Analysis of the curve of Spee and the curve of Wilson in adult Indian population: A three-dimensional measurement study

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Abstract
Statement of Problem: When reconstructing the occlusal curvatures dentists often use a 4-inch radii arc as a rough standard based on Monson spherical theory. The use of an identical radius for the curve of Spee for all patients may not be appropriate because each patient is individually different. The validity of application of this theory in the Indian population and the present study has been undertaken.

Aims and Objectives: This study is an attempt to evaluate the curve of Spee and curve of Wilson in young Indian population using three dimensional analysis. This study compared the radius and the depth of right and left, maxillary and mandibular curves of Spee and the radius of maxillary and mandibular curves of Wilson in males and females.

Materials and Methods: The cusp tips of canines, buccal cusp tips of premolars and molars and palatal/lingual cusp tips of second molars of 60 maxillary and 60 mandibular casts were obtained. Three-dimensional (x, y, z) coordinates of the cusp tips of the molars, premolars, and canines of the right and left sides of the maxilla and mandible were obtained with three dimensional coordinate measuring machine. The radius and the depth of right and left, maxillary and mandibular curves of Spee and the radius of maxillary and mandibular curves of Wilson were measured by means of computer software Metrologic-XG. Pearson's correlation test and Independent t-test were used to test the statistical significance ($\alpha = .05$).

Conclusion: The values of curve of Spee and curve of Wilson in Indian population obtained from this study were higher than the 4 inch (100 mm) radius proposed by Monson. These findings suggest ethnic differences in the radius of curve of Spee and curve of Wilson.

Key Words: Complete denture prosthodontics, curve of Spee, occlusion, regressive changes

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INTRODUCTION

The determination of the occlusal plane is one of the most important steps in prosthodontic rehabilitation of edentulous patients. The position of the occlusal plane forms the basis for ideal tooth arrangement. The three-dimensional arrangements of dental cusps and incisal edges in the natural human dentition are classically described as spherical, with the occlusal surfaces of all teeth touching a segment of the surface of a sphere, called the curve of Monson. It is divided into an anteroposterior curve called the curve of Spee and a mediolateral curve called the curve of Wilson. The curve of Spee is designed to permit protrusive disocclusion of the posterior teeth by the combination of anterior guidance and condylar guidance, and the curve of Wilson also permits lateral mandibular excursions free from posterior interferences. It is essential to know the standard value of occlusal curvature for examination and treatment of occlusal disharmony. When reconstructing the occlusal curvatures dentists often use 4-inch radii arc as a rough standard based on Monson spherical theory. The use of an identical radius for the curve of Spee for all patients may not be appropriate because each patient is individually different. The purpose of this study was to examine the curve of Spee and curve of Wilson in the maxillary and mandibular arches of the Indian population. The effect of gender on the curves was also investigated.

SUBJECTS AND METHODS

The present study was conducted in the Department of Prosthodontics in Sree Balaji Dental College, Naraynapuram, Chennai, Tamil Nadu. Sixty Indian subjects (30 males and 30 females, aged 19–24 years) participated in this study. All subjects for this study were selected based on the following criteria:

Inclusion criteria
• Indian ethnicity
• Angle's class I occlusion
• Complete permanent dentition except for the third molars.

Exclusion criteria
• History of orthodontic therapy
• History of temporomandibular disorders
• Dental prostheses which cover cusps
• Severe periodontal disease, caries
• Severe malocclusion
• Severe occlusal wear
• Clinically normal arch shapes with minimal dental crowding.

Studies show that the developmental curves and arch size do not change in this age group indicating that the occlusal curves appear to be relatively stable in adults. Irreversible hydrocolloid impressions of maxillary and mandibular arches were made with perforated metal stock trays. The cusp tips of canines, buccal cusp tips of premolars and molars, and palatal/lingual cusp tips of second molars of 60 maxillary and 60 mandibular casts obtained were marked with an indelible marker. Three-dimensional (x, y, z) coordinates of the cusp tips of the molars, premolars, and canines of the right and left sides of the maxilla and mandible were obtained with three-dimensional coordinate measuring machine (Three Dimensional Coordinate Measuring Machine–Guindy Machine Tools, India) [Figures 1 and 2].

RESULTS

Radius of the curve of Spee

The mean radius of the curve of Spee in males was approximately 126.95 mm in maxillary arch and 116.12 mm in mandibular arch. The mean radius of the curve of Spee in females was approximately 117.85 mm in maxillary arch and 105.82 mm in mandibular arch.

Radius of the curve of Spee in the right and left maxillary and mandibular arches in males and females showed a significant correlation.

Radius of curve of Spee in maxillary and mandibular arches of males and females showed a highly significant statistical difference. The radius of the curve of Spee in the maxillary arch was significantly greater than that in the mandibular arch.

Figure 1: Analysis of the casts. All the measured data were transferred to the computer software (Metrologic-XG). The radius and the depth of the right and left, maxillary and mandibular curves of Spee and the radius of maxillary and mandibular curves of Wilson were measured by means of computer software Metrologic-XG.
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Radius of curve of Spee in males and females showed a highly significant statistical difference. The radius of the curve of Spee in the males was significantly greater than that in the females. The values are represented in Bar Diagram 1.

Depth of the curve of Spee
The mean depth of the curve of Spee in males was approximately 1.31 mm in maxillary arch and 1.51 mm in the mandibular arch. The mean depth of curve of Spee in females was approximately 1.50 mm in the maxillary arch and 1.77 mm in the mandibular arch.

Depth of the curve of Spee in the right and left maxillary and mandibular arches in males and females showed a significant correlation.

Depth of the curve of Spee in maxillary and mandibular arches of males and females showed a highly significant statistical difference. The depth of the curve of Spee in the mandibular arch was significantly deeper than that in the maxillary arch.

Depth of the curve of Spee in males and females showed a highly significant statistical difference. The depth of the curve of Spee in females was significantly deeper than that in the maxillary arch. The values are represented in Bar Diagram 2.

Deepest cusp tip
Deepest cusp tip was the distobuccal cusp of the first molar in the maxillary arch and mesiobuccal cusp of the first molar in the mandibular arch.

Radius of the curve of Wilson
The mean radius of the curve of Wilson in males was approximately 127.80 mm in maxillary arch and 119.30 mm in mandibular arch. The mean radius of the curve of Wilson in females was approximately 118.43 mm in maxillary arch and 106.83 mm in mandibular arch.

Radius of the curve of Wilson in maxillary and mandibular arches of males and females showed a highly significant statistical difference. The radius of the curve of Wilson in the maxillary arch was significantly greater than that in the mandibular arch.

Radius of the curve of Wilson in males and females showed a highly significant statistical difference. The radius of the curve of Wilson in the males was significantly greater than that in the females. The values are represented in the Bar Diagram 3.
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Statistical analysis
Statistical analyses done for this study were:
• Pearson correlation test for finding the significant correlation in the right and left radius and depth of curve of Spee [Tables 1 and 2].
• Independent t-test for finding the significant difference while comparing the radius of the curve of Spee, depth of the curve of Spee, and curve of Wilson in maxillary and mandibular arches and in males and females [Table 3].

For Group I mandibular males and females, $P < 0.001$-99.9% is considered statistically significant.

DISCUSSION
Analysis of the curve of Spee may assist dentists in determining the development of the occlusion in the sagittal plane. Osborn reported that the curve of Spee had a positive correlation with the inclination of masster muscle. This forward tilt of the mandibular posterior teeth arrangement maximizes the muscular efficiency during chewing. The curve of Spee when pathologically altered by rotation, tipping, or extrusion, results in abnormal mandibular elevator muscle activity, especially of the masseter and temporalis muscles. It can also cause excursive interferences resulting in wear, fracture of restorations, and temporomandibular joint dysfunction. The maxillary and mandibular curves of Spee are analyzed in relation to the dominant direction of muscle force against them, it will be apparent that the axial alignment of all posterior teeth is nearly parallel with the strong inward pull of medial pterygoid muscles. The strongest component of lateral function occurs nearly parallel with the direction of medial pterygoid muscles, which bilaterally pull the condyles medially to the midmost position of centric relation. Aligning both maxillary and mandibular posterior teeth with the principal direction of muscle contraction produces the greatest resistance to masticatory forces and creates the inclinations that form the curve of Wilson.

The curve of Wilson is the mediolateral curve that contacts the buccal and lingual cusp tips on each side of the arch. It results from lingual inclination of the mandibular posterior teeth, making the lingual cusps lower than buccal cusps on the mandibular arch; the buccal cusps are higher than palatal cusps on the maxillary arch because of the buccal inclination of maxillary posterior teeth.

Table 1: The mean, standard deviation, and significance of Pearson correlation ratio between the radius of mandibular right and left curve of Spee in males

| Group          | $n$ | Mean   | SD    | Pearson correlation ratio Significant (two-tailed) |
|----------------|-----|--------|-------|-------------------------------------------------|
| Mandibular curve | 30  | 116.20 | 7.536 | 0.397                                           |
| of Spee radius-right | 30  | 116.03 | 9.852 | 0.39                                            |
| of Spee radius-left  | 30  | 106.47 | 6.307 | 0.670                                           |

Correlation is significant at 0.05 level. SD: Standard deviation

Table 2: The mean, standard deviation, and significance of Pearson correlation ratio between the radius of mandibular right and left curve of Spee in females

| Group          | $n$ | Mean   | SD    | Pearson correlation ratio Significant (two-tailed) |
|----------------|-----|--------|-------|-------------------------------------------------|
| Mandibular curve | 30  | 106.47 | 6.307 | 0.670                                           |
| of Spee radius-right | 30  | 105.17 | 7.733 | 0.670                                           |
| of Spee radius-left  | 30  | 106.47 | 6.307 | 0.670                                           |

Correlation is significant at 0.01 level. SD: Standard deviation

Table 3: The mean, standard deviation and T test values for curve of Spee for males and females

| Group          | Gender | $n$ | Mean   | SD    | Independent t-test Significant (two-tailed) |
|----------------|--------|-----|--------|-------|------------------------------------------|
| Mandibular curve | Males  | 30  | 116.12 | 7.295 | 0.000                                    |
| of Spee radius  | Females | 30  | 105.82 | 6.421 | 0.000                                    |
| Mandibular curve | Males  | 30  | 1.51   | 0.346 | 0.000                                    |
| of Spee depth   | Females | 30  | 1.77   | 0.163 | 0.001                                    |
| Mandibular curve | Males  | 30  | 119.30 | 8.429 | 0.000                                    |
| of Wilson radius| Females | 30  | 106.83 | 6.998 | 0.000                                    |

For Group I Mandibular males and females $P$ value is <0.001 99.9% significant. SD: Standard deviation

There are two reasons for the inclination of posterior teeth. One has to do with resistance to loading; second has to do with masticatory function. If the buccolingual inclination of posterior teeth is analyzed in relation to the dominant direction of muscle force against them, it will be apparent that the axial alignment of all posterior teeth is nearly parallel with the strong inward pull of medial pterygoid muscles. The strongest component of lateral function occurs nearly parallel with the direction of medial pterygoid muscles, which bilaterally pull the condyles medially to the midmost position of centric relation. Aligning both maxillary and mandibular posterior teeth with the principal direction of muscle contraction produces the greatest resistance to masticatory forces and creates the inclinations that form the curve of Wilson.
When the curve of Wilson is made too flat, ease of masticatory function may be impaired because of the increased activity required to get the food onto the occlusal table. The greater the relative height of mandibular lingual cusps, the greater the problem of chewing efficiency may become.[6] If the lingual cusps of mandibular postermiors assume a position above the optimum level, the thrusting of food bolus by the tongue toward the occlusal table will be impaired. Furthermore, if the buccal cusps of maxillary postermiors were to assume a position below the optimum level, the action of the buccinator muscle to push the food bolus toward the occlusal table, would be similarly affected. In both these conditions, the curve of Wilson gets altered, and masticatory efficiency is jeopardized. With a large lateral occlusal curvature (substantial lingual inclination of the mandibular molars), the inclinations of the inside slope of the mandibular buccal cusp against the horizontal plane increases, making interfering occlusal contacts of the nonworking side possible. Thus, during mandibular movement, abnormal periodontal sensation, and muscle tension could be caused by a geometric limitation, especially at the distal of the arch.[7-9]

Limitations of the present study include the small sample size. A small percentage of variation may occur due to individual teeth angulations (intersample variability).

Within the limitations of the study, the following conclusions can be drawn. In the selected subjects, the radius of the curve of Spee and curve of Wilson are greater than the 4 inch (100 mm) radius proposed by Monson. In Indian population, males have a greater radius of the curve of Spee and curve of Wilson compared to females. For males and females, the mean radius of curve of Spee and curve of Wilson are greater in maxillary arch than mandibular arch. Within maxillary and mandibular arches, the mean radius of the right and left curve of Spee was similar. This was observed in both the genders. Deepest cusp tip was the distobuccal cusp of the first molar in the maxillary arch and the mesiobuccal cusp of the first molar in the mandibular arch in both males and females.

CONCLUSION

Findings of this study can be taken as reference values for Indian population for prosthetic and orthodontic reconstruction. It is also suggested that the gender differences should be taken into consideration when reconstructing the occlusal curvatures. However, further studies should be done with a larger sample population. Future implications of this study of occlusal curvatures are correlating it with dentofacial measurements using computed tomography and studying the variations in the curve of Spee according to age changes, attritional changes, and temporomandibular joint disorders.

The occlusal plane is a marvelous example of interplay between form and function. Analysis of the occlusal plane should be a part of any dental examination because of its importance to coordinated function of the entire masticatory system. Adaptive changes in the occlusal plane are signals of possible dysfunction somewhere in the system.[10,11] A flat occlusal plane giving a linear occlusion direct the forces and so the occlusal load remains fairly constant.[12] This study shows that there is variation of the depth of curvature in worn out dentitions. Prosthodontic rehabilitation for these patients may be done in these patients with the use of twin-stage procedure as recommended by Hobo and Takayama.[13,14]

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Conflicts of interest
There are no conflicts of interest.

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