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# Investigation of the change in the degree of Frankfort mandibular plane angle after levelling the curve of spee in different malocclusion groups

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## Abstract

**BACKGROUND AND OBJECTIVES:** The curve of Spee is a naturally occurring phenomenon in the human dentition. Leveling the curve of Spee can affect the Frankfort-mandibular plane (FMP) Angle and thus the lower anterior facial height. This study examined the degree of change in FMP angle after leveling the curve of Spee in different malocclusion groups.

**METHODS:** In this study, 75 patients who were aged >14 years and had undergone fixed appliance therapy using a 0.022-slot MBT bracket system were included. The pre- and post-treatment casts and lateral cephalograms of the patients were divided into three groups, namely Class I, II, and III malocclusions, with 25 patients in each group. The curve of Spee and FMP angle were measured before and after orthodontic treatment, and their correlation was evaluated.

**RESULTS:** After leveling the curve of Spee, the FMP angle decreased in Class I and II groups and increased in Class III group. These results were statistically significant except in Class I malocclusion group. A mild positive correlation was observed between the curve of Spee and FMP angle in Class I and III malocclusion groups and a negative correlation in Class II malocclusion group.

**CONCLUSION:** The change in FMP angle, following the leveling of the curve of Spee, in Class II and III malocclusion group, is attributed to alterations in lower anterior facial height. The study observed a mild positive correlation between the curve of Spee and FMP angle in Class I and III malocclusion groups and a negative correlation in Class II malocclusion group.

**Keywords:**

Curve of spee, FMA, lower anterior facial height

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## Introduction

The curve of Spee is a naturally occurring phenomenon in the human dentition. This phenomenon was first described by Ferdinand Graf von Spee of Kiel, Germany, after studying the occlusion of skulls with abraded dentitions. He determined that the curvature is a cylinder with a radius of 6.5 to 7.0 cm located in the midorbital plane.[1] Spee's observations in 1890 led this natural curvature to be called as the curve of Spee. The curve of Spee is an imaginary curved line that follows the plane of occlusion and is convex in the maxilla and concave in the mandible from the sagittal view; the line lies on a cylinder that is tangent to the anterior border of the condyle, the occlusal surface of the mandibular molars, and the incisal edges of the mandibular incisors.[2]

The literature on the development of the curve of Spee is limited. Some studies have suggested the curve of Spee results



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from a combination of factors including the growth of orofacial structures, eruption of teeth, and development of the neuromuscular system.[3] The mandibular sagittal and vertical position relative to the cranium has been proposed to be related to the curve of Spee, which is present in various forms in mammals.

In modern orthodontics, the curve of Spee refers to natural progression upwards of the curvature of the teeth from the incisors through the premolars and molars. The development of the curve of Spee can be attributed to either the infra eruption of mandibular posterior teeth or the supra eruption of mandibular incisors. Freer (1999) described the average curve as flat and not exceeding a depth of 1.5 mm.[4] A relatively flat curve is suitable for normal occlusion, as described by the six keys of a normal occlusion by Andrews.[5]

Leveling of the curve of Spee has become a universally adopted treatment goal by clinicians as a flat occlusal plane enables achieving Angle class I canine relationship and interdigitation with relative ease through a reduction in occlusal interference. These modern ideas for a stable occlusion may be attributed to Andrews (1972),[5] who described the six ideal characteristics of normal occlusion. The curve of Spee ranges from flat to mild because it provides the best interdigitation. Following orthodontic treatment, the curvature tends to deepen. Therefore, by treating a flat or reverse curvature, allowances can be made for changes that may occur following treatment.

Andrews[5] noted that the occlusal plane in 120 non-orthodontically treated and ostensibly normal occlusions varied from being flat or having a slight curve of Spee. This finding led him to believe that the presence of the curve of Spee is associated with post-orthodontic treatment relapse. Andrews believed that although not all orthodontic normals had flat planes of occlusion, achieving a flat plane should be a treatment goal as a form of overtreatment. A deep curve of Spee may cause difficulty in achieving a Class I canine relationship and may result in occlusal interferences that will manifest during mandibular function.

Correction of the exaggerated curve of Spee can be achieved through the following tooth movements:
1. Extrusion of molars
2. Intrusion of incisors
3. Combination of both movements.

### Extrusion of posterior teeth

One millimeter of upper or lower molar extrusion effectively reduces the incisor overlap by 1.5–2.5 mm. A common method is the use of continuous arch wires.[6] A close variation of this technique is to use the mandibular reverse curve of Spee and/or the maxillary exaggerated curve of Spee wires. Progressively increasing step bends in an archwire levels the curve of Spee. Other common methods include the use of a bite plate, which enables the eruption of the posterior teeth.

### Intrusion of incisors

The intrusion of upper and/or lower incisors is a method used to level the curve of Spee in many adolescent and adult patients.

The four common methods employed to facilitate the intrusion of the upper incisors were formulated by:
- Burstone[7]
- Begg and Kesling[8]
- Ricketts[9]
- Greig.[10]

All the four designs involve the application of tip-back bends at the molars to provide an intrusive force at the incisors. All of them recognize the need for light and continuous force application.

Leveling the curve of Spee is an everyday practice in orthodontic offices. However, whether this technique affects the Frankfort–mandibular plane (FMP) angle value and thus lower anterior facial height remains to be investigated. Because lower anterior facial height is a crucial factor in orthodontic treatment planning, the effect of the curve of Spee on individuals in different malocclusion groups should be evaluated. Thus, this study compared these values to evaluate changes in the FMP angle for correction in the depth of the curve of Spee.

## Materials and Methods

### Aim of the Study

To evaluate the degree of change in the FMP angle after leveling the curve of Spee in different malocclusion groups.

### Objectives

1. To measure the curve of Spee and FMP angle of different skeletal patterns before and after orthodontic correction on casts and lateral cephalograms, respectively, in different malocclusion groups
2. To compare and statistically evaluate the change in the FMP angle after the leveling of the curve of Spee in each malocclusion groups.

### Ethical committee approval

This study was approved by the Institutional Ethics Committee of KMCT Dental College, Manassery, Kozhikkode.

## Study setting
This study was conducted in the Department of Orthodontics, KMCT Dental College, Manassery, Kozhikkode, in 2015.

## Study design
An in-vitro observational study.

## Inclusion criteria
All included patients were aged >14 years and had their lower second molar teeth erupted.

CLASS I MALOCCLUSION
1. Class I molar relationship
2. ANB angle: 2°–4°
3. Fully erupted first and second premolars and molars.

CLASS II MALOCCLUSION
1. Class II molar relationship
2. ANB angle: >4°
3. Fully erupted first and second premolars and molars.

CLASS III MALOCCLUSION
1. Class III molar relationship
2. ANB angle: ≤0°
3. Fully erupted first and second premolars and molars.

## Exclusion criteria
1. No history of orthodontic treatment
2. No absence of maxillary and mandibular permanent teeth except for the third molar
3. No severe craniofacial disorder, such as cleft palate
4. No presence with periodontal destruction.
5. No fracture or severe attrition of teeth.

## Study sample
The study sample consisted of 75 pre- and post-treatment casts and pre- and post-treatment lateral cephalograms obtained from the records of patients who received treatment at the Department of Orthodontics and Dentofacial Orthopaedics, KMCT Dental College.

The samples were divided into three categories as follows:
- GROUP 1: 25 Class I malocclusion cases
- GROUP 2: 25 Class II malocclusion cases
- GROUP 3: 25 Class III malocclusion cases.

## Armamentarium
1. Pre- and post-treatment casts and pre- and post-treatment lateral cephalograms of 25 patients with class I malocclusion, 25 patients with class II malocclusion, and 25 patients with class III malocclusion.
2. Digital caliper (INSIZE Series 1112, with a measuring range of 0 to 150 mm/0″–6″ and a resolution of 0.01 mm/0.0005″)
3. DIMAX 3 CEPH (PLANMECA)
4. PLANMECA ROMEXIS software.

## Method
### *Measurement of the depth of the curve of Spee in casts for each group*
The depth of the curve of Spee[11] was measured as the perpendicular distance between the deepest cusp tip and a flat plane laid on the top of the mandibular dental cast, touching the incisal edge of the incisors and the distal cusp tips of the lower second molar [Figure 1] using a digital caliper 64 (INSIZE Series 1112, with a measuring range of 0 to 150 mm/0″–6″ and a resolution of 0.01 mm/0.0005″; Figure 2). The measurement was performed on both the right and left sides of the dental arches in the cast, and the mean value of these two measurements was used as the depth of the curve of Spee.

The measurement was performed before and after orthodontic correction (after leveling the curve of Spee) for the three sample groups separately, and the difference was calculated [Figure 3].

### *Measurement of FMP angle from lateral cephalograms for each group*
The FMP angle (normal: 25° ±3°) is formed by the intersection of the Frankfort horizontal plane and the mandibular plane [Figure 4]. All lateral cephalograms were obtained using DIMAX 3 CEPH (PLANMECA). The digital radiographs were processed, and cephalometric analysis was performed using PLANMECA ROMEXIS software.

The measurement on lateral cephalograms was performed before and after orthodontic correction in the three sample groups separately, and the difference was calculated.

After obtaining the curve of Spee measurements from pre- and post-treatment casts and FMP angle measurements from pre- and post-treatment lateral

**Figure 1:** A flat plane laid on the top of the mandibular cast, touching the incisal edge of the incisors and the distal cusp tips of the lower second molar to measure the depth of the curve of Spee


**Figure 2:** Digital calliper

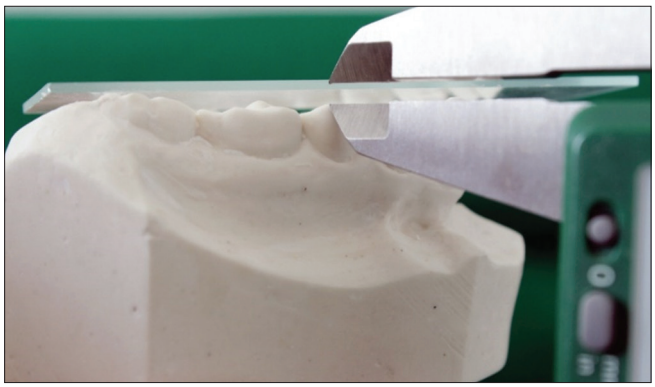

**Figure 3:** Measuring the depth of the curve of Spee using a digital calliper

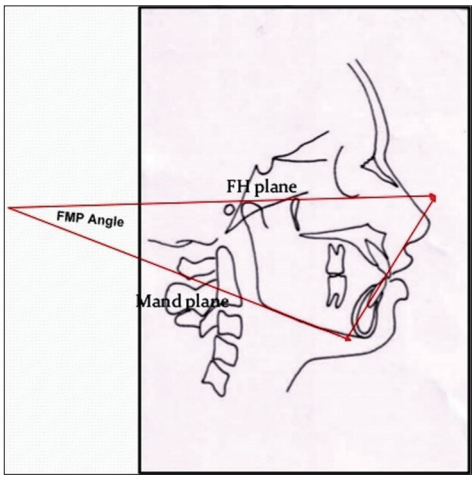


**Figure 4:** Frankfurt mandibular plane angle

cephalometric radiographs, both the data were compared, correlated, and statistically evaluated.

### Statistical analysis

All data were entered into a Microsoft Excel sheet and examined using SPSS version 20.0. To compare the Curve of Spee and FMP angle before and after treatment, a paired *t* test was performed. All values were expressed as the mean and standard deviation. A *P* value of <0.05 was considered statistically significant. Pearson correlation coefficients were calculated to determine the correlation between the curve of Spee and FMP angle.

## Results

Table 1 and Figure 5 present the measurement of the Curve of Spee in different malocclusion groups before and after treatment. The mean Curve of Spee for Class I, II, and III groups was 3.28, 3.13, and 3.06, respectively, before treatment and 0.91, 0.83, and 0.79, respectively, after treatment.

Table 2 and Figure 6 present the measurement of the FMP angle in different malocclusion groups before and after treatment. The mean FMP angle for Class I, II, and III groups was 26.42, 28.77, and 27.80, respectively, before treatment and 25.60, 25.25, and 32.32, respectively, after treatment.

After leveling the curve of Spee, the mean FMP angle decreased in Class I and Class II groups and increased in Class III group.

Table 3 presents the comparison of the curve of Spee in different malocclusion groups before and after treatment. A *P* value of <0.001 indicated a highly significant difference among the three groups.

Table 4 presents the comparison of FMP angle in different malocclusion groups before and after treatment. A *P* value of <0.001 indicated a highly significant difference between Class II and III groups. However, no significant results were obtained for Class I group.

Table 5 depicts the correlation between the curve of Spee and FMP angle in Class 1, II, and III malocclusion groups.

In Class I malocclusion group, the curve of Spee and FMP angle exhibited a mild positive correlation, with a correlation coefficient (*r*) of 0.4; however, the correlation was not significant.

In Class II malocclusion group, the curve of Spee and FMP angle revealed a negative correlation, with a correlation coefficient (*r*) of – 0.56; however, the correlation was not significant.

In Class III malocclusion group, the curve of Spee and FMP angle exhibited a mild positive correlation, with a correlation coefficient (r) of 0.4; however, the correlation was not significant.

## Discussion

Although leveling the curve of Spee is a routine procedure in orthodontic practice, few studies have

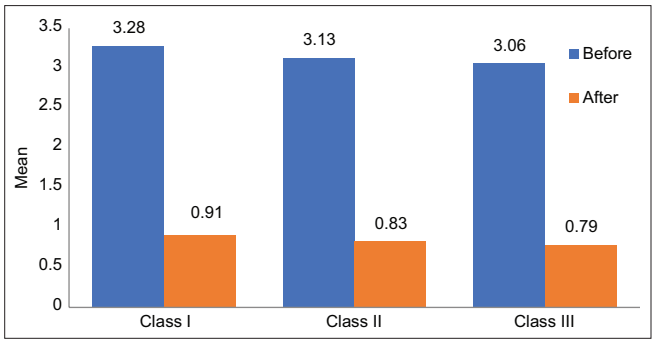


**Figure 5:** Measurement of the curve of Spee in different malocclusion groups before and after treatment

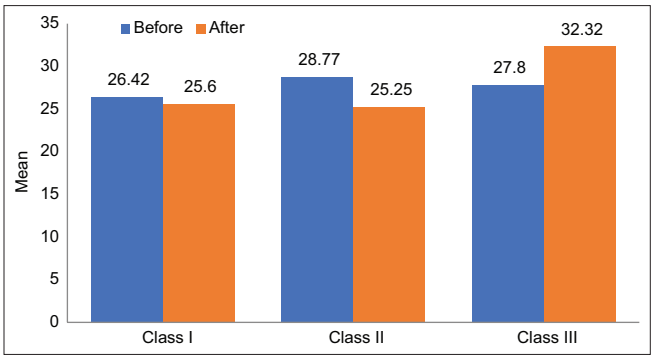


**Figure 6:** Measurement of the FMP angle in different malocclusion groups before and after treatment

evaluated the effect of the leveling of the curve of Spee on lower anterior facial height. Leveling the curve of Spee can affect the FMP angle and thus the lower anterior facial height. This study evaluated the degree of change in the FMP angle after leveling the curve of Spee in different malocclusion groups.

This study included patients who were aged >14 years and underwent fixed appliance therapy using 0.022-slot MBT bracket system. Their pre- and post-treatment casts and lateral cephalograms were obtained from the Department of Orthodontics and Dentofacial Orthopaedics, KMCT Dental College, and divided into three groups: Class I, II, and III malocclusions. The curve of Spee and FMP angle were measured before and after orthodontic treatment, and their correlation was examined.

In this study, the mean curve of Spee for Class I, II, and III groups were 3.28, 3.13, and 3.06, respectively, before treatment and 0.91, 0.83, and 0.79, respectively, after treatment [Table 1]. These findings indicate the curve of Spee was leveled in each group. After leveling the curve of Spee, we noted that the FMP angle decreased in Class I and II groups and increased in Class III group [Table 2].

In Class III group, this result is explained because the curve of Spee leveling occurred with greater movement of posterior teeth than anterior teeth; this agrees with the findings of other studies reporting the effect of continuous archwire mechanics on the clockwise opening rotation of the occlusal plane.[6,12-16] Rozzi *et al*.[17] concluded that the leveling of the curve of Spee depends on different dental parameters based on the skeletal vertical pattern. In patients with a low angle, orthodontic leveling of the curve of Spee occurred through buccal movement and mandibular incisor intrusion. In patients with a high angle, orthodontic leveling of the curve of Spee occurred through extrusion and uprighting of the mandibular posterior teeth.

When the Curve of Spee was compared among different malocclusion groups before and after treatment, a

**Table 1: Measurement of the curve of Spee in different malocclusion groups before and after treatment**

| Group | Before Mean (SD) | After Mean (SD) |
|---|---|---|
| Class I | 3.28 (0.60) | 0.91 (0.38) |
| Class II | 3.13 (0.65) | 0.83 (0.26) |
| Class III | 3.06 (0.66) | 0.79 (0.30) |

**Table 2: Measurement of the FMP angle in different malocclusion groups before and after treatment**

| Group | Before Mean (SD) | After Mean (SD) |
|---|---|---|
| Class I | 26.42 (5.52) | 25.60 (6.15) |
| Class II | 28.77 (6.04) | 25.25 (5.10) |
| Class III | 27.80 (3.19) | 32.32 (4.40) |

**Table 3: Comparison of curve of Spee among different malocclusion groups before and after treatment**

| Group | Before Mean (SD) | After Mean (SD) | *t* | *P* |
|---|---|---|---|---|
| Class I | 3.28 (0.60) | 0.91 (0.38) | 15.31 | <0.001** |
| Class II | 3.13 (0.65) | 0.83 (0.26) | 15.88 | <0.001** |
| Class III | 3.06 (0.66) | 0.79 (0.30) | 18.11 | <0.001** |

(Paired *t* test) (**P*<0.05; statistically significant) (***P*<0.001; highly statistically significant)

**Table 4: Comparison of FMP angle among different malocclusion groups before and after treatment**

| Group | Before Mean (SD) | After Mean (SD) | *t* | *P* |
|---|---|---|---|---|
| Class I | 26.42 (5.52) | 25.60 (6.15) | 2.06 | 0.06 |
| Class II | 28.77 (6.04) | 25.25 (5.10) | 6.08 | <0.001** |
| Class III | 27.80 (3.19) | 32.32 (4.40) | 8.71 | <0.001** |

(Paired *t* test) (**P*<0.05; statistically significant) (***P*<0.001; highly statistically significant)

*P* value of <0.001 indicated a highly significant difference among the groups. When the FMP angle was compared among different malocclusion groups before and after treatment, a *P* value of <0.001 indicated a highly significant difference between Class II and Class III

**Table 5: Correlation between curve of Spee and FMP angle in Class 1, Class II, and Class III malocclusion**

| Correlations | | | |
|---|---|---|---|
| **Class I** | | **Curve of Spee Class I** | **FMA angle Class I** |
| Curve of Spee Class I | Pearson Correlation | 1 | 0.43 |
| | Sig. (2-tailed) | | 0.36 |
| | *n* | 25 | 25 |
| FMP angle Class I | Pearson Correlation | 0.43 | 1 |
| | Sig. (2-tailed) | 0.36 | |
| | *n* | 25 | 25 |
| **Class II** | | **Curve of Spee Class II** | **FMA angle Class II** |
| Curve of Spee Class II | Pearson Correlation | 1 | -0.56 |
| | Sig. (2-tailed) | | 0.789 |
| | *n* | 25 | 25 |
| FMP angle Class II | Pearson Correlation | −0.56 | 1 |
| | Sig. (2-tailed) | 0.789 | |
| | *n* | 25 | 25 |
| **Class III** | | **Curve of Spee Class III** | **FMA angle Class III** |
| Curve of Spee Class III | Pearson Correlation | 1 | 0.42 |
| | Sig. (2-tailed) | | 0.72 |
| | *n* | 25 | 25 |
| FMP angle Class III | Pearson Correlation | 0.42 | 1 |
| | Sig. (2-tailed) | 0.72 | |
| | *n* | 25 | 25 |

groups. However the FMP angle finding was not significant in Class I malocclusion group [Tables 3 and 4].

In Class I malocclusion group, the curve of Spee and FMP angle were positively correlated ($r$ = 0.4), but the correlation was not significant. In Class II malocclusion group, the curve of Spee and FMP angle were negatively correlated ($r$ = −0.56), but the correlation was not significant. In Class III malocclusion group, the curve of Spee and FMP angle were positively correlated ($r$ = 0.4), but the correlation was not significant [Table 5].

In conclusion, we noted that after leveling the curve of Spee, the FMP angle decreased in Class I and II group and increased in Class III group. However, the results were not statistically significant in Class I group. In class II malocclusion, leveling the curve of Spee affected the lower anterior facial height by reducing the FMP angle. A decrease in the FMP angle might have reduced the anterior facial height might in Class II malocclusion; this phenomenon needs to be evaluated in future studies. After leveling the curve of Spee, the FMP angle increased in Class III malocclusion, indicating its effect on lower anterior facial height; this phenomenon needs to be evaluated in future studies. Moreover, a mild positive correlation was observed between the curve of Spee and FMP angle in Class I and III malocclusion groups and a negative correlation in Class II malocclusion group.

### Limitation of the study

This study evaluated the degree of change in the FMP angle after leveling the curve of Spee in different malocclusion groups. However, this study did not examine how the Curve of Spee was leveled in different malocclusion groups. This study did not determine whether the intrusion of incisors or extrusion of molars and premolars or both were used for leveling. Moreover, the biomechanics of the fixed appliance therapy was not considered.

### Recommendations

Additional studies examining more parameters involved in leveling the curve of Spee, such as the amount of intrusion of incisors, extrusion of molars, flaring of incisors, and measurement of lower anterior facial height separately, and their correlation with leveling of the curve of Spee in all the three malocclusion groups are warranted.

## Conclusion

The curve of Spee and FMP angle before and after orthodontic correction were measured on casts and lateral cephalograms, respectively, for Class I, II, and III malocclusions, and their correlation was examined.

After leveling the curve of Spee, the FMP angle decreased in Class I and II groups and increased in Class III group. These results were statistically significant except in Class I malocclusion group.

The change in the FMP angle, following the leveling of the curve of Spee, in Class II and III malocclusion group is attributed to alterations in lower anterior facial height.

The study observed a mild positive correlation between the curve of Spee and FMP angle in Class I and III malocclusion groups and a negative correlation in Class II malocclusion group.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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