Assessment of curve of spee in different malocclusions

Purpose
The aim of this study was to compare the depth of curve of Spee (COS) in Angle Class I, Angle Class II and Angle Class III malocclusions.

Materials and methods
The Samples were chosen among the diagnostic materials in İstanbul Medipol University Department of Orthodontics. Ninety plaster models were chosen, and were divided into 3 groups (n=30) according to Angle dental malocclusion classification. The depth of curve of Spee was measured on left and right sides of mandibular dental models and mean values were used as depth of curve of Spee. ANOVA test was used to evaluate normally distributed data. Comparison of the sides were performed by using paired sample t test. Significance level was set to p<0.05.

Results
The depth of COS was found as deepest in Class II malocclusion (2.9±0.8 mm) and was relative flat in Class III malocclusion (2.1±0.9 mm) and the difference was statistically significant (p<0.05). No significant difference was found between Angle Class I and Class III malocclusions.

Conclusion
Since the depth of curve of Spee is increased in Class II malocclusions, this factor should be considered in treatment planning.

Keywords: *Curve of spee; malocclusion; angle classification; mandible; orthodontics*

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Introduction

The curve of Spee (COS) was determined as an occlusal line, which is tangential part of a cylinder that begins at incisal edges of mandibular incisors and terminates at the anterior margin of mandibular condyle. The COS is an anatomic curvature and was first presented by Ferdinand Graf Von Spee in 1890 (1-3). It has been reported that overbite, mandibular incisor proclination, height of molar cusp, lower arch length, posterior contact and inclination of articular eminence are related with the arrangement of the teeth in sagittal plane (1, 4, 5). Balance of occlusal function is achieved by the consistence of these parameters and the COS (1, 5, 6). Condyle's horizontal position to occlusal plane has an effect on the COS (1). Graf Von Spee stated that maximum tooth contact could be achieved in chewing by means of this geometric arrangement (3, 7).

Chewing is the major function of maxillofacial component and effective chewing is related to crush/shear ratio of the teeth. In food processing, crush/shear ratio of buccal teeth increases, then efficient mastication can be achieved by virtue of COS. This indicates that, COS has also a mechanical function as well as its morphological function (7, 8). Although we have limited knowledge of the functional properties of the COS (1, 9), it is well known that increased depth of COS is frequently associated with deep-bite malocclusions (10).

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Andrews (11) described the six keys of the normal occlusion in 1972, and reported that the majority of the non-orthodontic normal individuals had a flat occlusion plane, therefore recommended that flattening the curve of Spee should be one of a goals of orthodontic treatment.

Considering the importance of flattening the COS for orthodontics, knowing the relationship between dental malocclusions and COS will allow us to treat these cases more successfully.

This study aims to compare depth of COS in Angle Class I, Angle Class II and Angle Class III malocclusions. The null hypothesis of this study was that there was no significant difference in the depth of curve of Spee between Angle Class I, II, and III cases. The null hypothesis was repeated 2 times, please delete the second sentence.

Materials and methods

Specimen characteristics and sample size calculation

Ninety plaster models were selected among the diagnostic materials of Istanbul Medipol University Department of Orthodontics. Ethics Committee of the same university approved the study with the number 10840098-604.01.01-E.15421. G*Power Ver. 3.0.10. was used for power analysis and it was found that 20 samples in each group would give the 80% power. Three study groups in equal numbers (n=30) were formed based on Angle classification (Class I, II, and III). The casts having fully erupted dentition except the third molars were enrolled in the study. Exclusion criteria for this study were as follows; previous orthodontic treatment, severe craniofacial disorders, posterior cross-bite, tooth anomaly, tooth wear, presence of occlusal fillings, presence of cusp fillings, presence of prosthetic restorations, and temporomandibular disorders. Mean age of the subjects was 13.60±1.03 years.

Model measurement

Manual measurement of the depth of COS was done with a digital caliper (Mitutoyo Corp, Kanogawa, Japan) and a plate (a flat plane). The plate was set on the mandibular plaster model as it was so as to touched the distal cusps of the second molars and incisal edges of the central incisors as described previously (4). The deepest cusp tip to the plate was recorded, using the digital caliper, and the depth of COS were recorded for each side. The right and the left sides were measured and mean value of them was used as the depth of COS. The measurement technique on models and cephalometric radiographs of the sample cases were presented in Figure 1 and 2. One hundred eighty measurements were performed for this study. Two weeks after the first measurement, 30 plaster models were randomly remeasured again by the same researcher to assess the method error (12).

Statistical analysis

A Statistical Software (IBM Corp. Released 2013. IBM Statistical Package for the Social Sciences Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.; USA) was used to evaluate the data. Shapiro-Wilks test was performed to check for normality. As the distribution met the assumptions of normal distribution, one way analysis of variance (ANOVA) test for multiple comparisons and Tamhane T2 or Tukey HSD post-hoc tests for detecting pairwise differences in the COS between malocclusions were used. Comparison of sides was performed by using paired samples t test. The results were presented as mean values (millimeter=mm) with standard deviations. The reliability of the measurements were checked with intra-class correlation (ICC) coefficient. Confidence level was set to 95% and $p < 0.05$ was considered statistically significant.

Results

Errors of the measurements were 0.3 to 0.5 mm and ICCs were 0.941-0.973. Descriptive and analytic statistics for measurement of the COS are given in Table 1. In Class I malocclusion, mean depth of COS was 2.3±0.6 mm, in Angle Class II malocclusion mean depth was 2.9±0.8 mm and in Angle Class III malocclusion mean depth was 2.1±0.9 mm. Mean value both left and right sides in Angle Class II was found higher than that of the other classes ($p < 0.001$). In Angle Class II malocclusion the COS was deepest and was flat in Class I and III malocclusion. The differences between Angle Class II malocclusion and the other Classes were statistically significant ($p < 0.001$). No significant difference was found between Angle Class I and Class III malocclusions.

Discussion

Most orthodontic problems in orthodontic patients are accompanied by an increased curve of Spee. When planning an orthodontic treatment, the depth of curve of Spee should be added to the amount of space needed to correct the crowding. During fixed orthodontic treatment, crowding will be corrected and the curve of Spee will flatten. As a result of this, extra space for leveling and aligning of the teeth will be needed. Andrews (11) and other authors (13, 14) mentioned that intercuspation would be optimal in the presence of a flat plane of occlusion and therefore flattening of the COS should be one of the goals of orthodontic treatment, especially in deep overbite cases. The evaluation of COS in orthodontics is important because the depth measurement of COS is a part of space analysis, which is directly related to the planning of orthodontic treatment (14, 15). Although there are different opinions about the development of the COS, it is important to know in which type of malocclusion this curve is more severe. Therefore, this study was performed to assess the relationship between different sagittal dental malocclusions and the depth of the COS.

Curve of Spee measurements can be performed by using different orthodontic diagnostic materials. Plaster models, photographs, 3D study models can be used for measurements (16-18). The plaster models were used in our study due to easy measurement of that materials. Various methods have been reported to measure the depth of COS in the literature but there is little consensus about the measurement methods. Techniques such as taking the perpendicular distance on

Table 1. *Mean values of the depth measurement of curve of Spee stratified by malocclusions and sides*

	Combined Mean±SD (mm)	p	Right Mean±SD (mm)	Left Mean±SD (mm)	p
Class I	2.3±0.6[a]	NS	2.3±0.8[a]	2.3±0.7[a]	0.968
Class II	2.9±0.8[b]	<0.001	2.9±0.9[b]	2.9±0.7[b]	0.543
Class III	2.1±0.9[a]	NS	2.1±0.9[a]	2.0±0.9[a]	0.801
p			0.002	<0.001	

a, b: There is no difference in the measurements which were marked with the same letter; NS: Non-significant

Figure 1. *Positioning of the flat surface over the model (upper left) and measurement of the depth of the Spee curve with the digital caliper (lower left) in a patient with Angle Class II malocclusion (right).*
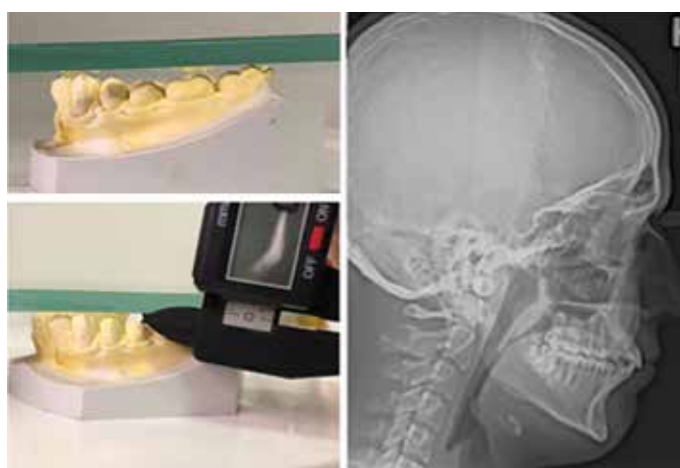
Figure 2. *Positioning of the flat surface over the model (upper left) and measurement of the depth of the Spee curve with the digital caliper (lower left) in a patient with Angle Class I malocclusion (right).*

left and right sides, perpendicular distance's average to each cusp tip (19), the sum of the perpendiculars (17) or the average of maximum depth on left and right sides (4, 13) were used previously to measure depth of COS. In the present study, the technique of Braun (4) was used.

Previous studies have stated that there was no significant change in the COS between the adolescence and adulthood periods. Therefore, models of the patients in permanent dentition period were included in the study (19-21).

Marshall *et al.* (7), evaluated the difference in the depth of COS between left and right sides of the arches and noted that

there were no significant differences in the mean values of COS between the sides. In this study, we measured on the left and right sides as in the study of Marshall *et al.* (7) and our findings were consistent with their study. Previous researches presented no significant differences in depth of COS between genders (20, 22). Hence, the gender difference was not considered in our study.

Shannon and Nanda (23), evaluated the relationships between the Frankfort plane angle, deep bite, Class II molar relationship, mandibular plane angle, overjet, and depth of the COS in their study. They have observed a relationship between Class II molar relationship and depth of the COS and stated that significantly deeper curves were found in Class II molar relationship than that of Class I ones. In the present study the mean value of COS in Class II patients was found to be deeper than that of the other ones and this finding supports the results of Shannon and Nanda's study (22).

Veli *et al.* (22) assessed the relationship between COS and vertical eruption of teeth in different malocclusions and they indicated that the depth of COS was found as deepest in Angle Class II division 1 group, followed by Class II division 2, Class I and Class III groups. The authors have found difference between Angle Class I and Angle Class III groups, which is not consistent with our study (22). Veli *et al.* (22) also assessed the depth of COS for both of the left and the right sides, and reported no significant difference in depth of COS between the sides. This result was similar with the findings of the present study.

The increased depth of COS has previously been shown to have a major role in development of dental deep-bites (7). Baydaş *et al.* (24) assessed the relationships between incisor positions, overbite, overjet, lower anterior crowding and COS in their longitudinal study and they have found significant correlations between overjet, overbite and the COS. In a previous study, it was reported that increased overbite was present in Class II division 2 patients, therefore these patients may have deeper COS. (22). The relationship between increased overbite and the COS was revealed in previous reports and this finding emphasizes the need of correcting the COS in orthodontic treatment. Orthodontists should diagnose the amount of COS as a contributing factor of deep bite and try to flatten this curve especially in Angle Class II patients.

This study was designed as a cross–sectional retrospective research in which pre-treatment models were evaluated. Both the design of the study and measurement materials were the limitations of this study. Evaluation of longitudinal changes of the depth of COS could give more detailed knowledge about the issue. Furthermore, radiographic measurements could be added to model measurements to increase the effect of the study.

Conclusion

Curve of Spee in patients with Class I and Class III malocclusion are more likely to be flat but those with Class II malocclusion demonstrated deeper curve of spee with no side-related difference. Therefore, it can be concluded that the malocclusion in sagittal direction has an impact on the depth of curve of Spee.

Türkçe öz: *Farklı maloklüzyonlarda Spee eğrisinin değerlendirilmesi. Amaç: Bu çalışmanın amacı, Angle Sınıf I, Angle Sınıf II ve Angle Sınıf III malokluzyonlarda Spee eğrisinin derinliğini karşılaştırmaktır. Gereç ve Yöntem: Çalışmada kullanılan örnekler, İstanbul Medipol Üniversitesi Ortodonti Anabilim Dalı'nda bulunan tanı materyalleri arasından seçilmiştir. Angle dişsel maloklüzyon sınıflamasına göre seçilen doksan tane alçı model, 3 gruba (n=30) ayrılmıştır. Spee eğrisinin derinliği mandibular dental modeller üzerinde sağ ve sol tarafta ölçülmüş ve ortalama değerler Spee eğrisinin derinliği olarak kullanılmıştır. Normal dağılım gösteren verileri değerlendirmek için ANOVA testi kullanılmıştır. Taraflara göre değerlendirmede eşleştirilmiş örneklem t testi kullanılarak yapılmıştır. Anlamlılık düzeyi p<0,05 olarak ayarlanmıştır. Bulgular: Spee eğrisi derinliği Sınıf II maloklüzyonda (2,9±0,8 mm) en derin, Sınıf III maloklüzyonda (2,1±0,9 mm) göreceli olarak düz bulunmuştur ve aralarındaki fark istatistiksel olarak anlamlı bulunmuştur (p<0,05). Angle Sınıf I maloklüzyon ile Angle Sınıf III maloklüzyon arasında anlamlı farklılık bulunmamıştır. Sonuç: Spee eğrisi derinliği, Sınıf II maloklüzyon vakalarında artmış olduğu için bu vakaların tedavi planlamasında bu faktörün göz önünde bulundurulması gerekmektedir. Anahtar kelimeler: Spee eğrisi; maloklüzyon; Angle sınıflaması; mandibula; ortodonti*

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