Early headgear effect on the eruption pattern of maxillary second molars

Yossi Abeda; Ilana Brinb

ABSTRACT

Objective: To test the hypothesis that the use of a combination headgear (HG) during the first phase of orthodontic treatment has no effect on the eruption pattern of the maxillary second permanent molars.

Materials and Methods: The records of the patients in a two-phase randomized clinical trial of early Class II treatment were utilized. The HG group comprised 47 patients, and the control (CON) group comprised 52 patients. The mean age of both groups was 9.4 years at the beginning of the clinical trial (T1). Cephalograms and panoramic views obtained at T1 and at the end of 15 months of phase I treatment or observation (T2) were utilized. The vertical and horizontal movements of the first and second upper molars (U6 and U7, respectively) were measured. The beginning of phase II (T3) and the end of phase II (T4) records were visually reviewed for follow-up of the eruption of the U7.

Results: The pattern of movement for the distal and vertical displacement of the U6 and U7 was significantly different in the HG and CON groups (P < .001). At the end of phase I, none of the U7 in either group were diagnosed as malposed or suspected for impaction. At the end of phase II, all but one U7 with a possible cystic lesion had erupted.

Conclusions: The hypothesis is rejected. Forces exerted by combination headgear to the U6 in phase I have a distalizing effect and a transitory slowing down effect on the eruption of the U7 buds. These latter teeth always erupted except when pathology occurred. (Angle Orthod. 2010;80:642–648.)

KEY WORDS: Second molar eruption; Combined headgear; Class II

INTRODUCTION

The eruption pattern of the maxillary second molar (U7) may be affected by early application of headgear (HG) prior to its intraoral eruption. Nanda and Dandajena1 observed that use of HG for an extended period of time may result in delayed eruption of the second molars. Bishara2 suggested the use of a clinical landmark to determine the optimal timing for HG treatment based on the relationship of the U7 to the maxillary first molar (U6). He suggested that when the crowns of the U7 have erupted past the apical third of the roots of the U6, as determined from periapical or panoramic radiographs, it is time to start extraoral forces attached to the U6 to avoid impaction. None of these studies related to the use of a specific type of HG.

A few studies investigated the effect of the unerupted U7 on the efficiency of noncompliance appliances for maxillary molar distalization.3,4 Kinzinger et al.4 noted that the U7 tooth bud acts like a fulcrum on its mesial neighbor and that the degree of tipping of the U6 was much greater in patients whose U7 was still in the budding stage. Bussick and McNamara3 observed no difference in the amount of molar correction with the pendulum appliance between patients who had the U7 erupted and those who did not. Taner et al.5 used a cervical headgear and Tortop and Yuksel6 a combination headgear and both reported a significant effect on distal tipping and eruption of the U7 when a distal force was applied to the U6.

However, no quantitative study of the effect of combination HG treatment on the eruption pattern of the U7 in a randomized clinical trial design was found in the literature. It was therefore the purpose of this project to investigate the possible effect of combination...
HG treatment in the first phase of orthodontic treatment on the eruption pattern of the U7 in a random population of Class II patients.

MATERIALS AND METHODS

The records of the patients in the University of North Carolina (UNC) two-phase randomized clinical trial of early Class II treatment were utilized. Fourteen patients were removed from the original UNC material because of the quality of the scanned cephalograms: five from the headgear (HG) group and nine from the control (CON) group. Finally, the HG group comprised 47 patients treated with a combination HG with a short outer bow (ending approximately at the mesial of the molar tubes) adjusted to deliver between 8 and 10 ounces to the headcap and with the neck strap force just sufficient to prevent buccal flaring of the upper molars. The CON group comprised 52 patients who did not receive any phase I treatment. The mean age of both groups was 9.4 years (HG group SD = 1.0 years; CON group SD = 1.2 years) at the beginning of the clinical trial. About 60% of the participants were male (60% in the HG group; 57% in the CON group), and about 90% of the patients exhibited a bilateral Class II molar (90% in the HG group; 93% in the CON group).

Cephalograms obtained at the beginning (T1) and at the end of 15 months (T2) of phase I treatment (for the HG group) or observation (for the CON group) were measured in this study. In addition, the records of the beginning of phase II and the end of treatment (T3 and T4, respectively) were available and were visually evaluated for confirmation of the U7 full eruption at these stages. However, no measurements were performed on these final sets because the influence of the fixed appliances and/or extractions on the eruption of U7 was beyond the scope of this study. Because the molar bands were not removed at the end of phase I in some of the patients, the technician was not blinded as to the treatment group of these patients.

The cephalograms were scanned. For digitization and measurements, the Viewbox 3.1.1.12 version of cephalometric software (dHAL SOFTWARE, Kifissia, Greece) was used. The following landmarks were identified (Figure 1): sella turcica (S); nasion (N); the most mesial (MM) and the most distal (MD) point on the crown contour of the U6 and U7; and root furcation (RF) point of the U6 and U7. The midpoint of the molar crown (MC) width was calculated, and the position of these teeth was measured from the midpont landmarks, utilizing the Viewbox software. In the process of landmark identification, the enhancement function was utilized.

Measurements on Cephalograms

For the evaluation of the displacement of the U6 and U7, the following measurements were performed (Figure 1):

- Vertical displacement was measured on a perpendicular line from the mid-crown point to the SN line.
- Horizontal displacement was measured from the mid-crown point to the SN-perp.
- Axial inclination of the U7 was measured as the angle between the long axis of the molar and the SN line. The long axis was defined as a line connecting the MC and RF points.

The measurements were performed by computing the positions of the mid-crown points for each side separately, and the bilateral mean was applied for the statistical evaluation. When T1–T2 calculations were used, negative signs denoted eruption in the vertical dimension or mesial movement in the horizontal dimension.

Statistical Analyses

Ten random cases were remeasured, and the standard error was calculated using Dahlberg’s formulas for each variable. The method error was found to be low (Table 1) except for the furcation measurements and these were omitted from further analysis. Thus, the mean of the right and left linear measurements and their SD values were calculated.

The paired t-test was applied to test the significance of the change between the two time points within each group and between the groups. A P value of 5% or less was considered as statistically significant.

RESULTS

For the linear measurements, the range of the standard error was 0.4 mm to 0.7 mm with one exception of 2.3 mm for the horizontal displacement of U6 at T2 (Table 1). The error for the angular measurements was high, ranging from 4.7° to 8.3°, and consequently the angular measurements were deleted from further consideration.

At the beginning of phase I, the horizontal and vertical positions of the U6 and U7, respectively, were similar in both groups (Table 2). The change in the horizontal and vertical positions of these teeth in the HG and CON groups with time (T1–T2) are presented in Tables 3 and 4, respectively. These changes within each group were statistically significant except for the maxillary U7 in the horizontal dimension.

Comparison between the HG and CON groups by the molar response is presented in Table 5, and demonstrates significant differences for both molars.
in both dimensions. When the changes between the U6 and U7 were studied closely within each group, a significant change in both dimensions was found for the U6 and U7 in the CON group (Table 6). This was true for the HG group as well for the vertical dimension only. However, the U6 and U7 moved the same distance distally in this group.

In the HG group, the U6 demonstrated an average distal displacement of 2.6 mm and a moderate (1.5-mm) vertical eruption, while in the CON group it moved to the mesial 1.2 mm, on average, with a 2.5-mm eruption (Table 5). The U7 erupted toward the occlusal plane in both groups, although the eruption in the HG group, on average, was significantly slowed down when compared to that of the CON group as can be seen in Table 5 (CON mean: 4.8 mm; HG mean: 2.6 mm). In the HG group, the average distal displacement of the U7 was 2.8 mm, while there was

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurement Error at T1</th>
<th>Measurement Error at T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>U6 molar vertical displacement</td>
<td>0.6 mm</td>
<td>0.6 mm</td>
</tr>
<tr>
<td>U6 molar horizontal displacement</td>
<td>0.7 mm</td>
<td>2.3 mm</td>
</tr>
<tr>
<td>U6 molar furcation</td>
<td>5.9</td>
<td>4.7</td>
</tr>
<tr>
<td>U7 molar vertical displacement</td>
<td>0.5 mm</td>
<td>0.7 mm</td>
</tr>
<tr>
<td>U7 molar horizontal displacement</td>
<td>0.4 mm</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>U7 molar furcation</td>
<td>8.3</td>
<td>6.6</td>
</tr>
</tbody>
</table>

* U6 indicates upper maxillary first molar; U7, upper maxillary second molar; T1, at the beginning of the clinical trial; T2, at the end of 15 months of phase I treatment or observation.
virtually no displacement of this tooth, on average, in the CON group (mean: 0.1 mm) (Table 5).

Visual evaluation of the records at the end of phase I indicated a normal eruption path of all U7 in both groups. At the end of phase II, visual review of the records suggested that all but one U7 were erupted. The unerupted U7 was possibly impeded by a cystic lesion.

DISCUSSION

Study of the U7 eruption pattern in untreated patients with skeletal Class II suggested that in these individuals, the U7 may erupt earlier than in individuals with skeletal Class I malocclusion. In addition, it was found that the U7 erupt as soon as there is enough space in the upper jaw (Tschechne et al.). However, we do not know if this is also true for patients undergoing early HG treatment for Class II malocclusion. A common treatment sequence in these patients consists of distal movement and/or growth modification by HG to the first molars in the first phase of treatment, and application of fixed appliances with or without HG in the second phase. The clinical experience indicates that in most cases at the end of treatment, the U7 erupt into the oral cavity uneventfully following this treatment protocol. However, there are cases in which one or both of the U7 are severely delayed or even impacted following the HG treatment. It should be kept in mind that the incidence of impacted U7 in a random population is 0.08% (Andreasen et al.). The delay was observed in our clinical experience especially in very compliant patients, who used their headgears more than the recommended 14 hours per day. This phenomenon prompted us to analyze the possible changes in the eruptive pattern of U7 adjacent to U6 to which HG was applied.

Our results are limited to linear measurements since angular measurements of molar displacement were omitted due to a large method error (Table 1). This error can be explained by the relatively early developmental stage of the U7 of the young patients in this study, rendering the root-furcation difficult to locate precisely on the cephalograms. This premise is supported by the larger method error found in the U7 angular measurement compared with the U6 (Table 1), which was high as well. Most other measurement errors were comparable to errors in studies with similar methodologies except for the U6 horizontal displacement at T2.

In this study the SN reference plane was chosen because of the high reproducibility of the relevant cephalometric landmarks. We are aware of the fact that this measurement method will not differentiate between growth effects and dental movement effect. However, because of the randomization effect, the position of the molars was similar in both groups (Table 2), and the growth pattern could be assumed to be similar as well. Thus, any difference between the groups regarding the pattern of eruption of U7 is supposed to be due to the treatment only.

The eruption pattern of U7 under the influence of combination HG to the U6 in Class II patients was found to be significantly altered during phase I when compared with the CON group (Table 5).

In the Horizontal Dimension

In the CON group, the U7 did not change position horizontally at this stage of development. However, in the HG group U7 and U6 were displaced distally in the horizontal dimension to a similar extent (Table 6). The amount of distal movement of the U7 in this study was somewhat larger than that found by Tortop and

Table 2. Comparison of the Position (± SD) in mm of the Maxillary Molars in the Headgear (HG) and Control (CON) Groups at the Beginning of Phase I (Independent Samples t-Test)*

<table>
<thead>
<tr>
<th>Position</th>
<th>HG (n = 47)</th>
<th>CON (n = 52)</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>U7 molar vertical position</td>
<td>49.5 ± 3.6</td>
<td>48.7 ± 4.4</td>
<td>.348</td>
</tr>
<tr>
<td>U7 molar horizontal position</td>
<td>23.8 ± 3.2</td>
<td>24.6 ± 3.1</td>
<td>.194</td>
</tr>
<tr>
<td>U6 molar vertical position</td>
<td>61.0 ± 3.1</td>
<td>60.2 ± 3.5</td>
<td>.244</td>
</tr>
<tr>
<td>U6 molar horizontal position</td>
<td>29.4 ± 3.8</td>
<td>30.2 ± 4.3</td>
<td>.360</td>
</tr>
</tbody>
</table>

* U7 indicates upper maxillary second molar; U6, upper maxillary first molar; T1, at the beginning of the clinical trial; T2, at the end of 15 months of phase I treatment or observation.

Table 3. Comparison of the Horizontal and Vertical Molar Position in mm (± SD) in the Headgear (HG) Group (n = 47) (Paired Samples t-Test)*

<table>
<thead>
<tr>
<th>Position</th>
<th>T1</th>
<th>T2</th>
<th>T1–T2</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>U7 molar vertical position</td>
<td>49.5 ± 3.6</td>
<td>52.1 ± 3.5</td>
<td>2.6 ± 3.0</td>
<td>.000</td>
</tr>
<tr>
<td>U7 molar horizontal position</td>
<td>23.8 ± 3.2</td>
<td>24.6 ± 3.1</td>
<td>.8 ± 1.6</td>
<td>.150</td>
</tr>
<tr>
<td>U6 molar vertical position</td>
<td>61.0 ± 3.1</td>
<td>62.5 ± 3.5</td>
<td>1.5 ± 1.7</td>
<td>.000</td>
</tr>
<tr>
<td>U6 molar horizontal position</td>
<td>29.4 ± 3.8</td>
<td>32.8 ± 4.0</td>
<td>3.4 ± 2.2</td>
<td>.000</td>
</tr>
</tbody>
</table>

* U7 indicates upper maxillary second molar; U6, upper maxillary first molar; T1, at the beginning of the clinical trial; T2, at the end of 15 months of phase I treatment or observation.

Table 4. Comparison of the Horizontal and Vertical Change in Molar Position in mm (± SD) in the CON group (n = 52) (Paired Samples t-Test)*

<table>
<thead>
<tr>
<th>Position</th>
<th>T1</th>
<th>T2</th>
<th>T1–T2</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>U7 molar vertical position</td>
<td>48.7 ± 4.4</td>
<td>53.5 ± 5.5</td>
<td>4.8 ± 1.9</td>
<td>.000</td>
</tr>
<tr>
<td>U7 molar horizontal position</td>
<td>24.6 ± 3.1</td>
<td>24.5 ± 3.5</td>
<td>.1 ± 1.5</td>
<td>.779</td>
</tr>
<tr>
<td>U6 molar vertical position</td>
<td>60.2 ± 3.5</td>
<td>62.7 ± 3.7</td>
<td>2.5 ± 1.1</td>
<td>.000</td>
</tr>
<tr>
<td>U6 molar horizontal position</td>
<td>30.2 ± 4.3</td>
<td>31.4 ± 4.5</td>
<td>1.2 ± 1.5</td>
<td>.000</td>
</tr>
</tbody>
</table>

* U7 indicates upper maxillary second molar; U6, upper maxillary first molar; T1, at the beginning of the clinical trial; T2, at the end of 15 months of phase I treatment or observation.

 Negative value denotes vertical eruption.

 Negative value denotes distal movement.
They used a similar appliance for approximately 5 months and an observation period of 2 years and found 2.3 mm of distal movement. Taner et al. who used a cervical HG found 2.3 mm of distal movement of the U7 over 11.3 months. Both studies however, measured the movement to a different reference plane.

It is also interesting to note the difference between the U6 displacements in the two groups. In the horizontal dimension, the U6 in the CON group was displaced to the mesial 1.2 ± 1.5 mm (Table 4). This can be explained by the normal growth process as well as by mesial drift following the loss of the second deciduous molar, which could occur concomitantly. In the HG group, the U6 were displaced distally 2.6 ± 2.2 mm. Thus, when the mesial migration that normally occurs (CON group) and the distal displacement due to the HG were combined, the change in position of the U6 in the two groups amounted to a mean of 3.8 mm (1.2 + 2.6 = 3.8).

When the negligible migration which normally occurs (CON group) and the distal displacement due to the HG were combined, the change in the U7 position in the HG groups amounted to a mean of 2.7 mm (2.8 – 0.1 = 2.7). It can be suggested then, that the net distal displacement of the U7 in the HG group was about the same as that of the U6 in the HG group (2.8 and 2.6 mm, respectively) (Table 6). However, the change in position of the U7 in the treatment group was about 71% (2.7/3.8) of the change in position of the U6.

In the Vertical Dimension

In the HG group, the vertical eruption of the U6 was impeded by 1 mm. The U6 erupted −1.5 ± 1.7 mm for the HG group and −2.5 ± 1.1 mm for the CON group (Table 6), probably because of the combination HG configuration exerting an intrusive component of force.

Although the HG treatment allowed for the U7 vertical intra-alveolar eruption, this process was delayed and more variable compared with the controls (2.6 ± 3.0 mm vs 4.8 ± 1.9 mm, respectively). This mean delay of 2.2 mm (4.8 – 2.6 = 2.2) amounted to about 46% (2.2/4.8) of the normal vertical eruption in the controls. The amount of vertical displacement of the U7 in this study was larger than that found by Taner et al. who used a cervical HG, but for a shorter period of time. On the other hand, Tortop and Yuksel suggested a vertical displacement of the U7 of 0.5 mm only during treatment with combined HG for about 5 months and a 2-year observation period. The large variability in the eruption response of the U7 to HG therapy as indicated by the various authors may also be caused by differences in compliance with HG use.

Thus, overall it can be concluded that a 15-month duration of use of a combination headgear may result in delayed eruption of the U7 but not in its impaction. This is in agreement with Nanda and Danjema who observed that prolonged use of HG results in delayed eruption of U7. It can also be hypothesized that the more distal eruption of U7 points to a longer eruption path, which may last for a longer period of time.

The vertical delay could be explained by the fact that the second molars might have served as a fulcrum for the distal tipping of the U6 (Figure 2), similar to the situation described in the case of the pendulum appliance. Thus, the temporary distal tipping of the U6 blocked the eruption path of the U7 until uprighting of the U6 occurred and the U7 completed its eruption.

In addition, it is known that the eruption of the U7 is limited by the space distal to the U6 in the dental arch. The distal movement of the U6 in the HG group possibly also encroached on the U7 space, thus causing a delay in its eruption. Thus, the tendency

### Table 5. Comparison Between the Changes in Molar Position in mm (± SD) With Time in the Headgear (HG) and Control (CON) Groups (Independent Samples t-Test)*

<table>
<thead>
<tr>
<th>Difference</th>
<th>HG (n = 47)</th>
<th>CON (n = 52)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>U7 molar vertical difference T1–T2</td>
<td>−2.6 ± 3.0</td>
<td>−4.8 ± 1.9</td>
<td>.000</td>
</tr>
<tr>
<td>U7 molar horizontal difference T1–T2</td>
<td>2.8 ± 1.6</td>
<td>0.1 ± 1.5</td>
<td>.000</td>
</tr>
<tr>
<td>U6 molar vertical difference T1–T2</td>
<td>−1.5 ± 1.7</td>
<td>−2.5 ± 1.1</td>
<td>.001</td>
</tr>
<tr>
<td>U6 molar horizontal difference T1–T2</td>
<td>2.6 ± 2.2</td>
<td>−1.2 ± 1.5</td>
<td>.000</td>
</tr>
</tbody>
</table>

* U7 indicates upper maxillary second molar; U6, upper maxillary first molar; T1, at the beginning of the clinical trial; T2, at the end of 15 months of phase I treatment or observation.

** Negative value denotes vertical eruption.

† Negative value denotes mesial movement.

### Table 6. Comparison of the Change in Position in mm (± SD) Between the U6 and U7 in the Headgear (HG; n = 47) and Control (CON; n = 52) Groups (Paired Samples t-Test)*

<table>
<thead>
<tr>
<th>Change</th>
<th>U7</th>
<th>U6</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical change in HG group</td>
<td>−2.6 ± 3.0</td>
<td>−1.5 ± 1.7</td>
<td>.000</td>
</tr>
<tr>
<td>Horizontal change in HG group</td>
<td>2.8 ± 1.6</td>
<td>2.6 ± 2.2</td>
<td>.734</td>
</tr>
<tr>
<td>Vertical change in CON group</td>
<td>−4.8 ± 1.9</td>
<td>−2.5 ± 1.1</td>
<td>.000</td>
</tr>
<tr>
<td>Horizontal change in CON group</td>
<td>0.1 ± 1.5</td>
<td>−1.2 ± 1.5</td>
<td>.000</td>
</tr>
</tbody>
</table>

* U7 indicates upper maxillary second molar; U6, upper maxillary first molar.

** Negative value denotes vertical eruption.

† Negative value denotes mesial movement.
**Figure 2.** Patient 4801. (A) Panoramic view before treatment (T1). (B) End of phase I—note the temporary distal tipping of the U6, which blocks the eruption path of the U7. (C) Uprighting of the U6 occurred during phase II, and the U7 completed its eruption.
towards early eruption of maxillary U7 in Class II patients is reversed by early orthodontic treatment with combination headgear (phase I). It should be noted that this delay in eruption of the U7 may lead to a later start of the second phase of orthodontic treatment while the orthodontist awaits the eruption of these teeth. The occurrence of impaction of U7 is very rare and follows only extreme HG use, beyond the recommended number of hours, which is also rarely encountered. Visual evaluation of the roentgenograms of the patients observed in this study, obtained at the end of phase II (T4), did not reveal any impacted U7 except for one U7. Close inspection of the posttreatment panoramic radiograph reveals a possible cystic lesion. This occurrence may be unrelated to the HG treatment, but clear etiology cannot be determined.

The contention of Bishara that in order to avoid impaction of U7 following the application of HG forces to the U6, treatment should be started only when the U7 buds are in the height of the apical third of the adjacent U6 was not examined in this study. However, visual evaluation of the T1 panoramic views in all cases in this study revealed the presence of the above-mentioned relationships between the U6 and U7. Thus, the HG treatment was started at the optimal timing according to Bishara, which could also explain the lack of impactions (except for one case with a possible cystic lesion).

There are some limitations to this study, one of them being the conservative two-dimensional presentation of the region of interest. It would be significantly more informative to follow the eruptive process of the U7 in three dimensions, but high cost and high radiation exposure to the patient limit 3D clinical use. In addition, the relatively small sample size did not allow subdivision into maxillary or mandibular Class II or subdivision by gender. These approaches could give additional insight into the question of altered eruption pattern of the U7.

CONCLUSIONS

- The forces exerted by combination headgear to the U6 at phase I orthodontic treatment have a slowing down effect by 46% on the vertical eruption of U7 compared with untreated controls.
- This effect is transitory because all U7 without pathologic signs were in occlusion at the end of phase II.
- Most of the horizontal movement of the U6 was expressed in the U7 movement.

ACKNOWLEDGMENTS

The authors wish to thank Dr Joan Tulloch for the possibility to study the clinical material obtained with the help of the NIH grant R01-DE 08708. Also, our thanks go to Dr Ceib Phillips for her constructive remarks.

REFERENCES


Angle Orthodontist, Vol 80, No 4, 2010