Original Article

Class II Non-Extraction Patients Treated with the Forsus Fatigue Resistant Device Versus Intermaxillary Elastics

Graham Jonesa; Peter H. Buschangb; Ki Beom Kimc; Donald R. Oliverd

ABSTRACT

Objective: To evaluate the Forsus Fatigue Resistant Device (FRD) as a compliance-free alternative to Class II elastics.

Materials and Methods: A sample of 34 (14 female, 20 male) consecutively treated nonextraction FRD patients (12.6 years of age) were matched with a sample of 34 (14 female, 20 male) consecutively treated nonextraction Class II elastics patients (12.2 years of age) based on four pretreatment variables (ANB, L1-GoMe, SN-GoMe, and treatment duration). Pretreatment and posttreatment cephalometric radiographs were traced and analyzed using the pitchfork analysis and a vertical cephalometric analysis. t-Tests were used to evaluate group differences. Group differences were evaluated using t-tests.

Results: No statistically significant differences were found in the treatment changes between the groups. There was a general trend for mesial movement of the maxilla, mandible, and dentition during treatment for both groups. The mandibular skeletal advancement and dental movements were greater than those in the maxilla, which accounted for the Class II correction. Lower incisor proclination was evident in both groups. Vertically, the maxillary and mandibular molars erupted during treatment in both groups, while lower incisors proclined. With the exception of lower molar mesial movements and total molar correction, which were significantly (P < .05) greater in the Forsus group, there were no statistically significant group differences in the treatment changes.

Conclusions: The Forsus FRD is an acceptable substitute for Class II elastics for noncompliant patients.

KEY WORDS: Cephalometrics; Forsus; Intermaxillary elastics; Pitchfork analysis; Treatment outcomes

INTRODUCTION

Class II malocclusion presents a major and common challenge to orthodontists. Based on overjet greater than 4 mm, the National Health and Nutrition Examination Survey (NHANES III) data indicate an 11% prevalence of Class II malocclusion in the US popu-
ically demonstrate mesial movement of the mandibular molars, tipping of the mandibular incisors, and variable effects associated with mandibular growth.\(^1\)\(^{–}\)\(^{20}\) Only one study has compared the effects of Class II correction obtained with elastics and fixed interarch (Herbst) appliances.\(^4\) While molar corrections were similar, anterior lower facial height and the mandibular plane angle increased more in the elastics group than in the Herbst group. The skeletal improvement was 10% in the elastics group, compared with 66% in the Herbst group.

More studies are needed comparing the effects of Class II elastics with the effects of compliance-free appliances, which may be necessary to achieve successful treatment. The skeletal and dental changes produced by interarch appliances may be substantially different from those produced with Class II elastics. Potential differences between appliance systems must be identified and understood, so that an appropriate decision can be made when deciding on treatment alternatives.

The present study was designed to evaluate the effects of the Forsus Fatigue Resistant Device (FRD) (3M Unitek Corp, Monrovia, Calif). The FRD is a three-piece, semirigid telescoping system incorporating a superelastic nickel-titanium coil spring that can be assembled chair-side in a relatively short amount of time. It is compatible with complete fixed orthodontic appliances and can be incorporated into preexisting appliances. The FRD attaches at the maxillary first molar and onto the mandibular archwire, distal to either the canine or first premolar bracket. As the coil is compressed, opposing forces are transmitted to the sites of attachment. Our purpose was to determine the skeletal and dental effects produced during Class II correction with the Forsus FRD and to compare these effects with those produced during Class II correction with elastics.

**MATERIALS AND METHODS**

**Sample**

A pretreatment sample (T1) of 98 consecutively treated patients (41 Forsus FRD and 57 Class II elastics) was selected from the offices of two private practice orthodontists (74 records from practice A and 24 records from practice B). The criteria for patient selection were:

- Pretreatment occlusion of at least end-on Class II malocclusion;
- Treatment completed without any permanent teeth extracted (excluding third molars);
- Class I posttreatment occlusion;
- Starting age between of 9.0 years and 17.0 years;

More studies are needed comparing the effects of Class II elastics with the effects of compliance-free appliances, which may be necessary to achieve successful treatment. The skeletal and dental changes produced by interarch appliances may be substantially different from those produced with Class II elastics. Potential differences between appliance systems must be identified and understood, so that an appropriate decision can be made when deciding on treatment alternatives.

The present study was designed to evaluate the effects of the Forsus Fatigue Resistant Device (FRD) (3M Unitek Corp, Monrovia, Calif). The FRD is a three-piece, semirigid telescoping system incorporating a superelastic nickel-titanium coil spring that can be assembled chair-side in a relatively short amount of time. It is compatible with complete fixed orthodontic appliances and can be incorporated into preexisting appliances. The FRD attaches at the maxillary first molar and onto the mandibular archwire, distal to either the canine or first premolar bracket. As the coil is compressed, opposing forces are transmitted to the sites of attachment. Our purpose was to determine the skeletal and dental effects produced during Class II correction with the Forsus FRD and to compare these effects with those produced during Class II correction with elastics.

**MATERIALS AND METHODS**

**Sample**

A pretreatment sample (T1) of 98 consecutively treated patients (41 Forsus FRD and 57 Class II elastics) was selected from the offices of two private practice orthodontists (74 records from practice A and 24 records from practice B). The criteria for patient selection were:

- Pretreatment occlusion of at least end-on Class II malocclusion;
- Treatment completed without any permanent teeth extracted (excluding third molars);
- Class I posttreatment occlusion;
- Starting age between of 9.0 years and 17.0 years;

More studies are needed comparing the effects of Class II elastics with the effects of compliance-free appliances, which may be necessary to achieve successful treatment. The skeletal and dental changes produced by interarch appliances may be substantially different from those produced with Class II elastics. Potential differences between appliance systems must be identified and understood, so that an appropriate decision can be made when deciding on treatment alternatives.

The present study was designed to evaluate the effects of the Forsus Fatigue Resistant Device (FRD) (3M Unitek Corp, Monrovia, Calif). The FRD is a three-piece, semirigid telescoping system incorporating a superelastic nickel-titanium coil spring that can be assembled chair-side in a relatively short amount of time. It is compatible with complete fixed orthodontic appliances and can be incorporated into preexisting appliances. The FRD attaches at the maxillary first molar and onto the mandibular archwire, distal to either the canine or first premolar bracket. As the coil is compressed, opposing forces are transmitted to the sites of attachment. Our purpose was to determine the skeletal and dental effects produced during Class II correction with the Forsus FRD and to compare these effects with those produced during Class II correction with elastics.

**MATERIALS AND METHODS**

**Sample**

A pretreatment sample (T1) of 98 consecutively treated patients (41 Forsus FRD and 57 Class II elastics) was selected from the offices of two private practice orthodontists (74 records from practice A and 24 records from practice B). The criteria for patient selection were:

- Pretreatment occlusion of at least end-on Class II malocclusion;
- Treatment completed without any permanent teeth extracted (excluding third molars);
- Class I posttreatment occlusion;
- Starting age between of 9.0 years and 17.0 years;

More studies are needed comparing the effects of Class II elastics with the effects of compliance-free appliances, which may be necessary to achieve successful treatment. The skeletal and dental changes produced by interarch appliances may be substantially different from those produced with Class II elastics. Potential differences between appliance systems must be identified and understood, so that an appropriate decision can be made when deciding on treatment alternatives.

The present study was designed to evaluate the effects of the Forsus Fatigue Resistant Device (FRD) (3M Unitek Corp, Monrovia, Calif). The FRD is a three-piece, semirigid telescoping system incorporating a superelastic nickel-titanium coil spring that can be assembled chair-side in a relatively short amount of time. It is compatible with complete fixed orthodontic appliances and can be incorporated into preexisting appliances. The FRD attaches at the maxillary first molar and onto the mandibular archwire, distal to either the canine or first premolar bracket. As the coil is compressed, opposing forces are transmitted to the sites of attachment. Our purpose was to determine the skeletal and dental effects produced during Class II correction with the Forsus FRD and to compare these effects with those produced during Class II correction with elastics.
movements and mesial mandibular skeletal and dental movements, which aid in Class II correction, were assigned positive values. Movements that worsen Class II relations were assigned negative values. Incisor movements that affect overjet were also measured and summarized. All measurements were made at the level of the functional occlusal plane, which was drawn through the occlusal contact points of the molars and premolars.

Because the Forsus and Class II elastics were expected to produce vertical and angular changes of the dentition not described by the PFA, seven additional measurements were included:

— maxillary incisor (U1) angulation to the sella-nasion line (SN);
— U1 incisal edge vertical distance perpendicular to ANS-PNS;
— maxillary molar (U6) mesial contact point vertical distance perpendicular to anterior nasal spine-posterior nasal spine (ANS-PNS);
— mandibular incisor (L1) angulation to the mandibular plane (Go-Me);
— L1 incisal edge vertical distance perpendicular to Go-Me;
— mandibular molar (L6) mesial contact point vertical distance perpendicular to GoMe;
— functional occlusal plane (FOP) to SN.

Table 3. Pretreatment Comparison of Elastics and Forsus Groups for Matched Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elastics</th>
<th>Forsus</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANB, deg</td>
<td>4.6</td>
<td>5.3</td>
</tr>
<tr>
<td>L1-GoMe, deg</td>
<td>95.7</td>
<td>93.8</td>
</tr>
<tr>
<td>SN-GoMe, deg</td>
<td>32.4</td>
<td>33.1</td>
</tr>
<tr>
<td>Treatment duration, years</td>
<td>2.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>

* Sig indicates significance.

Statistical Methods

Statistical analysis was preformed using SPSS version 14.0 (SPSS Incorporated, Chicago, Ill). The skewness and kurtosis statistics indicated normal distributions. Mean and standard deviation were used to describe central tendencies and dispersion. Independent t-tests were used to evaluate group differences. Paired t-tests were used to evaluate changes over time.

To ensure intraexaminer reliability, nine randomly selected radiographs were retraced and remeasured. The Cronbach alpha test for reliability showed that the intraclass correlation was 0.987.

RESULTS

Cephalometric Comparison: Vertical and Angular Treatment Changes

No significant (P < .05) pretreatment (T1) differences existed between the two treatment groups for the variables used for matching (ANB, L1-GoMe, SN-GoMe, and treatment duration) (Table 3). The pretreatment ANB was 0.7° greater in the Forsus group.
L1-GoMe, SN-GoMe, and treatment duration were closely matched. U1-SN angulation was significantly larger in the elastics group than in the Forsus group (103.1° and 98.3°, respectively).

Statistically significant (P < .05) group differences were found posttreatment (T2) between the groups for L1-GoMe and the OP-SN angle (Table 4). None of the other posttreatment differences between the groups were statistically significant.

The vertical and angular treatment changes showed no statistically significant (P < .05) group differences. For both groups, the U1-SN and L1-GoMe angulations increased, the upper incisor tip moved inferiorly, and the lower incisor tip moved closer to GoMe. The upper and lower molars increased their vertical distances from ANS-PNS and GoMe, respectively. The occlusal plane rotated clockwise in both groups.

**Treatment Changes Measured By Pitchfork**

The PFA showed that the maxilla and mandible moved mesially 1.5 mm and 3.8 mm, respectively, in the elastics group; the average apical base change was 2.3 mm (Table 5, Figure 2). The maxillary molar moved mesially 0.6 mm, and the mandibular molar moved mesially 0.7 mm. Including the apical base change, total molar change was 2.4 mm. The upper incisor moved mesially 0.3 mm, and the lower incisor moved mesially 0.8 mm. Total incisor change was 2.8 mm. All changes except maxillary incisor movement were statistically significant (P < .05).

In the Forsus group, the maxilla moved mesially 1.7 mm, and the mandible moved mesially 4.4 mm; the average apical base change was 2.6 mm. The maxillary molar moved mesially 1.2 mm, and the mandibular molar moved mesially 1.8 mm. The total molar change was 3.2 mm. The upper incisor moved mesially 0.7 mm, and the lower incisor moved mesially 1.2 mm. Total incisor change was 3.2 mm. All changes except

---

**Table 4.** Comparison of Pretreatment and Posttreatment Variables and Treatment Changes in the Elastics and Forsus Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elastics</td>
<td>Forsus</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>U1-SN, deg</td>
<td>103.1*</td>
<td>7.9</td>
</tr>
<tr>
<td>U1-ANS-PNS, mm</td>
<td>25.9</td>
<td>2.8</td>
</tr>
<tr>
<td>U6-ANS-PNS, mm</td>
<td>18.3</td>
<td>2.2</td>
</tr>
<tr>
<td>L1-GoMe, deg</td>
<td>95.8</td>
<td>6.2</td>
</tr>
<tr>
<td>L6-GoMe, mm</td>
<td>26.1</td>
<td>2.0</td>
</tr>
<tr>
<td>OP-SN, deg</td>
<td>17.9</td>
<td>3.8</td>
</tr>
</tbody>
</table>

* Statistical significance between groups (P < .05); SD indicates standard deviation; Sig, significance.

**Table 5.** Pitchfork Analysis Comparison of Treatment Changes in Elastics and Forsus Groups. Positive Signs Indicate Movements in a Direction Which Aids Class II Correction (Distal Movements in the Maxilla/Mesial Movements in the Mandible). Negative Signs Indicate Movements Which Make Class II Occlusion More Severe (Mesial Movements in the Maxilla/Distal Movements in the Mandible).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elastics Group</th>
<th>Forsus Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Max, mm</td>
<td>-1.5**</td>
<td>1.3</td>
</tr>
<tr>
<td>Mand, mm</td>
<td>3.8**</td>
<td>2.5</td>
</tr>
<tr>
<td>ABCH, mm</td>
<td>2.3**</td>
<td>1.7</td>
</tr>
<tr>
<td>U6, mm</td>
<td>-0.6**</td>
<td>1.1</td>
</tr>
<tr>
<td>L6, mm</td>
<td>0.7***</td>
<td>1.3</td>
</tr>
<tr>
<td>U6/L6, mm</td>
<td>2.4***</td>
<td>1.2</td>
</tr>
<tr>
<td>U1, mm</td>
<td>-0.3</td>
<td>2.6</td>
</tr>
<tr>
<td>L1, mm</td>
<td>0.8*</td>
<td>2.0</td>
</tr>
<tr>
<td>U1/L1, mm</td>
<td>2.8**</td>
<td>2.2</td>
</tr>
</tbody>
</table>

* Statistical significance between groups (P < .05); Sig indicates significance.

**Figure 2.** Pitchfork summaries of treatment changes. (A) Treatment changes in the elastics group. (B) Treatment changes in the Forsus group. (C) Summary of differences between groups (Forsus vs elastics).
maxillary incisor movement were significantly greater than zero ($P < .05$).

The pitchfork analysis showed group differences for the lower molar movements and total molar corrections (Figure 2). The Forsus group displayed 1.1 mm more mesial movement and 0.8 mm greater molar correction. During treatment, the mandible and maxilla moved mesially, with the mandible moving more than the maxilla in both groups. The upper molars, and the upper and lower incisors, were moved mesially in similar amounts in both groups. Overjet was improved in both groups.

**DISCUSSION**

The molar relationships of patients treated with elastics were corrected primarily due to mandibular growth changes. Anterior mandibular displacement accounted for 3.8 mm or approximately 158% of the 2.4 mm molar correction. Mesial mandibular molar movements accounted for 29% of the total correction.

In contrast, treatment changes in the maxilla worked against the molar corrections, with anterior maxillary skeletal and dental movements limiting the correction by approximately 63% and 25%, respectively. Similar amounts of mandibular and maxillary advancements have been previously reported for Class II elastic treatments. Mesial movement of the maxilla is commonly found in elastics patients, even with the use of headgear. Nonextraction Class II patients treated with standard edgewise appliances, Class II elastics, and headgears show mandibular displacements and dental movements accounting for approximately 66% and 22% of the Class II correction, and distal maxillary molar movement contributed another 29%; anterior maxillary skeletal movements limit the correction by approximately 20%.

The use of a prescription appliance without headgear could account for the maxillary molar anchorage loss observed in this study. Molar anchorage can be enhanced with headgear or Begg anchor bends. According to a personal communication from Dr L. Johnson of St. Louis Mo, anchorage loss in patients treated with prescription appliances is approximately 1 mm greater than with standard edgewise treatment. Because total molar correction was less than previously reported with the PFA, suggesting a less severe initial Class II relationship, greater maxillary molar anchorage loss could be tolerated while achieving satisfactory occlusal results. Nelson et al showed similar amounts of molar correction in patients successfully treated with Class II elastics and the Begg appliance.

The vertical relationships of the teeth and occlusal plane in the elastics patients indicate treatment modifications of normal growth. Maxillary and mandibular molars, as well as the maxillary incisors, erupted during treatment, as previously reported for elastics treatment. Untreated controls show similar or slightly greater amounts of maxillary molar eruption over a comparable time span, but less mandibular molar eruption. This suggests that Class II elastics may have extruded the mandibular molars during treatment. Since neither practitioner placed a curve of Spee nor anchorage bends into the archwires, the mandibular molar extrusion might have been compensation to the more limited amounts of maxillary molar eruption that occurred. The OP-SN decreased (rotated counterclockwise) 1.0°, which was contrary to the clockwise rotation previously reported for elastics, but the differences are relatively small. Differences could be attributed to the use of the functional occlusal plane in this study, rather than the more commonly used Down’s occlusal plane or Pancherz’s occlusal reference line. The functional occlusal plane is less likely to rotate clockwise when the upper incisors procline, than occlusal planes that rely on the incisors.

Molar correction for the patients treated with the Forsus FRD appliance was also predominately due to mesial mandibular skeletal and dental movements. Anterior mandibular displacement and mesial mandibular molar movements accounted for approximately 138% and 56% of Class II correction, respectively. Treatment changes with the Forsus also worked against molar correction, as mesial maxillary skeletal and dental movement limited correction by 91%. DeVincento, who quantified the skeletal and dental contributions to Class II correction with the Eureka Spring, showed distal movements of the maxilla and maxillary molars (contributing 11% and 33%, respectively), mesial mandibular molar movement contributing an additional 60%, and relative posterior movement of the mandible limiting molar correction by 4%. However, DeVincento used the pterygoid vertical reference line to calculate dental and skeletal changes.

The functional occlusal plane, which was used as a reference in this study, tends to show relatively greater skeletal contributions in Class II correction. Karacay et al reported no maxillary movement, approximately 1 mm anterior mandibular displacement, and equal amounts of distal maxillary molar and mesial mandibular molar movements in patients treated with the Forsus Nitinol Flat Spring (NFS). Distal movements of maxillary molars have been previously reported with the Forsus NFS and similar appliances. The studies showing the greatest distal movements of the maxillary molars measured the effects immediately after interarch appliance removal. Mesial movement with growth and anchorage loss due to additional orthodontic treatment may mask or negate these distal

*Angle Orthodontist, Vol 78, No 2, 2008*
movements. After Class I molar occlusion is achieved and appliances are removed, mesial maxillary molar movement might be expected to keep pace with the mandibular molars.

The Forsus group produced less vertical change than the elastics group. The eruption of the maxillary and mandibular molars compares well with previous reports of Forsus NFS and Jasper Jumper treatments.11,12,16,29 Immediately after appliance removal, the Forsus NFS, Jasper Jumper, and Eureka Spring have been shown to intrude the maxillary molars.11-13,18,30 If intrusion was initially achieved with Forsus treatment, it was followed by eruption, probably associated with normal growth. The change in L1-GoMe angulation was 2.5° greater in the Forsus group than in the elastics group, but this difference was not statistically significant. As the lower incisor tip proclined, the vertical distance from incisal tip to mandibular border should be expected to decrease in proportion to its proclination.

A number of the group differences appeared to be clinically relevant but were not statistically significant. This was due to the amount of variation in treatment changes seen between subjects in each group. Large variation in treatment changes is a common finding among treated Class II patients and is likely due to the variation in treatment. Clinically relevant but were not statistically significant. As the lower incisor tip proclined, the vertical distance from incisal tip to mandibular border should be expected to decrease in proportion to its proclination.

CONCLUSIONS

- The Forsus FRD is an acceptable substitute for Class II elastics for patients who appear to be non-compliant.
- Greater forward displacement of the mandible is the predominant factor contributing to success when treating Class II patients with either Class II elastics or the Forsus FRD appliance.

ACKNOWLEDGMENTS

The authors wish to acknowledge Drs Kevin Walde and William Vogt for generously providing the records, to Dr Heidi Israel for statistical advice, and to Dr Lysle E. Johnston Jr for assistance during this project.
sions with the Jasper Jumper appliance—a preliminary re-


21. Johnston LE Jr. Balancing the books on orthodontic treat-


22. Egolf RJ, BeGole EA, Upshaw HS. Factors associated with 

orthodontic patient compliance with intraoral elastic and 

headgear wear. Am J Orthod Dentofacial Orthop. 1990;97: 

336–348.

23. Johnston LE Jr. A comparative analysis of Class II treat-

ments. In: Vig PS, Ribbens KA, eds. Science and Clinical 

Judgment in Orthodontics. Ann Arbor, Mich: Center for Hu-


correction in fixed appliance treatment of class II, division 

1, malocclusions: sagittal and vertical components. Am J 


and dental changes with nonextraction Begg mechanother-

apy in patients with Class II division 1 malocclusion. Am J 


26. Bien SM. Analysis of the components of force used to effect 

27. Zingeser M. Vertical response to Class II division 1 therapy. 


29. Karacay S, Akin E, Olmez H, Gurton AU, Sagdic D. Forsus 

Nitinol Flat Spring and Jasper Jumper corrections of Class 


30. Heinig N, Goz G. Clinical application and effects of the For-
