

Correlation between Changes in the Curve of Spee and the Changes in the Irregularity Index, Overjet and Overbite during and following Orthodontic Treatment: A Clinical Study

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ABSTRACT

Objectives: Leveling and aligning is normally the first stage in the contemporary orthodontic practice. The objective of this study was to relate the changes in the curve of Spee to the changes in the irregularity index, overjet and overbite during and following orthodontic treatment.

Materials and methods: For this purpose, 50 patients were selected. All the subjects had either Angle's Class I molar relationship or Class II molar relationship with divisions 1 or 2 incisor relationship. They were treated orthodontically with nonextraction approach only. Measurements of curve of Spee, irregularity index, overjet and overbite were made using the dental casts taken before the start of the treatment (T1), after the completion of the treatment (T2) and 2.6 years (mean) following the completion of the treatment (T3).

Results: There was mild correlation between the changes in the curve of Spee and the changes in the irregularity index, overjet and overbite during and 2.6 years (mean) following the completion of orthodontic treatment.

Interpretation and conclusion: According to the results of this study, leveling the curve of Spee during orthodontic treatment was weakly correlated with the other variables tested.

Keywords: Curve of Spee, Irregularity index, Overjet and overbite.

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INTRODUCTION

For many orthodontic patients, leveling the mandibular curve of Spee is an important part of correcting the deep bite in comprehensive treatment.¹ The objective of this study was to relate the changes in the curve of Spee to the changes in the irregularity index, overjet and overbite during and following orthodontic treatment.

MATERIALS AND METHODS

Source of Data

Pretreatment (T1), posttreatment (T2) and postretention (T3) dental casts of 50 patients treated at Department of Orthodontics

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and Dentofacial Orthopedics, Bapuji Dental College and Hospital, Davangere, were evaluated. The mean age of the sample was 14.5 years, with minimum and maximum ages of 11 years and 26 years respectively at the beginning of the treatment. The mean postretention period was 2.6 years, with the range of 1 year to 6 years.

Criteria for Collection of Data

The following criteria were used in the random selection:¹

- All permanent teeth, including the first molars present and fully erupted at the start of the treatment
- All subjects had either Angle's Class I molar relationship or Class II molar relationship, divisions 1 or 2 incisor relationship (Class III malocclusions were excluded)
- All patients treated with nonextraction approach.

Materials used in the Study (Figs 1 and 2)

- Pretreatment, posttreatment and postretention dental casts (Fig. 1A) of 50 orthodontically treated patients
- Laptop (IBM, R 51 Think pad) with Adobe Photoshop 7.0 installed; Digital camera: Nikon, Coolpix 4500, Optical Zoom 4 ×, 4.0 Megapixels; 0.3 mm HB lead pencil; eraser; ruler; divider and calculator (Fig. 1B)
- A standardized photographic setup (Figs 2A and B).



Fig. 1A: Materials used in the study: Pretreatment, posttreatment and postretention dental casts of an orthodontically treated patient



Fig. 1B: Materials used in the study: Laptop, digital camera, 0.3 mm HB lead pencil, divider, ruler, eraser and a calculator



Fig. 2A: A standardized photographic setup: The setup as used to capture the right side of the lower cast



Fig. 2B: A standardized photographic setup: The setup as used to capture the occlusal view of the lower cast

Method of Collection of Data

Measurements were made using the plaster casts taken before the start of the treatment (T1), at the completion of the orthodontic therapy (T2) and at 2.6 years (mean) postretention (T3). A digital camera mounted on a standardized photographic setup¹ was used to photograph the right side of the lower cast at T1, T2 and T3. A constant camera to object distance of 25 cm was used for all the photographs.

The photographs which were taken to capture the right side of the lower cast were taken in a plane perpendicular to the occlusal plane tangent to the buccal surface of the first molar and canine and centered on the first premolar¹ (Figs 2 and 3).

The linear displacement of the anatomic contact points of each mandibular incisor from the adjacent tooth anatomic contact point was measured on the occlusal photograph (Figs 2 and 4).

The photographs were analyzed using Adobe Photoshop 7.0 software installed in IBM laptop to measure the depth of

the curve of Spee and irregularity index. This software enabled calibration of photographs by defining the length of a standard ruler photographed with the dental casts.

On each photograph of the right side of the lower cast, a reference line was drawn from the incisal edge of the central incisor to the distal cusp tip of the first molar. Perpendicular lines were constructed on this line from the incisal edge of the lateral incisor and the cusp tips of the canine, the premolars and the mesial buccal cusp of the first molar.² The sum of these distances represents the depth of the curve of Spee and is used in this study (Fig. 5).

The sum of the five linear displacements is the irregularity index and represents the relative degree of anterior irregularity. Perfect alignment from the mesial aspect of the left canine to the mesial aspect of the right canine would theoretically have a score of 0. Increased crowding represented by greater displacement would, therefore, have a higher index score⁵ (Fig. 6).



Fig. 3: Right lateral view of the lower cast (with ruler for calibration)



Fig. 4: Occlusal view of the lower cast (with ruler for calibration)

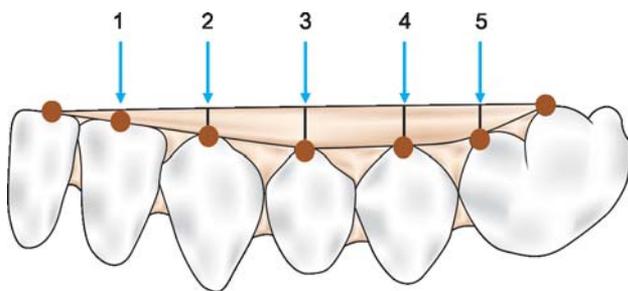


Fig. 5: Measurement of curve of Spee: 1 + 2 + 3 + 4 + 5 = Depth of curve of Spee

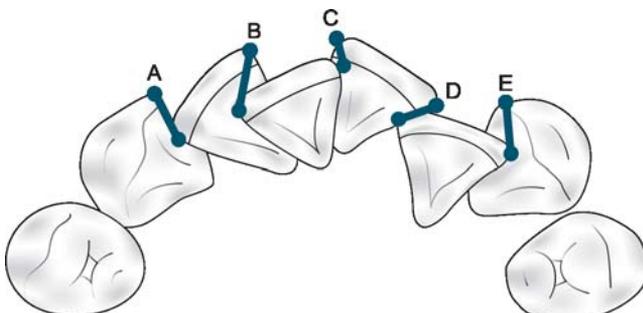


Fig. 6: Measurement of irregularity index: A + B + C + D + E = Irregularity index

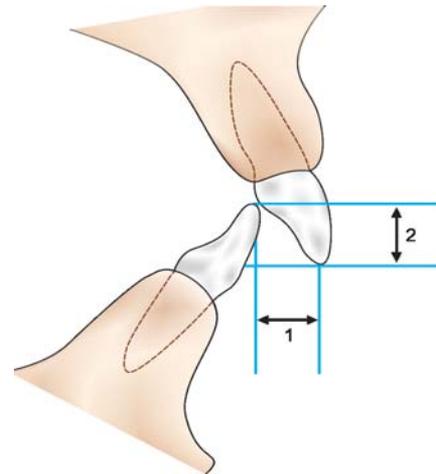


Fig. 7: Measurement of overjet (1) and overbite (2)

Overjet and overbite were measured on the casts at T1, T2 and T3 using a ruler (Fig. 7).

All the measurements were made by a single observer.

Statistical Analyses

The descriptive statistics is shown by mean and standard deviations. The mean value of each variable at different time periods is compared by one-way ANOVA and the pairwise comparison is done by Studentized Newman Keul's test. In order to give confidence interval, pairwise comparison was also done using Tukey's post-hoc test. The related variation between the variables was calculated by Karl Pearson's coefficient of correlation. $p < 0.05$ was considered as statistically significant.

For reliability, t-test was applied. $p\text{-value} > 0.05$ was considered significant.

RESULTS

The descriptive statistics comparing the changes in the depth of the curve of Spee with the changes in the irregularity index, overjet and overbite during the time interval T2-T1 is shown in Table 1.

The mean values for the changes in the depth of the curve of Spee, irregularity index, overjet and overbite were -3.32 mm (± 3.61), -5.87 mm (± 3.68), -2.62 mm (± 2.80) and -1.74 mm (± 1.27) respectively.

There was a mild correlation between the changes in the depth of the curve of Spee and the changes in the irregularity index ($r = 0.19$), overjet ($r = 0.23$) and overbite ($r = 0.14$) during the time interval T2-T1. The correlation between the changes in the depth of the curve of Spee and the changes in the irregularity index ($p > 0.05$) and overbite ($p > 0.05$) during this time interval was, however, not significant.

Graph 1 depicts the comparison of the mean changes in each of the tested variables (depth of the curve of Spee, irregularity index, overjet and overbite) during the time interval T2-T1. The highest change was observed in the irregularity index (-5.87 ± 3.68 mm) and the least change was observed in the overbite (-1.74 ± 1.27 mm) during this time period.

Table 1: Correlation analysis for comparison of changes in curve of Spee with changes in irregularity index, overjet, overbite between T2 and T1

Parameters	Mean	SD	r	Slope	p	Reliability testing		
						t-value	Df	p* value
Curve of Spee	-3.32	3.61	—	—	—	—	—	—
Irregularity index	-5.87	3.68	0.19	0.20	p > 0.05 Not significant	1.340782	48	p > 0.05 Not significant
Overjet	-2.62	2.80	0.23	0.18	p > 0.05 Not significant	1.637384	48	p > 0.05 Not significant
Overbite	-1.74	1.27	0.14	0.04	p > 0.05 Not significant	0.9795961	48	p > 0.05 Not significant

All values are in millimeters; SD: Standard deviations; r: Correlation coefficients; p: Level of significance; Df: Degree of freedom; p*: Level of significance; t-test.

Table 2: Correlation analysis for comparison of changes in curve of Spee with changes in irregularity index, overjet, overbite between T3 and T2

Parameters	Mean	SD	r	Slope	p	Reliability testing		
						t-value	Df	p* value
Curve of Spee	0.51	1.71	—	—	—	—	—	—
Irregularity index	1.41	1.98	0.02	0.21	p > 0.05 Not significant	0.1385918	48	p > 0.05 Not significant
Overjet	0.57	0.86	0.005	0.003	p > 0.05 Not significant	0.03464145	48	p > 0.05 Not significant
Overbite	0.35	0.92	0.04	0.02	p > 0.05 Not significant	0.2773501	48	p > 0.05 Not significant

All values are in millimeters; SD: Standard deviations; r: Correlation coefficients; p: Level of significance; Df: Degree of freedom; p*: Level of significance; t-test.

The mean values for the changes in the curve of Spee, irregularity index, overjet and overbite during the time interval T3-T2 (Table 2) were 0.51 mm (± 1.71), 1.41 mm (± 1.98), 0.57 mm (± 0.86) and 0.35 mm (± 0.92) respectively.

The correlation between the amount of relapse of the curve of Spee and the relapse of the lower anterior irregularity (irregularity index) ($r = 0.02$), overjet ($r = 0.005$) and overbite ($r = 0.04$) following the completion of the orthodontic treatment was mild and not significant ($p > 0.05$).

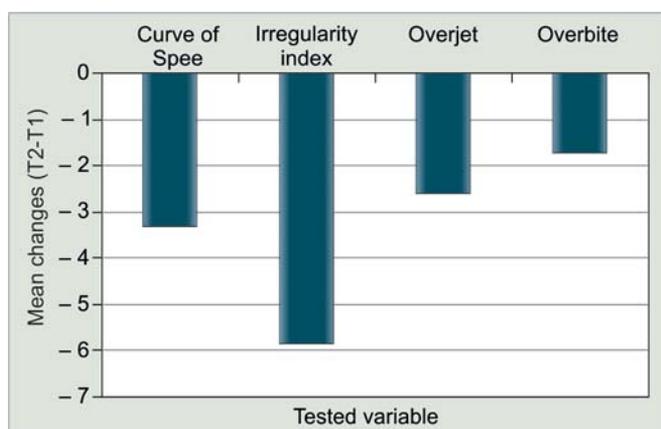
The highest tendency for the relapse was observed in the irregularity index (1.41 ± 1.98 mm), while the least tendency

for the relapse was observed in the overbite (0.35 ± 0.92 mm) (Graph 2).

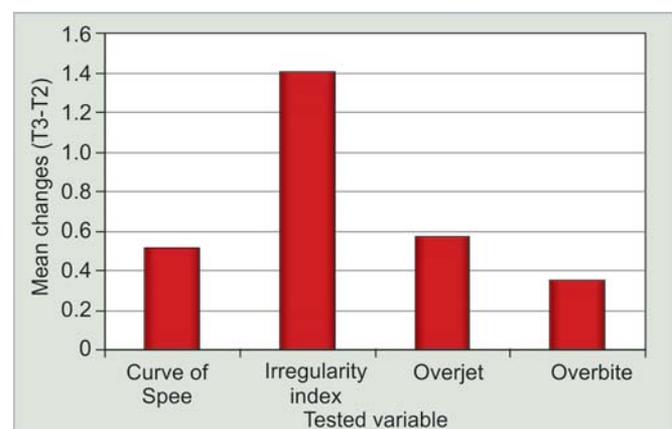
The results for reliability testing are summarized in Tables 1 to 3.

The mean values for the changes in the curve of Spee, irregularity index, overjet and overbite during the time interval T3-T1 were -2.80 mm (± 3.62), -4.31 mm (± 4.04), -2.05 mm (± 2.58) and -1.39 mm (± 1.20) respectively (Table 3).

The correlation between the changes in the curve of Spee and the changes in the irregularity index ($r = 0.019$, $p > 0.05$) and that between the changes in the curve of Spee and the



Graph 1: Comparison of mean changes in each of the tested variables between T2 and T1



Graph 2: Comparison of mean changes in each of the tested variables between T3 and T2

Table 3: Correlation analysis for comparison of changes in curve of Spee with changes in irregularity index, overjet, overbite between T3 and T1

Parameters	Mean	SD	r	Slope	p	Reliability testing		
						t-value	Df	p* value
Curve of Spee	-2.80	3.62	—	—	—	—	—	—
Irregularity index	-4.31	4.04	0.02	0.02	p > 0.05 Not significant	0.1385918	48	p > 0.05 Not significant
Overjet	-2.05	2.58	0.24	0.17	p > 0.05 Not significant	1.195192	48	p > 0.05 Not significant
Overbite	-1.39	1.20	0.08	0.02	p < 0.01 Very significant	0.1385918	48	p > 0.05 Not significant

All values are in millimeters; SD: Standard deviations; r: Correlation coefficients; p: Level of significance; Df: Degree of freedom; p*: Level of significance; t-test.

changes in the overjet ($r = 0.24, p > 0.05$) were not significant. However, there was a highly significant positive correlation between the changes in the depth of curve of Spee and the changes in the overbite ($r = 0.077, p < 0.01$) during the time interval T3-T1.

The highest change was observed in the irregularity index (-4.31 ± 4.04 mm) and the least change was observed in the overbite (-1.39 ± 1.21 mm) during time interval T3-T1 (Graph 3).

Table 4A shows the statistical comparison of the means of different variables (curve of Spee, irregularity index, overjet and overbite) at different periods of time (T1, T2, T3) using one-way ANOVA and Studentized Newman-Keul’s test.

Table 4B shows the pairwise comparison of the means of different variables (curve of Spee, irregularity index, overjet and overbite) at different periods of time (T1, T2, T3) using Tukey’s post-hoc test.

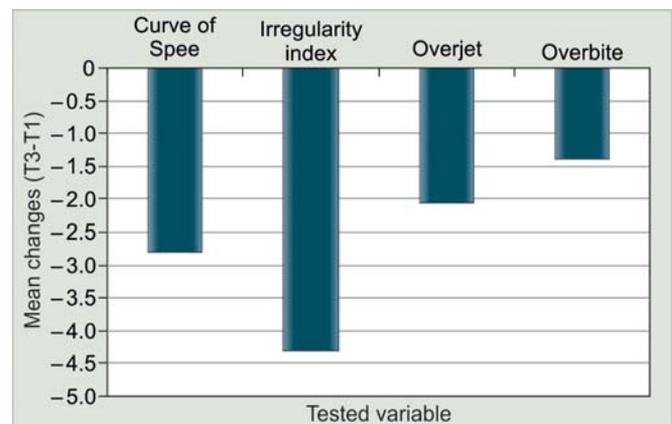
The mean depth of curve of Spee at T1, T2 and T3 was 3.66 mm (± 3.53), 0.34 mm (± 1.41) and 0.86 mm (± 1.91) respectively.

Graph 4 shows the comparison between the mean depth of the curve of Spee at different time periods (T1, T2, T3). The mean depth of curve of Spee decreased from 3.66 to 0.34 mm as the curve was leveled during the treatment. However, it increased from 0.34 to 0.86 mm following the completion of the orthodontic treatment.

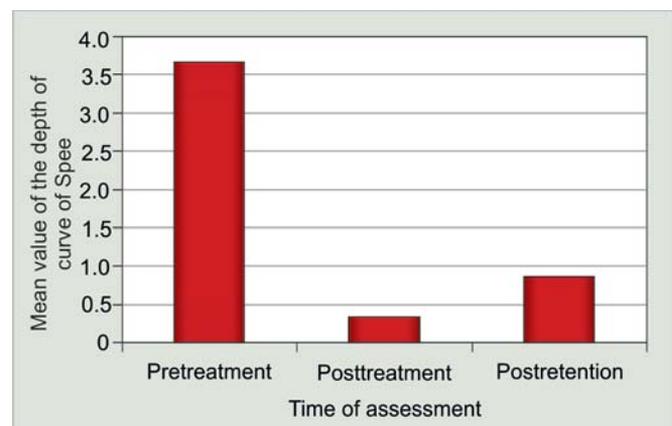
One-way ANOVA revealed highly significant difference ($F = 26.37, p < 0.001$) between the mean values of the depth of the curve of Spee at different time periods (T1, T2, T3). This was followed by pairwise comparison using Studentized Newman-Keul’s test which showed significant difference, between the mean values of the depth of the curve of Spee between T1 and T2 and between T1 and T3. This was not true for the comparison made between T2 and T3. These results were in accordance with the Tukey’s post-hoc test.

The mean value for the irregularity index at T1, T2 and T3 was 6.15 mm (± 3.81), 0.36 mm (± 0.65) and 1.77 mm (± 1.92) respectively.

Graph 5 shows the comparison between the mean values of irregularity index at different time periods (T1, T2, T3). The



Graph 3: Comparison of mean changes in each of the tested variables between T3 and T1



Graph 4: Comparison of mean depth of Curve of Spee at three different time periods

mean irregularity index decreased from 6.15 to 0.36 mm during the treatment. However, it increased from 0.36 to 1.77 mm following the completion of the orthodontic treatment.

One-way ANOVA revealed highly significant difference ($F = 73.35, p < 0.001$) between the mean values of the irregularity index at different time periods (T1, T2, T3). Studentized Newman-Keul’s showed significant difference between the mean values of the irregularity index between T1 and T2 and between T1 and T3. This was not true for the comparison made between T2 and T3. Tukey’s post-hoc test

Table 4A: Comparison of means of different variables (curve of Spee irregularity index, overjet and overbite) at different periods of time (T1, T2, T3) using one-way ANOVA and Studentized Newman-Keul's test

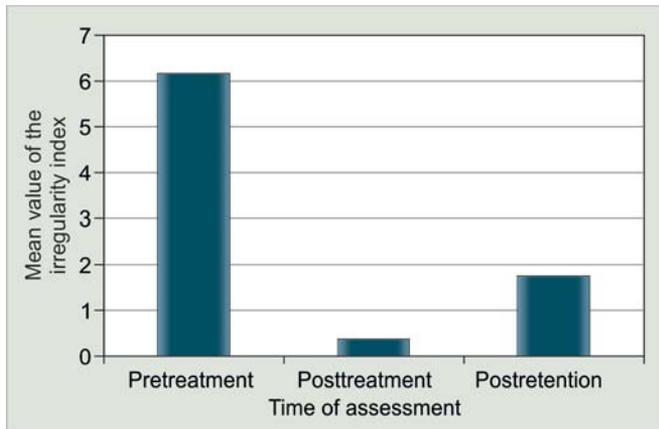
Time of assessment	Curve of Spee		Irregularity index		Overjet		Overbite	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pretreatment	3.66	3.53	6.15	3.81	4.90	2.94	3.42	1.40
Posttreatment	0.34	1.41	0.36	0.65	2.28	0.81	1.68	0.74
Postretention	0.86	1.91	1.77	1.92	2.85	0.94	2.03	1.06
F* value	26.37		73.35		27.95		34.83	
Significance	p < 0.001 (HS)		p < 0.001 (HS)		p < 0.001 (HS)		p < 0.001 (HS)	
Pairwise comparison**	T1&T2, T1&T3		T1&T2, T1&T3		T1&T2, T1&T3		T1&T2, T1&T3	

All values are in millimeters; SD: Standard deviations; *One-way ANOVA; p: Level of significance; HS: Highly significant; **Studentized Newman-Keul's test

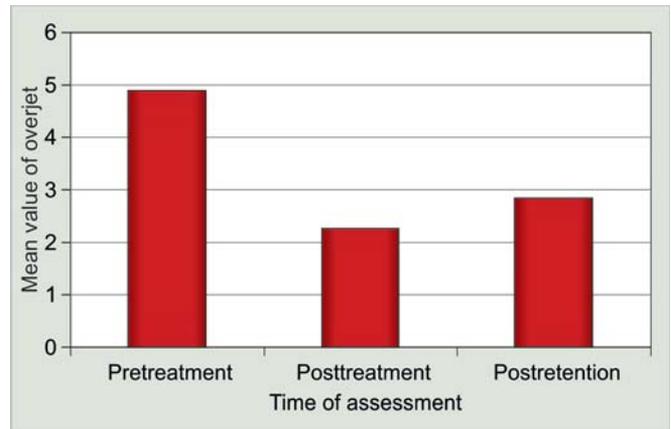
Table 4B: Pairwise comparison of means of different variables (curve of Spee, irregularity index, overjet and overbite) at different periods of time (T1, T2, T3) using Tukey's post-hoc test

Parameters	Time of assessment		Mean difference	Significance (p* value)	95% confidence interval	
					Lower bound	Upper bound
Curve of Spee	T1	T2	3.316	< 0.001	2.15318499	4.478815
	T1	T3	2.824	< 0.001	1.66118499	3.986815
	T3	T2	0.492	0.57690	-0.67081501	1.654815
Irregularity index	T1	T2	5.786	< 0.001	4.608089433	6.963911
	T1	T3	4.354	< 0.001	3.176089433	5.531911
	T3	T2	1.432	0.01269	0.254089433	2.609911
Overjet	T1	T2	2.620	< 0.001	1.747357726	3.492642
	T1	T3	2.050	< 0.001	1.177357726	2.922642
	T3	T2	0.570	0.27235	-0.302642274	1.442642
Overbite	T1	T2	1.740	< 0.001	1.217798601	2.262201
	T1	T3	1.390	< 0.001	0.867798601	1.912201
	T3	T2	0.350	0.25449	-0.172201399	0.872201

The level of significance is set at 0.05; p < 0.05 is considered to be statistically significant; *Tukey's post hoc test



Graph 5: Comparison of mean irregularity index at three different time periods



Graph 6: Comparison of mean overjet at three different time periods

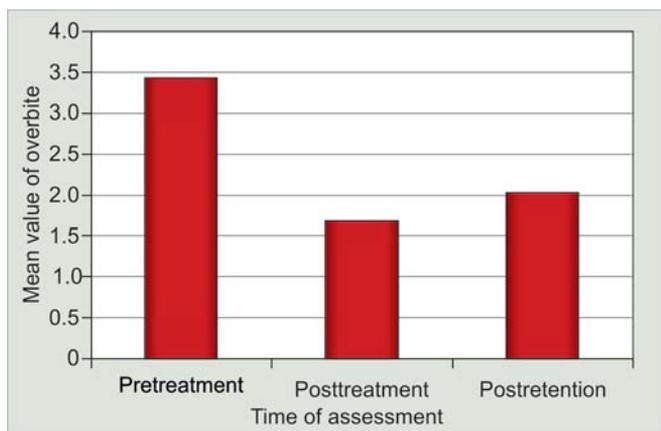
however, showed that there is statistically significant difference between each of these pairs.

The mean value for overjet at T1, T2 and T3 was 4.9 mm (± 2.94), 2.28 mm (± 0.81) and 2.85 mm (± 0.94) respectively.

Graph 6 shows the comparison between the mean values of overjet at different time periods (T1, T2, T3). The mean overjet decreased from 4.9 to 2.28 mm during the treatment. However, it increased from 2.28 to 2.85 mm following the completion of the orthodontic treatment.

One-way ANOVA revealed highly significant difference ($F = 27.95$, $p < 0.001$) between the mean values of the overjet at different time periods (T1, T2, T3). Studentized Newman-Keul's showed significant difference between the mean values of the overjet between T1 and T2 and between T1 and T3. This was not true for the comparison made between T2 and T3. These results were also in accordance with the Tukey's post-hoc test.

The mean value for overbite at T1, T2 and T3 was 3.42 mm (± 1.40), 1.68 mm (± 0.74) and 2.03 mm (± 1.06) respectively.



Graph 7: Comparison of mean overbite at three different time periods

Graph 7 shows the comparison between the mean values of overbite at different time periods (T1, T2, T3). The mean overbite decreased from 3.42 to 1.68 mm during the treatment. However, it increased from 1.68 to 2.03 mm following the completion of the orthodontic treatment.

One-way ANOVA revealed highly significant difference ($F = 34.83, p < 0.001$) between the mean values of the overbite at different time periods (T1, T2, T3). Studentized Newman-Keul's showed significant difference between the mean values of the overbite between T1 and T2 and between T1 and T3. This was not true for the comparison made between T2 and T3. This was also found to be true when the Tukey's post-hoc test was applied.

DISCUSSION

According to Germane et al,³ leveling of the curve of Spee is associated with an increase of the arch circumference; however, the amount of additional arch space required for leveling of the curve is not predictable. Proclination of the lower incisors has also been associated with leveling of the curve as is reported by Al Qabandi et al.⁴ The correlation between the changes in the curve of Spee and the changes in the irregularity index, overjet and overbite during the orthodontic treatment was mild and not significant in the present study.

The correlation between the relapse of the curve of Spee and the relapse of the irregularity index, overjet and overbite was mild and not significant in this study. The mild correlation was in confirmation with the study performed by De Praeter et al.⁵ In both the studies, the highest correlation was found for the amount of overbite relapse, indicating that the relapse of the curve of Spee is associated with a deepening of the bite postretention. The highest correlation in this study, however, was only $r = 0.04$.

Curve of Spee was, however, found to be relatively stable after treatment.⁶ This finding is in confirmation with the studies

conducted by Shannon KR and Nanda RS¹ and De Praeter et al.⁵

The present study reveals that the correlation between the changes in the curve of Spee and the changes in the irregularity index, overjet and overbite during the time interval T3-T1 was mild. However, unlike the correlation between the changes in the curve of Spee and those of irregularity index and overjet, correlation between the changes of the curve of Spee and overbite was significant. This indicated that the relapse in the overbite was responsible in part for the changes in curve of Spee during this time interval.

A possible mechanism for the tendency for relapse of overbite, but not the curve of Spee, could be that the bite was deepened by extrusion of the upper anterior teeth rather than the lower anterior teeth. Since, the curve of Spee in this study was measured only in the lower jaw, this could explain the stability of the measured curve of Spee.

CONCLUSION

This study evaluated the factors affecting the long-term stability of the leveled curve of Spee. The changes in the curve of Spee were compared with the changes in the irregularity index, overjet and overbite during and 2.6 years (mean) following the completion of orthodontic treatment. There was mild correlation between the changes in the curve of Spee and the changes in the irregularity index, overjet and overbite during and 2.6 years (mean) following the completion of orthodontic treatment.

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