An Evaluation of the Curve of Spee in the Maxilla and Mandible of Human Permanent Healthy Dentitions: A Cross Sectional Analytical Study in a Group of Nepalese Population

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ABSTRACT

Introduction: Familiarity with the typical measurements of the maxillary and mandibular curves of Spee can assist clinicians in formulating sagittal plane occlusion and proves beneficial in delivering prosthetic rehabilitation for patients with occlusal derangement. The objective of this study is to evaluate and compare the radius and depth of the Spee curve in the maxillary and mandibular arches among both male and female individuals within young Nepalese population.

Materials and Methods: The study comprised 21 men and 21 women aged between 18 and 30 years. Alginate impressions were made for both the maxillary and mandibular arches and dental stone casts were subsequently created. Digital images of the right side of maxillary and mandibular dental casts were captured using a digital camera and subsequently transferred to a computer. The tips of the distal cusps of molars, premolars, and canines in both the maxillary and mandibular arches were identified. Utilizing the computer software (Corel DRAW), the radius and depth of the Spee curve were measured based on the digital photographs of the dental casts.

Results: The results indicated a substantial difference in the depth of the Spee curve between the mandibular and maxillary arches ($p<0.001$), with the mandibular arch displaying a significantly greater depth. Furthermore, the Spee curve was notably deeper in females ($p=0.045$) compared to males. However, there was no statistically significant difference in the depth of the Spee curve in the mandible between genders ($p=0.171$).

Conclusions: The radius of the Spee curve was unaffected by the gender or arch of the subjects under investigation. Nevertheless, the Spee curve was observed to be significantly flatter in the maxillary arch when contrasted with the mandibular arch. Additionally, a notable difference in the depth of the Spee curve was identified between females and males, with females displaying a greater depth.

Key words: *Radius; Depth; Curve of Spee, Cuspid, Compensating curves*

INTRODUCTION

The Curve of Spee, which exists in the ideal natural dentition, allows harmony to exist between the anterior tooth and condylar guidance.[1] From the sagittal view, if an imaginary line is drawn through the buccal cusp tips of the posterior teeth, following the plane of occlusion, a curved line that is convex for the maxillary arch and concave for the mandibular arch is established. This curve was first described by Spee in 1890 and was referred to as the curve of Spee.[2]

The orientation of the occlusal plane is an important clinical procedure in prosthodontic treatment, thus the determination of the

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occlusal plane is one of the most important clinical procedures during tooth arrangement while rehabilitating edentulous patients.[1, 3] Proper management of the occlusal plane is also an essential consideration when multiple long-span posterior restoration are designed and during several clinical situations such as multiple implants, cleft palate and prosthetic rehabilitation for maxillofacial injuries.[4]

The purpose of this study was to examine the differences in the curve of Spee between the maxillary and mandibular arches in a group of young Nepalese population. The effect of gender on the curve of Spee was also investigated.

MATERIALS AND METHODS

It was a cross sectional analytic study conducted in Kantipur Dental College and Hospital with the permission of IRC KDC Ref No 07/021 in June 2021, for duration of a month. Verbal consent was taken from the study population of 18-26 years old Nepalese population who visited outpatient department of Kantipur Dental College and Hospital. Inclusion criteria were >18 years old, complete permanent dentition, including the second molars (at least 28 teeth) with bilateral angle class I first permanent molar and canine relations, and overjet and overbite of 2 to 4 mm. Subjects with a history of previous or current orthodontic treatment and disorders of temporomandibular joint, severe caries or periodontal disease, dental restorations which cover cusps, severe attrition, severe malocclusion were excluded.

$$\text{Sample size)} = \frac{2\,(Z_\alpha + Z_\beta)^2\, s^2}{d^2}$$

$Z\alpha$ = z deviate corresponding to the α error rate =1.96 for 95% reliability

$Z\beta$ = z deviate corresponding to the β error rate =1.28 at 90% power

s = standard deviation = (0.346+0.163)/2 = 0.2545

d = mean difference between two groups = 1.77-1.51 = 0.26

n = sample size required per group = 20.14118 per group

N=2n=2*20.14118= 40.28236

However, we included 42 patients in this study.

Alginate impression material (Plastalgin, Soptodont France) was use to make impressions of both the maxillary and mandibular arches and poured with Type III dental stone (Kalstone, Kalabhai Karson, India) to obtain casts. The dental casts were positioned within the base former with careful attention to align the buccal surface of the posterior teeth on the right side parallel to the outer border of the base former on the corresponding side. Subsequently, the dental casts were trimmed to ensure that the occlusal plane was parallel to the base. The occlusal plane was determined by referencing the incisal edges of the central incisors and the cusp tips of the furthest posterior teeth (either second molars or third molars).

Photographs of the right side of each cast were captured using a digital camera (Nikon D5000, Nikon, Tokyo, Japan). Care was taken to maintain a consistent 90° angle of incidence between the camera and the buccal surface of the posterior teeth.[5] The camera's height was fixed to match that of the dental casts, and the camera-to-cast distance remained at 50 cm, with photographs taken at maximum (4X) optical zoom. Both the camera and dental casts were positioned on a marked sheet of cardboard to ensure reproducibility of the setup across multiple shots.

This setup not only standardized the degree of enlargement in all photographs but also facilitated repeated image capture without altering the arrangement. Additionally, a millimeter graph paper was affixed to the right side of each cast to aid in image calibration

when recording measurements on the computer screen.

Following the photo session, each digital image of the dental casts was transferred to the computer for analysis. Using a trial version of computer software (Corel DRAW, Corel Corporation, New York, USA), the radius and depth of the Spee curve were measured.

The steps followed during the measurement of the curve of Spee were as follows:

Measurement of Radius of Curve of Spee: The arc was formed by connecting the cusp tips of the canine, the mesio-buccal cusp tip of the first molar, and the distal cusp of the second molar. The width (W) of this arc was determined by measuring from the tip of the canine to the tip of the distal cusp of the second molar. This measurement was taken using a ruler adjusted to the horizontal magnification of millimeter graph paper.To measure the height (H) of the arc, a perpendicular line was drawn from the tip of the canine to the disto-buccal cusp of the second molar, reaching the maximum curvature of the arc. The length of this line was measured using a ruler adjusted to the vertical magnification of millimeter graph paper (Figure 1and 3). To calculate the radius of the circle, an online calculator was employed, utilizing the formula Radius (r) = $H/2+W^2/8H$, where:

W represents the length of the chord that defines the base of the arc, while H corresponds to the height measured at the midpoint of the base of the arc.

These individual measurements were input into a spreadsheet using Microsoft® Excel 2007, and subsequently, the total and average values for the radius of the curve of Spee were computed for each subject.

Measurement of Depth of Curve of Spee: A reference plane was established, extending from the buccal cusp of the canine to the disto-buccal cusp tip of the second molar. Perpendicular lines were then drawn from this reference line to the cusp tips of the premolars, the first molar, and the mesio-buccal cusp of the second molar. The greatest length among these perpendicular lines determined the depth of the curve of Spee and was considered in this study (Figure 2 and 4). The individual lengths of these perpendicular lines were recorded in a spreadsheet using Microsoft® Excel 2007, and subsequently, the total and average values for the curve of Spee were calculated for each subject. SPSS (version 11.5) was used for statistical analysis.

Mean and standard deviations were calculated for each measured parameter. The independent sample t test was used to evaluate the difference in the curve of Spee between male and female, and the paired t test was used to test the difference between maxillary and mandibular arches. For all analyses, the level of statistical significance was defined as $p \leq 0.05$.

RESULTS

Mean age of the participants was 21.86±2.69 years, ranging from 18 to 30 years. Table 1 gives the mean arch radius of maxillary and mandibular arches in total sample. Comparing the radius and depths of curve of Spee in between maxillary and mandibular arch (table 1), it was found that the depth of the curve of Spee in the mandibular arch was significantly deeper than that in the maxillary arch ($p<0.001$).

Comparing radius and depths of curve of Spee in male and female as shown in Table 2, curve of Spee was significantly deeper in female ($p=0.045$) than that in male. However, there is no statistical significant difference in depth of curve of Spee in mandible in between the genders ($p=0.171$).

Table 1: Radius and depth of curve of Spee (N=42)

	Arch	Mean ±SD in mm	p-value
Radius	Maxilla	117.7657±14.04171	<0.001
	Mandible	104.1690±12.84423	
Depth	Maxilla	1.4643±0.18134	<0.001
	Mandible	1.6371±0.21490	

Table 2: Comparison of Mean radius and depth of curve of Spee between two genders

Arch	Variable	Male (N=21) Mean ±SD in mm	Female (N=21) Mean ±SD in mm	p-value
Maxilla	Radius	123.0419±13.44712	112.4895±12.84184	0.013
	Depth	1.4086±0.15448	1.5200±0.19243	0.045
Mandible	Radius	108.5933±12.93962	99.7448±11.38672	0.024
	Depth	1.5914±0.22839	1.6829±0.19525	0.171

The regression equation derived from these data are shown in Table 3

Table 3: Regression equations

Variable	Regression equation for total	Regression equation for male	Regression equation for female
Radius	Y=0.794x+35.079	Y=0.64x+53.585	Y=0.866x+26.069
Depth	Y=0.698x+0.321	Y=0.526x+0.572	Y=0.875x+0.048

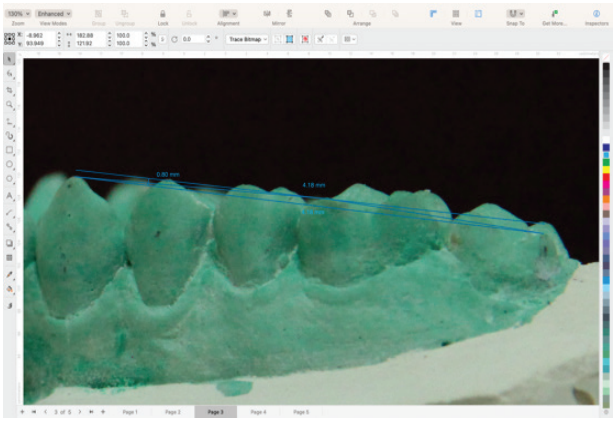

Figure 1: *Measurement of radius of curve of Spee in maxillary arch.*

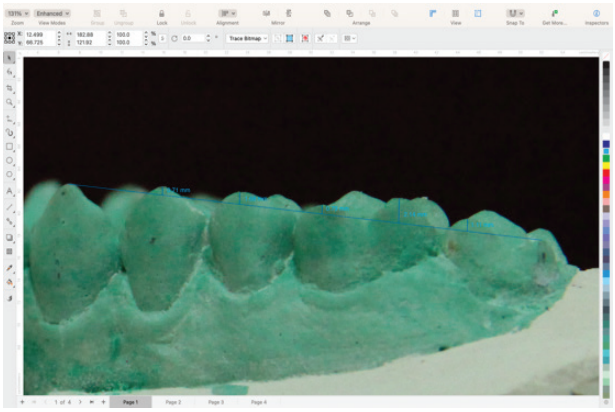

Figure 2: *Measurement of depth of curve of Spee in the maxillary arch.*

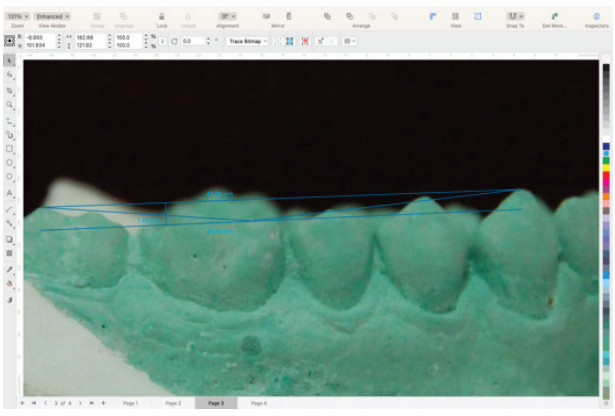

Figure 3: *Measurement of radius of curve of Spee in mandibular arch.*

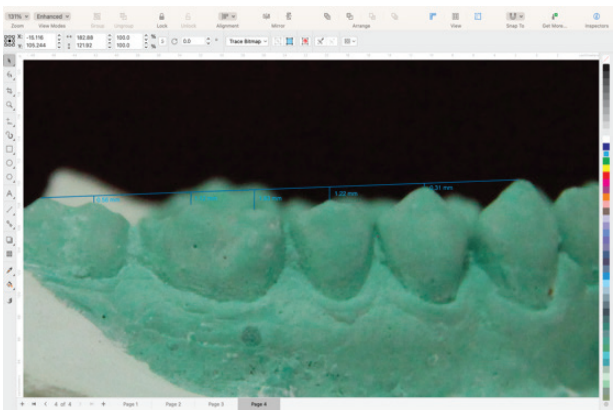

Figure 4: *Measurement of depth of curve of Spee in the mandibular arch.*

DISCUSSION

A critical clinical aspect in the rehabilitation of extensive posterior restorations involves the re-establishment of the occlusal plane. The restoration of compensating curves serves as the foundation for achieving an ideal arrangement of teeth.[1] The aim of this study was to evaluate the radius and depth of the curve of Spee in both the maxillary and mandibular arches and to investigate the potential influence of gender on the curve of Spee within young individuals from Nepal.

The findings revealed a significant difference in the depth of the curve of Spee between the mandibular and maxillary arches ($p<0.001$), with the mandibular arch exhibiting a notably greater depth. Additionally, the curve of Spee was found to be significantly deeper in females ($p=0.045$) compared to males. However, there was no statistically significant difference in the depth of the curve of Spee in the mandible between genders ($p=0.171$).

The findings indicated that the radius of the curve of Spee did not exhibit statistical significance, regardless of the arch or gender.[6–8] Consistent with other studies, the occlusal curvature of the mandibular arch was not significantly influenced by sex.[9] While the current study did not assess the impact of age, existing research suggests a natural tendency for both the depth and radius of the curve of Spee to decrease with advancing age.[10]

It is crucial to establish an appropriate occlusal curvature that harmonizes with the natural dentition, considering factors like posterior disocclusion, anterior guidance, condylar guidance, the inclination of the plane of orientation, cusp height, and other occlusal elements.[5] The presence of the curve of Spee facilitates protrusive disocclusion of the posterior teeth by synchronizing anterior and condylar guidance. Additionally, the curve of Spee enhances the crush-shear ratio between the posterior teeth, thereby improving the masticatory efficiency of these teeth. [11, 12] Given the potential variations in tooth size among different populations and ethnic groups, it becomes crucial to understand the specific values of the depth of the curve of Spee within a particular age group and population. Surprisingly, the interpretation of the curve of Spee varies among researchers, as evident from differences in their approaches to quantification.

In this investigation, precise measurements were obtained using computer software and an online calculator, allowing for accurate assessments by enlarging the images up to 1600% of their actual size. This approach facilitated measurements to the fractional millimeter. It is noteworthy that various methods employed by researchers for similar studies include photography, study models, radiography, and three-dimensional scans.[6–8, 13–15]

The curve of Spee is often called “the compensating curve”, since it compensates the movement of the jaw during mastication, such compensation, should precisely be applied when prosthodontic reconstruction is to be undertaken. Posterior tooth interferences can lead to hyperactivity in the temporalis and masseter muscle.[12] Restorations with appropriate anterior guidance help in preventing wear, fracture of restorations and tempormandibular joint dysfunction.

CONCLUSION

The gender or arch of the subjects examined did not have an impact on the radius of the Spee curve. However, the Spee curve was notably flatter in the maxillary arch compared to the mandibular arch. Moreover, there was a significant difference in the depth of the Spee curve between females and males, with females exhibiting a greater depth.

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