Evaluation of the Depth of the Curve of Spee in Untreated Orthodontic Patients in the University of Benin Teaching Hospital, Benin City, Nigeria.

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ABSTRACT

Objective: Curve of Spee is a naturally occurring curve of the occlusal plane in the human dentition which begins at the tips of the incisors following the buccal cusps of the premolars and molars and continuing to the anterior border of the ramus, and it plays several roles in human dentition. The aim of this study was to evaluate the depth of Curve of Spee in untreated Orthodontic patients in Benin City, Nigeria.

Methods: Dental casts of 100 untreated orthodontic patients were selected and classified using Angle's method. Using a digital caliper (European Directive ROHS 2002/95/CE) the depth of curve of Spee was measured as the perpendicular distance between the deepest cusp tip and a flat plane that was laid on the occlusal surface of the maxillary and mandibular dental casts, touching the incisal edges of the central incisor and the most distal cusp of the most posterior teeth in the upper and lower arches. The data was computed with SPSS version 21.0 and analyzed for frequencies, percentages and means. Variations between variables were evaluated with the Chi-square test. P values at < 0.05 were set as significant.

Results: The mean depth of the curve of Spee in the mandibular arch on the right side was 2.4± 0.90 mm, while on the left side it was 2.3 ± 1.0 mm. The average depth of the mandibular curve of Spee was 2.3 ± 0.8 mm. The mean depth of the curve of Spee in the maxillary arch on the right side was 2.6 ± 1.3 mm, while on the left side it was 2.6 ± 1.2 mm. The average depth of the maxillary curve of Spee was 2.6 ± 1.2 mm. The depth of the curve of Spee in the maxillary arch was greater than the value obtained for the mandibular arch, but not statistically significant (P=0.05).

Conclusion: This study recorded higher values in depth of curve of Spee in the maxillary arch when compared to the mandibular arch. The difference was not statistically significant.

Keywords: Curve of Spee, untreated orthodontic patients

INTRODUCTION

The Curve of Spee (COS) is a naturally occurring curve of the occlusal plane in the human dentition which was first described in 1890 by a German anatomist called Ferdinand Graf von Spee and it was thereafter named after him. Spee wrote an article on the subject matter in 1890 which was later republished in 1980 (Spee et al, 1980). 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 molars and the incisal edges of the mandibular incisors (Senthi et al., 2012).

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 molars to the incisal edges of the incisors when viewed in the sagittal plane (Almotareb, 2017). The morphological arrangement of the teeth in the sagittal plane has been related to the slope of the articular eminence, craniofacial morphology, lower incisor proclination, the overbite, the molar cusp height and lower arch circumference (Almotareb, 2017). However, it is suggested that 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 (Almotareb, 2017). Andrews (Andrews, 1972), 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 the occlusal plane was relatively flat. He proposed that flattening the occlusal plane should be the treatment goal in orthodontics (Andrews, 1972). This concept especially as applied to deep overbite patients has been supported by others (Tweed, 1966; Schudy, 1968; Burstone, 1977; Garcia, 1985). Previous studies (Almotareb, 2017; Marshall et al, 2008) reported that the primary dentition has a curve of Spee ranging from flat to mild, whereas the adult curve of Spee is more pronounced. Previous studies (Bishara et al., 1989; Carta and McNamara, 1998; Sondhi et al., 1980) reported that there was no significant change in the depth of curve of Spee between adolescence and adulthood periods.

The development of curve of Spee probably results from combination of factors including eruption of teeth, growth of orofacial structures, and development of the neuromuscular systems (Almotareb, 2017; Marshall et al., 2008).

The curve of Spee is correlated with overjet and overbite. It is directly proportional to overjet and overbite of an individual. By increasing overjet and overbite, it will result in deeper curve of Spee (Kathri & Sanap, 2018; Jain et al, 2012).

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Curve of Spee is described as deepest in class II malocclusion while it is flatter and with insignificant variances in class I and class III subjects. It was established that the depth of the curve of Spee is greatest in Class II Division 1, followed by Class II Division 2, Class I, and Class III. However, there is no significant difference between Class II Division 1 or Class II Division 2 (Surrendran et al, 2016).

An increased depth of curve of Spee is often seen in brachycephalic facial patterns and associated with short mandibular bodies (Banu et al, 2017).

Previous studies (Carta and McNamara, 1998; Veli et al, 2015), reported no significant difference in depth of curve of Spee between male and females, while others also reported that the depth of curve of Spee was not influenced by gender (Ferrario et al., 1992; Ferrario et al., 1997; Hui et al., 2004).

Leveling of the occlusal plane is almost always indicated, and according to Proffit (Proffit et al., 2007), should be performed as a part of the first major stage of comprehensive orthodontic treatment. Techniques for leveling the curve of Spee includes; extrusion of premolars and molars, intrusion of incisors, or by combination of both. The method selected should be based on the specific characteristics of not only the patient's malocclusion, but also their overall craniofacial proportions (Proffit et al., 2007).

Several authors have described various methods in the measurement of the depth of curve of Spee (Bishara et al., 1989; Sondi et al., 1980; Braun et al., 1996). Sondi et al (Sondi et al., 1980) reported that the depth of curve of Spee is the sum of all perpendicular distances from cusp tips of canine, premolars, and mesiobuccal cusp tip of the first molar to the occlusal plane (line connecting distobuccal cusp of the molar and incisor) from the right side only. Bishara et al. (Bishara et al., 1989), determined the depth of curve of Spee as the average of the sum of the perpendicular distances from cusp tips of the canine, premolars and mesiobuccal cusp of the first molar to a reference line drawn from the incisal edge of the central incisor to the distal cusp tip of the second molar. Braun et al (Braun et al, 1996), reported that manual measurement of the depth of curve of Spee was done with a digital caliper and a plate (flat

plane). The plate was set on the mandibular plaster model so as to touch the distal cusps of the second molars and incisal edges of the central incisors. The deepest cusp tip to the plate was recorded with a digital caliper. The depth of curve of Spee was recorded for each side, the mean value of the right and left sides was used as the depth of curve of Spee. Bernstein et al (Bernstein et al 2007), described the measurement of the depth of curve of Spee using a lateral cephalometric radiograph. A line joining a molar cusp and incisor tip is used as reference plane and the distance to the most intruded premolar is measured either by a ruler on a plain film, or by a computer software program on a digital film.

The characteristics of curve of Spee in the mandibular arch have been investigated (Spee et al, 1980; Ferrario et al, 1992; Ferrario et al, 1997; Sushma et al, 2017). However, few studies have examined the characteristics of the curve of Spee in the maxillary arch (Hui et al, 2004; Sushma et al, 2017). Hui et al (Hui et al, 2004), reported that the depth of the curve of Spee differed between the maxillary and mandibular arches. They reported that the curve of Spee in the maxillary arch was significantly flatter than in the mandibular arch (Hui et al, 2004). Sushma et al (Sushma et al, 2017) reported that the depth of the curve of Spee was larger in maxillary than mandibular arches. The aim of this study was to evaluate the depth of curve of Spee in the maxillary and mandibular arches in untreated orthodontic patients in University of Benin Teaching Hospital, Benin City.

MATERIALS AND METHODS

This cross-sectional study was carried out on study casts of pre-treatment orthodontic patients of the University of Benin Teaching hospital, Benin City after obtaining clearance from the Ethical Committee of the College of Medical Science, University of Benin, Benin City. Dental casts of 100 untreated orthodontic patients (of the orthodontic unit) of the University of Benin Teaching Hospital, Benin City were evaluated. Privacy and confidentiality of the information from the dental casts was maintained throughout the duration of the study. Inclusion criteria was:

i Angle's class 1 cases with crowding
ii Angle's class 1 cases with spaces
iii No history of previous orthodontic treatment
iv Dental casts which were properly prepared, based and unbroken
v Dental casts with only permanent teeth present (at least 1-6 in all quadrants).

Exclusion criteria were:

i Cases with anterior open bite (AOB).
ii Cases with deep overbite.
iii Previous orthodontic treatment.
iv Severe craniofacial disorders.
v Posterior cross bite.
vi Tooth anomaly/tooth wear.
vii Presence of occlusal filling.
viii Dental casts with missing teeth or those with primary teeth as well as those in the mixed dentition stage.
ix Dental casts without an opposing jaw were also excluded.

The molar relationship was assessed according to Angle's system (Angle, 1899). In this system (Angle, 1899), for Class I molar relationship, the mesio-buccal cusp of upper first permanent molar occludes in the buccal groove of the lower first permanent molar. The disto-buccal cusp of upper first permanent molar occludes in the buccal groove of the lower first permanent molar in Class II, in a Class III molar relationship, the mesio-buccal cusp of the upper first permanent molar occludes in the interdental space between the mandibular first and second molars. In this study only study cast with Angle's class I classification were evaluated. Crowding and spacing of the mandibular and maxillary dental cast was classified using the Brass wire/caliper method described by Carey (Carey, 1958) and Huckaba (Huckaba, 1964). A brass wire of about 0.5mm was contoured to lie over the incisal edges of the anterior teeth and the centres of the contact areas of the teeth in the buccal segments. The site where the wire crossed the distal contact point of the first permanent molars was marked. The arch perimeter was then measured between these marks. The individual mesio-distal widths of the teeth (first permanent molar to first permanent molar was measured between the mesial and distal contact points using a digital caliper. From the sum of the tooth widths in each arch and the recorded arch perimeter, the arch length discrepancy was calculated.

Arch Length Discrepancy = Arch Perimeter – Sum of mesio-distal widths of first permanent molar to first permanent molar.

The method described by Braun et al (Braun et al., 1996) was applied in this study. A flat plane (metre rule) was placed on one side of the occlusal surface of each study cast (right or left), touching the incisal edges of the central incisor and the most distal cusp of the most posterior teeth. Using a digital caliper (European Directive ROHS 2002/95/CE), the depth of the curve of Spee was measured as the perpendicular distance between the deepest cusp tip and the flat plane. The mean for each cast was obtained from the values for right and left sides. Ten casts were evaluated two weeks

apart by the same researcher (IGO- first author), and the using t-test, intra-examiner reliability (of the measurements) of 0.8 was obtained (0.6 and above are acceptable reliability).
Data was computed and analyzed using the SPSS version 21.0 software. Data generated were subjected to statistical analysis to determine the variables (frequencies, percentages and means). Differences between variables were evaluated with Chi-square test. P values at <0.05 were set as significant.

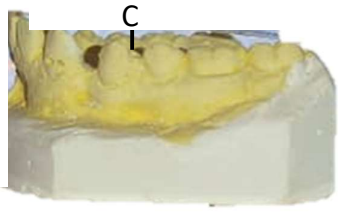
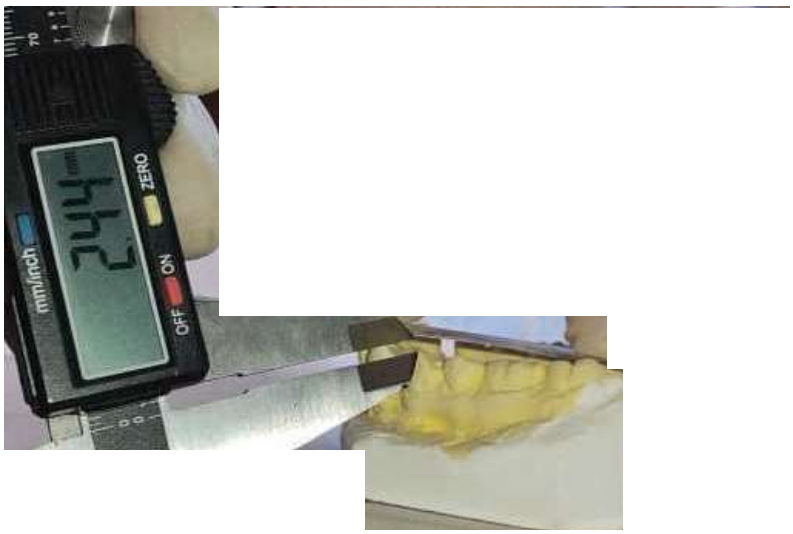


Figure 1: Perpendicular Line C Shows the Depth of Curve of Spee – Left Mandibular Arch



Measurement of Depth of Curve of Spee Showed in Figure 1 using a Digital Caliper (European Directive ROHS 2002/95/CE).

RESULTS

A total number of 100 dental casts of untreated orthodontic patients was evaluated. Table 1 shows the mean depth of the curve of Spee in the mandibular arch on the right is 2.4mm while that on the left is 2.3mm. It has a standard deviation of ±0.90 on the right side while that on the left is ±1.0. Mean depth of curve of Spee in the mandible is

2.3±0.8 mm. Table 2 shows the mean depth of the curve of Spee in the maxillary arch. The mean depth of the curve of Spee in maxillary arch on the right and left are 2.6 mm and 2.6mm respectively. The standard deviation for the right side is ±1.3 while on the left is ±1.2. Mean depth of curve of Spee in the maxilla is 2.6±1.2 mm

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Table 1: Mean depth of the curve of Spee in the mandibular arch

	Mandibular Arch	
	(Right)	(Left)
Total (n)	100	100
Mean (mm)	2.4	2.3
Std. Deviation	0.9	1.0

Table 2: Mean depth of the curve of Spee in the maxillary arch

	Maxillary Arch	
	(Right)	(Left)
Total (n)	100	100
Mean (mm)	2.6	2.6
Std. Deviation	1.3	1.2

Table 3 shows comparison between the mean values of the depth of the curve of Spee in both arches using t test. The maxillary arch has a mean depth of the curve of Spee of 2.6 mm with a standard deviation of ±1.2, while the mean and standard deviation of the mandibular arch was 2.3 ±0.8 mm. Comparison between the mean values of the mandibular and maxillary arches using t test resulted in a P value of 0.05. This shows that although the values of the mean depth of the curve of Spee in the maxillary arch was higher than the means of the mandibular arch, the difference was not statistically significant (P=0.05).

Table 3 Comparison between Mandibular and Maxillary arches

	Mandibular Arch	Maxillary Arch
Total (n)	100	100
Mean (mm)	2.3	2.6
Std. Deviation	0.8	1.2

t test;P=0.05;

DISCUSSION

The curve of Spee is defined as an imaginary line which begins at the tips of the incisors following the buccal cusps of the natural premolars and molars and continuing to anterior border of the ramus (Spee et al, 1980). It represents the arrangement of the mean of the curvature of occlusal surfaces of the mandibular as well as maxillary arches. An important aspect of comprehensive orthodontic treatment in recent times is the leveling of the curve of Spee (Spee et al, 1980; Huckaba, 1964). Previous studies reported no significant difference in the depth of curve of Spee between male and females (Carta & McNamara, 1998; Veli et al, 2015), while others reported that the depth of curve of Spee was not influenced by gender (Ferrario et al, 1992; Ferrario et al, 1997; Hui et al, 2004). In this study, gender comparison was not assessed.

The measurement of the curve of Spee doesn't require a rigid approach as several authors have used several techniques (Bishara et al, 1989; Sondi et al, 1980; Braun et al, 1996; Bernstein et al, 2007). Dating back to when the curve of Spee was first described, Spee himself actually examined the dentitions of human archeological skulls and then noted the presence of the curve (Spee et al, 1980). In this study, the cast model approach described by Braun et al which is quick and reliable was used to evaluate the depth of curve of Spee (Braun et al, 1996).

A previous study (Banu et al, 2017) reported an increased depth of curve of Spee is often seen in brachycephalic facial patterns and associated with short mandibular bodies. However, this study did not assess the facial profile of study population.

Previous studies (Kathri & Sanap, 2018; Surrendran et al, 2016) reported that the curve of Spee was deepest in Class II malocclusion, while it is flatter and with insignificant variances in Class I and Class III subjects. They also reported that the depth of curve of Spee is greatest in Class II, Division 1

malocclusion, followed by Class II, Division 2, Class I, and Class III malocclusions, and there was no significant difference between Class II, Division 1or Class II, Division 2 malocclusions (Kathri and Sanap, 2018; Surrendran et al, 2016). In this study only dental casts with Angle's Class I malocclusion were assessed.

It was reported that the curve of Spee ranged from flat to mild in the primary dentition whereas it was more pronounced in adults (Almotareb, 2017; Marshall et al, 2008). Previous studies (Bishara et al, 1989; Carta & McNamara, 1998; Sondi et al, 1980) reported that there was no significant change in the depth of curve of Spee between the adolescence and adulthood periods. In this study, only study casts of patients in the permanent dentition period were evaluated.

Hui et al (Hui et al, 2004), reported that the depth of curve of Spee differed between the maxillary and mandibular arches, they showed that the curve of Spee in the maxillary arch was significantly flatter than in the mandibular arch, while the study by Sushma et al (Sushma et al, 2017), showed that the radii and the depth of the curve of Spee were larger in maxillary than mandibular arches. In this study, the depth of the curve of Spee was larger in the maxillary arch when compared to the mandibular arch, but the difference was not statistically significant.

CONCLUSION

In this study the depth of curve of Spee of untreated orthodontic patients in Benin City was greater in the maxillary arch compared to the mandibular arch, the difference was not statistically significant.

RECOMMENDATIONS

1. The depth of the curve of Spee is very important in orthodontic treatment and should be considered before proceeding with treatment of malocclusion cases.
2. Leveling of the curve of Spee should be done when and where necessary.
3. Intensive teaching of the curve of Spee should be incorporated into the undergraduate orthodontic curriculum.
4. The orthodontist should strive to achieve a curve of Spee that is near flat as possible for efficient and effective mastication.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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