Treatment Effects of Cervical Headgear and Lower Utility Arch Mechanics in Angle Class II Division 1 Low-Angle Patients

Objective: A prospective study was performed to evaluate the effects of cervical headgear and lower utility arch (CHG+LUA) in Class II division 1 low-angle patients and to determine whether reverse response occurred during the upper first molar distalization period.

Subjects and Methods: Thirty patients were included in the study and were divided in two groups. The first group was treated with CHG+LUA while the second group was treated only with cervical headgear (CHG). After achieving Angle class I molar relation, the cephalograms were taken.

Results: The assessment of cephalometric findings showed that significant reduction of maxillary protrusion, molar distalization, and extrusion were obtained in both groups. LUA influenced the lower molar uprighting and the lower incisor intrusion significantly. The rotation of the mandible showed a significant increase in CHG group while it remained constant in CHG+LUA group.

Conclusion: These results showed that reverse response effect, which may be an effective way of controlling the mandibular rotational response, could be achieved by CHG+LUA.

Keywords
Cervical headgear, lower utility arch, Class II division 1

Özet
Amaç: Sınıf II bölüm 1 malokuzyona sahip low-angle hastalarda servikal headgear ve alt utility ark (CHG+LUA) uygulamasının etkilerini incelemek ve üst birinci molar distalizasyonu sırasında mandibulada “ters yanıt” etkisinin olup olmadığını araştırmaktır.

Bireyler ve Yöntem: Tedaviye dahil edilen toplam 30 birey iki gruba ayrılmış, birinci gruba CHG+LUA, diğer gruba sadece CHG uygulanmıştır. Angle sınıf I molar ilişkisi elde edildikten sonra lateral sefalogramlar alınmıştır.

Bulgular: Sefalometrik değerlendirilmelelinden elde edilen bulgular, her iki grupta da maksiller protruzyonu azalmış, molar distalizasyonu ve ekstruzyonu elde edildiğiğini göstermektedir. Alt utility ark, alt molara anlamlı dikleşmeye ve alt kesicilede anlamlı intrüyona neden olmuştur. Mandibüler rotasyon CHG grubunda anlamlı şekilde artarken, CHG+LUA grubunda sabit kalmıştır.

Sonuç: Araştırma sonuçları, mandibular rotasyonun kontrolünde etkisi bir yol olan “ters yanıt” etkisinin CHG+LUA uygulaması ile elde edilebileceğini göstermiştir.

Anahtar Kelimeler
Servikal headgear, alt utility ark, Sınıf II bölüm 1
INTRODUCTION

Extraoral traction is the most reliable method for management of maxillary protrusion and still continues to be a major treatment alternative for the orthodontists.

The decision as to which type of headgear to use in the treatment of growing patients with skeletal and dental class II malocclusion has been discussed by many investigators1-6. Cervical headgear has been most frequently used in cases of skeletal maxillary protrusion, producing distal displacement of the maxilla, increasing the vertical dimension and generating mandibular clockwise rotation7,8. Because some studies have shown the upper molar extrusion and the opening rotation of the mandible besides the distalization effect of cervical headgear5,9,10, many orthodontists tend to avoid using cervical headgear when a patient with class II maxillary protrusion has a vertical growth pattern. Some investigators have stated that mandibular plane angle opens with the cervical headgear11,12, while others have disagreed with this statement, believing that mandibular plane closes or does not change with treatment1,13. Many authors have reported significant changes in vertical parameters when patients treated with cervical headgear compared to patients treated without the use of headgear14-16, or patients treated with occipital or high-pull headgear12,16,17. However, Ricketts et al18 suggested that the effect of cervical headgear did not occur as it has been accepted in the literature. According to the authors18, when a cervical headgear is used in high-angle patients, the extrusion of both maxillary molar and maxilla causes a reciprocal clockwise rotation of the mandible, resulting in a higher face height. On the contrary, in low-angle patients, the authors stated that the extrusive forces of cervical headgear cause changes in the dentition rather than in the facial proportions. In those cases, where a cervical headgear is used in combination with a lower utility arch, the mandible may rotate in a counterclockwise direction. This effect is called “reverse response” of the mandible and the mandibular arch. This is almost entirely a functional response and adverse to the common concepts.

The purpose of this prospective study was (1) to evaluate the skeletal and dental effects of cervical headgear and lower utility arch (CHG+LUA) in Class II division 1 low-angle patients whether reverse response occurs (2) and to compare the dental and skeletal differences between CHG+LUA and CHG during the upper first molar distalization.

SUBJECTS and METHOD

The sample consisted of thirty patients (14 boys and 16 girls) either in the late mixed or permanent dentition ranging in age from 9.08 to 13 years. The inclusion criteria for the patients in the study were as follows: (1) Class II division 1 skeletal maxillary protrusion with a low-angle growth pattern (SNA>80°, ANB>4°, maxillary depth angle>90°, lower facial height< 47°, FMA<25°, GoGnSN < 32°) (2) Half to one full cusp upper molar deviation (3) None or minimal crowding (4) Good cooperation

The subjects were divided into two groups randomly. The first group consisted of 15 patients (8 boys and 7 girls) with a mean age of 10.54 ± 1.05 years, whose treatment included an orthopedic cervical headgear in conjunction with a lower utility arch18,19. The second group consisted of 15 patients (6 boys and 9 girls) with a mean age of 10.52 ± 0.96 years, whose treatment included an orthopedic cervical headgear only. These patients did not wear any other appliances during the distalization. The first group was closely matched for age and dentoskeletal characteristics with the patients in the second group (Table I).

The headgear used for both groups was Kloehn type (GAC International, Bohemia, NY) with a long outer bow. All the patients were instructed to wear the CHG 14-16 hours per day with an orthopedic force of 500 gm18. The lateral cephalograms were taken at the start of treatment (T1) and after molar distaliz-
tion was completed (T2). The radiographs were traced by one investigator (M.A.) to verify anatomic landmarks (Figure 1A). The duration of distalization was 1.23 ± 0.42 years in the CHG+LUA group and 1.17 ± 0.30 years in the CHG group. The skeletal and dentoalveolar effects of CHG + LUA and CHG were then compared by cephalometric analysis.

Maxillary and mandibular skeletal responses were documented by comparing the means of cephalometric measurements at T1 and T2 (Figure 1B).

The dental measurements (Figures 1C and 1D) were obtained through maxillary and mandibular superimpositions, respectively. Maxilla was superimposed on the palatal plane at ANS and mandible was superimposed on the corpus axis at Pm. The long axis of maxillary and

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**FIGURE 1a**

1. Nasion 14. L6 mesial apex
2. Sella 15. L6 bifurcation
3. Orbitale 16. B point
4. Porion 17. Pm
5. A point 18. Pogonion
6. U1 crown 19. Menton
7. U1 apex 20. Gonion
8. U6 mesiobuccal cusp tip 21. Xi point
9. U6 mesiobuccal apex tip 22. R1
10. U6 trifurcation 23. R3
11. L1 crown 24. ANS
12. L1 apex 25. PNS
13. L6 mesiobuccal cusp

**FIGURE 1b**

1. SNA (°) 6. GoGnSN (°)
2. SNB (°) 7. FMA (°)
3. Palatal plane-FH (°) 8. Lower facial height (°)
4. Maxillary depth (°) 9. Cant of occlusal plane (°)
5. Facial depth (°)

**FIGURE 1c**

1. Palatal plane
2. Line perpendicular to palatal plane from ANS
3. U6, distalization of the crown (mm)
4. U6, distalization of the trifurcation (mm)
5. U6, angulation (°)
6. U6, vertical displacement (mm)
7. U1, horizontal displacement of the crown (mm)
8. U1, horizontal displacement of the apex (mm)
9. U1, angulation (°)
10. U1, vertical displacement (mm)
mandibular first molar teeth were constructed by drawing a line through the apexes and the mesiobuccal and mesial cusp tips for the upper and lower first molars. The long axes of incisor teeth were constructed through the incisal edge and apex. The angular differences in teeth positions were measured as the angles between the long axis of each maxillary and mandibular tooth and the lines perpendicular to palatal plane and corpus axis at T1 and T2. To determine the amount of molar distalization, the distances between the cusp tip of the maxillary first molar and the line perpendicular to palatal plane from ANS and the cusp tip of the mandibular first molar and the line perpendicular to corpus axis from Pm were used. The distances of the trifurcation and the bifurcation were also measured to determine the amount of tipping after distalization. The amount of horizontal displacements of maxillary and mandibular incisors was measured on a line parallel to the palatal plane and corpus axis respectively. The vertical movements of the maxillary and mandibular first molars and incisors were determined by measuring the perpendicular distances between the mesiobuccal cusp tip of the maxillary molar, mesial cusp tip of the mandibular first molar and incisal edges of the maxillary and mandibular incisor teeth relative to the palatal plane and corpus axis at T1 and T2.

Statistical analysis

The means and standard deviations were calculated for each cephalometric variable. Paired t-test was performed in each group to analyze the changes from T1 to T2. Student t-test was used to evaluate intergroup differences at different periods (T1-T2). To determine the accuracy of the method, 15 cephalograms were retraced and recalculated by the same investigator. The reliability coefficients were between 0.93 and 0.99 for linear measures, and between 0.91 and 0.97 for angular measures, indicating a high level of consistency.

RESULTS

Maxillary depth angle decreased significantly in CHG+LUA and CHG groups with a mean change of 1.87° and 1.93° respectively (p<0.05, Table II). The mean changes in SNA angle did not indicate a significant reduction in both groups (p>0.05, Table II) while palatal plane angle decreased significantly in CHG group (p<0.05, Table II).

The upper first molar (U6) in CHG + LUA and CHG groups moved distally with respect to its crown (4 mm, and 1.77 mm respectively, p<0.05, Table III). However, the distalization of the trifurcation of the upper first molar showed significant difference in CHG + LUA group (2.4 mm, p< 0.05, Table III), while there was no significant difference in the CHG group (0.77 mm, p> 0.05, Table III) during cervical headgear therapy. The change in the angulation of the U6 was statistically different in the CHG+LUA group, indicating that the tooth was distalized by tipping of the crown rather than the bodily movement.
On the other hand, the angulation of the U6 in CHG group did not change significantly (-0.17º, p> 0.05, Table III). In both groups, the upper first molar showed significant vertical change (1.07 mm, and 1.43 mm respectively, p< 0.05, Table III). The only significant change of the upper incisor (U1) in the CHG +LUA group was found in the horizontal displacement of the upper incisor’s apex (0.93 mm lingually, p< 0.05, Table III). The horizontal, the angular and the vertical changes in the position of the U1 did not differ in the CHG group (p>0.05, Table III).
The mandibular skeletal measurements showed no statistically significant changes in both groups (SNB, facial depth angle) (p>0.05, Table IV) while there was a significant increase in FMA, and lower facial height in the CHG group (p<0.05, Table IV).

**TABLE III**

*T1 (pretreatment) and T2 (after the distalization period) values of maxillary dental measurements*

<table>
<thead>
<tr>
<th>Variables</th>
<th>CHG+LUA (n=15)</th>
<th>CHG (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>U6, distalation of the crown (mm)</td>
<td>-36.17 ± 3.41</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>-40.17 ± 3.72</td>
<td></td>
</tr>
<tr>
<td>U6, distalization of the trifurcation (mm)</td>
<td>-37.13 ± 2.69</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>-39.53 ± 2.76</td>
<td></td>
</tr>
<tr>
<td>U6, angulation (º)</td>
<td>15.27 ± 6.52</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>20.87 ± 7.42</td>
<td></td>
</tr>
<tr>
<td>U6, vertical displacement (mm)</td>
<td>20.90 ± 2.93</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>21.97 ± 2.71</td>
<td></td>
</tr>
<tr>
<td>U1, horizontal displacement of the crown (mm)</td>
<td>-1.17 ± 3.26</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>-1.70 ± 3.50</td>
<td></td>
</tr>
<tr>
<td>U1, horizontal displacement of the apex (mm)</td>
<td>-10.33 ± 2.09</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>-11.27 ± 1.94</td>
<td></td>
</tr>
<tr>
<td>U1, angulation (º)</td>
<td>21.40 ± 6.43</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>21.90 ± 7.009</td>
<td></td>
</tr>
<tr>
<td>U1, vertical displacement (mm)</td>
<td>29.37 ± 2.62</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>30.03 ± 2.27</td>
<td></td>
</tr>
</tbody>
</table>

* p<0.05  
SD: standard deviation  NS: not significant
The crown of the lower first molar (L6) in the CHG+LUA group was distalized and tipped back significantly (with a mean difference of 2.5 mm and 8.3˚, p< 0.05, Table V). The vertical change in the position of the L6 was not shown to be significantly different in CHG+LUA group. The crown of the lower incisor (L1) in the CHG+LUA group retroclined and intruded significantly with a mean difference of 4.73˚ and 1.13 mm respectively (p<0.05, Table V). The cant of occlusal plane increased 2.47˚ (p<0.05, Table V) in the CHG+LUA group while there was no significant change in the CHG group. In CHG group, all the variables determining the L6 and L1 positional changes, did not also show any significant difference during distalization (p>0.05, Table V).

Within all the skeletal measurements regarding the maxilla and the mandible, neither of the variables showed any significant difference between the two groups. The distalization of the U6 was significantly different between the two groups (p<0.05, Table VI). In CHG+LUA group, both the crown and the trifurcation moved distally with a mean difference of 4 mm and 2.4 mm respectively. On the other hand, in the CHG group, the distalization of the crown and the trifurcation was 1.77 mm and 0.97 mm respectively. The horizontal displacement of the U1 was significantly different between the two groups (p<0.05, Table VI). In the CHG+LUA group, U1 moved 0.53 mm lingually while in the CHG group, U1 moved 0.8 mm labially. For the L6, the distalization of the crown (2.5 mm for the CHG+LUA group and 0 mm for the CHG group) and the bifurcation (2.4 mm for the CHG+LUA group and 0.97 mm for the CHG group) and the
<table>
<thead>
<tr>
<th>Variables</th>
<th>T1 (pretreatment)</th>
<th>T2 (after the distalization period)</th>
<th>P</th>
<th>T1 (pretreatment)</th>
<th>T2 (after the distalization period)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>L6, distalization of the crown (mm)</td>
<td>-32.80 ± 2.41</td>
<td>-35.30 ± 2.70</td>
<td>0.006* NS</td>
<td>-33.77 ± 2.35</td>
<td>-34.46 ± 0.16</td>
<td>NS</td>
</tr>
<tr>
<td>L6, distalization of the bifurcation (mm)</td>
<td>-33.80 ± 0.74</td>
<td>-34.56 ± 2.70</td>
<td>NS</td>
<td>-34.37 ± 0.16</td>
<td>-34.46 ± 0.16</td>
<td>NS</td>
</tr>
<tr>
<td>L6, angulation (º)</td>
<td>-10.33 ± 10.49</td>
<td>18.77 ± 6.15</td>
<td>0.011* NS</td>
<td>11.20 ± 7.0</td>
<td>11.0 ± 4.45</td>
<td>NS</td>
</tr>
<tr>
<td>L1, horizontal displacement of the crown (mm)</td>
<td>-8.70 ± 1.87</td>
<td>-7.53 ± 2.83</td>
<td>NS</td>
<td>-7.67 ± 1.03</td>
<td>-6.27 ± 1.72</td>
<td>NS</td>
</tr>
<tr>
<td>L1, horizontal displacement of the apex (mm)</td>
<td>-8.70 ± 1.87</td>
<td>-8.30 ± 2.83</td>
<td>NS</td>
<td>-8.00 ± 1.03</td>
<td>-7.63 ± 1.16</td>
<td>NS</td>
</tr>
<tr>
<td>L1, angulation (º)</td>
<td>6.47 ± 5.72</td>
<td>1.73 ± 8.91</td>
<td>0.012* NS</td>
<td>4.80 ± 4.56</td>
<td>25.40 ± 1.80</td>
<td>NS</td>
</tr>
<tr>
<td>L1, vertical displacement (mm)</td>
<td>25.50 ± 2.0</td>
<td>2.00 ± 2.24</td>
<td>0.017* NS</td>
<td>26.50 ± 2.0</td>
<td>2.00 ± 2.24</td>
<td>NS</td>
</tr>
<tr>
<td>Cant of occlusal plane (º)</td>
<td>18.13 ± 0.98</td>
<td>2.00 ± 2.24</td>
<td>0.019* NS</td>
<td>19.10 ± 3.84</td>
<td>2.00 ± 2.24</td>
<td>NS</td>
</tr>
</tbody>
</table>

*p<0.05
SD: standard deviation  NS: not significant
angulation (8.43° for the CHG+LUA group and -0.20° for the CHG group) were significantly different between the study groups (p<0.05, Table VI). The vertical displacement of L1 was also significantly different between the two groups (p<0.05, Table VI). (L1 intruded with a mean difference of 1.13 mm in the CHG+LUA group while extruded with a mean difference of 1.10 mm in the CHG group).

## DISCUSSION

A prospective investigation was undertaken to determine the effects of CHG+LUA in Class II division 1 low-angle patients. The orthopedic effect of CHG has previously been the subject of many studies. In contrast with the common concepts about the mandibular rotational effects, Ricketts et al suggested that a reverse response could occur when a CHG was used with a LUA in low-angle patients. According to the authors, the extruding upper molar picks up the lower molar, uprighting that tooth in a distal rotation. This action allows the maxilla to be compressed and rotated distally without rotation of the mandible and is referred to as the reverse response of the LUA. However, CHG therapy accompanying by LUA has been rarely investigated. The only investigation reported in the literature was the retrospective study of Cook et al, which was performed in high-angle patients. The purpose of this study was not to focus on posttreatment effects but to evaluate pure effects of CHG+LUA during the molar distalization period as the overall change for the entire period of treatment may hide the CHG effect.

In this study, the maxilla moved distally in terms of maxillary depth angle. Our finding is in accordance with the finding of many studies indicating the restriction of the maxilla with the use of CHG. However, SNA angle did not show any significant difference during the distalization while some authors interpreted differences in SNA reduction. The observation period in this study included only the distalization period, which might be insufficient to achieve an orthopedic movement.

The literature regarding the effect of CHG on the palatal plane angle is still unclear. Although many authors reported that anterior nasal spine to be positioned downward more than posterior nasal spine, rotation of the palatal plane was changed significantly only in CHG group. Boecler et al reported no change in the angulation of the palatal plane with CHG therapy in contrast to our finding.

### TABLE VI

<table>
<thead>
<tr>
<th>Variables</th>
<th>CHG+LUA (n=15)</th>
<th>CHG (n=15)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>U6, distalization of the crown (mm)</td>
<td>-4.0 ± 2.65</td>
<td>-1.77 ± 2.46</td>
<td>0.02*</td>
</tr>
<tr>
<td>U6, distalization of the trifurcation (mm)</td>
<td>-2.4 ± 1.48</td>
<td>-0.97 ± 1.93</td>
<td>0.03*</td>
</tr>
<tr>
<td>U1, horizontal displacement of the crown (mm)</td>
<td>-0.53 ± 1.42</td>
<td>0.8 ± 1.80</td>
<td>0.03*</td>
</tr>
<tr>
<td>L6, distalization of the crown (mm)</td>
<td>-2.5 ± 3.01</td>
<td>0 ± 1.57</td>
<td>0.008*</td>
</tr>
<tr>
<td>L6, distalization of the bifurcation (mm)</td>
<td>-2.4 ± 1.48</td>
<td>0.97 ± 1.93</td>
<td>0.03*</td>
</tr>
<tr>
<td>L6, angulation (º)</td>
<td>8.43 ± 5.47</td>
<td>-0.20 ± 7.52</td>
<td>0.001*</td>
</tr>
<tr>
<td>L1, vertical displacement (mm)</td>
<td>-1.13 ± 1.62</td>
<td>1.10 ± 2.75</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

*p<0.05
SD: standard deviation  NS: not significant
The results of this study indicate that there was a significant distalization of U6 in both groups. This finding is in accordance with the findings reported in the literature\textsuperscript{1,9}. However, the amount of distalization in CHG group was less than that of CHG + LUA group. Although the duration of distalization was almost the same, a difference between the amounts of distalization occurred. This might be due to the variation in the amount of molar cusp deviation at the start of treatment. Another possible explanation for this might be the angular changes between the two groups during the distalization period. To investigate the type of molar movement, distalization of the trifurcation of U6 was also evaluated. The amount of distalization of the trifurcation was less than the crown movement in contrast with the studies reported in the literature\textsuperscript{20,25}. Furthermore, Schiavon Gandini et al\textsuperscript{25} showed that the distal relocation of U6 was more significant in the apex due to the 20° upward angulation of the external bow. Additionally, Cook et al\textsuperscript{20} did not observe any distal tipping when the outer bows of the CHG were bent upward. The downward vector of the extraoral force produced a more downward movement of U6 in both groups. Cook et al\textsuperscript{20} reported the upper molar extrusion either with or without treatment, suggesting that the molar extrusion could not be attributed to only cervical headgear due to the ongoing downward growth of the maxilla.

In this study, the lower first molar moved distally and the lower incisors intruded and retroclined significantly in the CHG+LUA group as described by Ricketts et al.\textsuperscript{18} The bioprogressive theory of cortical anchorage hypothesizes that bends in the utility arch will move the roots of the first lower molars toward the buccal cortical bone of the mandible, leading to the extrusion of the lower first molars and the intrusion of lower incisors. The upper molar in the CHG+LUA group extruded, then uprighted the lower first molar in a distal rotation, confirming the reverse response effect of the LUA. In contrast with our findings, Cook et al did not find any reverse response effect in their study group.

Additionally, L1 and the cant of the occlusal plane were also changed by the LUA. The LUA might have a reaction at the molar to upright it however, cortical anchorage might prevent the significant molar extrusion even when the incisor intrusion mechanics were used. Meanwhile, Cook et al\textsuperscript{20} did not find any molar response while they found a significant intrusion and proclination of the lower incisors.

Since no other appliances were worn by the patients in our study during the period of the investigation, it can be stated that CHG+LUA used in this study produced Class II correction without producing an opening rotation of the mandible. GoGnSN, FMA and lower facial height angles did not demonstrate any significant changes between T1 and T2 in CHG+LUA group, confirming that when a CHG is used in conjunction with a LUA, the mandible may remain constant without any rotation. Ricketts et al\textsuperscript{18} also suggested that the extrusive forces of CHG was translated through the utility arch to the lower dentition, allowing maxilla to move distally without rotation of the mandible. Cook et al\textsuperscript{20} reported different results with our findings regarding mandibular rotation, this might be due to their study group which was different from that of our study.

A limitation of this study was that the groups were relatively small. However, the characteristics of the patients and the application of the appliances were highly homogeneous and the study was designed prospectively. Most of the studies pertaining to CHG are either retrospective or CHG has been combined with edgewise appliances; functional appliances, bite plates, extractions and the groups in these studies are not usually homogeneous. Additionally, there is only one study in the literature, investigating the speculation of Ricketts et al.\textsuperscript{18} Future studies including larger study groups and posttreatment effects should be undertaken for the long-term effects of CHG+LUA.

CONCLUSION

Both CHG+LUA and CHG groups restricted maxillary sagittal growth and resulted in an
extrusion of upper first molars. The lower first molar uprighted and moved distally with LUA, however, it could not prevent the extrusion but might restrict the excessive extrusion of the upper first molar. The reverse response of the LUA did not affect the mandibular rotation in low-angle patients thus, mandible remained stable without any rotation in the CHG+LUA group. However, opening rotation of the mandible occurred in the CHG group.

REFERENCES


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