and neuromuscular system development all have a profound influence on the line of occlusion and the COS. COS is also affected by vertical location and mandibular sagittal comparative to the cranium. Variations in face patterns in humans result in a differentiating COS. Deep overbites, on the other hand, are typically associated with an exaggerated COS [10-12]. The presence of a normal curve of Spee allows teeth to withstand occlusal stresses; on contrary an exaggerated COS causes muscular imbalance, ultimately leading to incorrect functional occlusion [13, 14, 15]. A reduced gonial angle is correlated with overbite. Batham et al., investigated that individual skeletal and dental characteristics in terms of deep bite and overbite have got various etiological causes with a key contributing factor being an enlarged COS and a reduced gonial angle [16].

Methodology

A total of 276 patients with pre-treatment lateral cephalograms and dental cast models were investigated in the Orthodontics and Dentofacial Orthopedics Unit of a Tertiary Care Hospital in Mardan, Pakistan from January 2021 to December 2022. Ethical approval was obtained and patients with no prior history of orthopedic treatment for functional jaw, prosthodontic treatment, no prior history of cleft lip and palate and craniofacial disorders were enrolled. All the patients were categorized into three groups based on the depth of curve of Spee (COS): Group-I (flat curvature < 2 mm), Group-II (normal curvature 2-3 mm), and Group-III (deep curvature > 3 mm). Lateral cephalometry was done to measure the four angular and four linear parameters. Patients with a prior history of any systemic disease, restoration, orthodontic treatment, and cuspal coverage treatment were excluded. Molar relation, overbite, COS depth, and overjet were measured based on occlusion class. Any individual having tooth related congenital anomalies and prior history of neck trauma were excluded as well. The depth of COS was determined by measuring the perpendicular distance between the deepest cusp tip and a flat plane put on top of the mandibular dental cast, touching the incisal margins of the central incisors and the distal marginal ridge of the most posterior teeth in the lower arch. The measurements were taken on the right and left sides of the arch, and the mean value of these two measurements was used to calculate the depth of COS. Cephalometric radiographs were obtained as per the usual clinical practice.

SPSS version 27 was used for data analysis. Descriptive analysis was performed on the data to determine the mean, range, standard deviation, and 95% confidence interval was taken. Statistical analysis was done using One-way analysis of variance (ANOVA) to examine group differences as well as Chi-square test. Twenty radiographs were chosen at random to find and eliminate inaccuracies related to radiographic measures including artifacts. Lead pencil tracings of cephalograms were done and all measurements were redone six weeks following the initial measurements.

Results

The overall mean overjet (mm) in Group-I, II, and III was 4.68±2.42 mm, 5.92±3.12 mm, and 7.78±2.99 mm respectively. The Horizontal Skeletal measurements (º) such as SNA, SNB, ANB, and β-angle in Group-I (81.74±5.72, 77.68±5.62, 4.52±2.72, and 31.58±7.42), Group-II (82.64±5.21, 78.96±5.42, 4.72±2.84, and 30.92±5.46), and Group-III (82.66±4.22, 78.94±5.12, 5.72±3.29, and 30.42±9.78) were recorded. Vertical skeletal measurements such as N-ANS, ANS-GN, U6-NF, and L-6 MP in Group-I (44.89±3.12, 56.94±5.24, 20.18±2.12, and 26.78±3.74), Group-II (45.64±6.52, 56.82±7.18, 19.76±4.92, and 28.12±6.82), and Group-III (46.32±5.72, 56.02±6.62, 20.42±5.32, and 29.21±5.52) were recorded. There was a statistically significant difference in horizontal measurement parameters in terms of overjet in three groups ($p<0.001$) whereas no such association was found regarding vertical skeletal measurements. Comparison of overjet measurement in three groups are shown in Table-I. Horizontal and vertical skeletal measures of the study population are shown in Table-II. Statistics for patients in Classes I, II, and III are shown in Table-III.

Table-I Comparison of overjet measurement in three groups

Groups	Overjet (mm) (Mean ± SD)
Group-I	4.68±2.42
Group-II	5.92±3.12
Group-III	7.78±2.99

Table-II Horizontal and vertical skeletal measures of the study population

Groups	Group-I (n=92)	Group-II (n=92)	Group-III (n=92)	ANOVA test *p*-value (F)
Horizontal				
SNA	81.74±5.72	82.64±5.21	82.66±4.22	0.552 (0.557)
SNB	77.68±5.62	78.96±5.42	78.94±5.12	0.957 (0.042)
ANB	4.52±2.72	4.72±2.84	5.72±3.29	0.123 (2.245)
β-angle	31.58±7.42	30.92±5.46	30.42±9.78	0.723 (0.342)
Vertical				
N-ANS	44.89±3.12	45.64±6.52	46.32±5.72	0.795 (0.174)
ANS-GN	56.94±5.24	56.82±7.18	56.02±6.62	0.374 (1.010)
U6-NF	20.18±2.12	19.76±4.92	20.42±5.32	0.783 (0.249)
L6-MP	26.78±3.74	28.12±6.82	29.21±5.52	0.449 (0.848)

Table-III Statistics for patients in Classes I, II, and III

Molar relation	Class-I	Class-II	Class-III
Curve of Spee (COS)	1.8 ± 0.84	3.2 ± 1.12	2.1 ± 1.03

ANB	2.1 ± 1.10	6.2 ± 1.22	3.2 ± 1.81
n (%)	20 (21.7)	58 (63)	62 (67.4)

Discussion

The present study mainly focused on the assessment of the individual's skeletal and dental parameters with variations in the depth of COS and found that increased depth is a frequent characteristic in mandibular dentition among orthodontic patients. Orthodontists rarely evaluate and treat patients considering the curve of Spee (COS) in all situations hence the need of cephalometric and anthropometric planning is pivotal. Dental discrepancies as well as consideration of the curvature of Spee are significant diagnostic factors which should not be left undocumented [17, 18]. Evaluation of the Spee curve's connection to the understanding of odonto-skeletal morphology is critical. It is noted that a combination of variables cause variance in the Spee curve's depth [19].

According to Foletti et al., the COS is connected to the skull related mandibular position in many forms [20]. With brachycephalic face patterns, an enlarged Spee curve is common and related to short mandibular bodies [21]. Uzuner et al., measured the depth of COS on thirty-three untreated subjects [22]. The depth of the COS is regarded as a significant parameter for therapeutic methods. Age and gender has no significant effect on COS depth which is consistent with previous studies [23, 24].

The evaluation of the connection of the COS with odonto-skeletal morphology is critical for understanding the effect of many variables that contribute to variation in its depth [25, 26]. Despite the fact that Spee curve levelling is a common occurrence, little research has been conducted on this occurrence in orthodontic practices done to investigate the relationship between the Spee curve and a variety of factors influencing its depth, which may be good for determining the viability of levelling the Spee curve as a result of orthodontic treatment. This can be regarded as the essential scientific information gap which needs to be explored.

Krusi et al. [27] totaled the perpendicular distances, Fawaz et al. [28] calculated the average of the sum of the perpendicular distances to each cusp tip, Rozzi et al. [29] and Braun and Sayar et al., [30] calculated the sum of the greatest depths on both sides. Growth had little influence on the COS since the depth remained relatively constant during adulthood as opposed to the flat curve in deciduous dentition and maximal deepening during teenage dentition [31]. The results of our study revealed that the depth of curvature of the horizontal dental parameters had an impact on COS. Overjet in Group I patients varied from 0 to 10 mm while that of Group II varied from 0-13 mm and in Group III was 1-14 mm. The most noticeable distinctions for overjet were discovered between the deep COS and flat COS groups. Findings by Dritsas et al., support these results [32].

Paes da Silva et al, [33] also undertook a research to analyze and compare the depth of curve of Spee in class I, class II division-1 class II division-2, class II subdivision and class III malocclusion and found that the curve of Spee was deepest in class II division-2 malocclusion which resembles our study findings as well. Al-Moghrabi et al. [34] discovered a maximum COS depth in Class II Division-1 subjects and a minimum depth in Class III malocclusion subjects. Overbite has a significant influence on COS depth and its associated modification in the mandibular arch. The depth of the curvature of COS in the mandibular arch rises when there is an increase in overjet and overbite [35].

Conclusion

The present study found that the depth of curve of Spee (COS) was associated with increased overjet, molar relation, and overbite. Peculiarly, all horizontal skeletal metrics (SNA, SNB, ANB, and β-angle) were affected by changes in COS depth.

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