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Original Article

Effects of a modified activator: activator combined with J hook headgear in the treatment of hyperdivergent class II malocclusion during the late mixed teeth period

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Abstract: The aim of this study was to compare the effect of a combination of activator and J hook headgear to that of the headgear-activator. The traditional activator was modified to combine with a J hook headgear which had two hooks mesial to the upper canine for extraoral traction instead of the labial arch. In addition, there is an optional screw in the middle of the palatal parts to widen the arch in narrow arch cases. Sixty-eight cases (34 boys and 34 girls, with an average age of 10.2 years old) were recruited. They were divided into two groups (Group MA: modified activator and J hook headgear group, Group HA: headgear-activator combination group). Lateral standardized cephalograms were taken before and after the treatment. The cephalograms were measured by the same doctor with the Dolphin software. There was no significant difference in the changes of SNA, U1-NA, U1-NA (mm), U1-SN, and U6-PP between the two groups. However, the changes in U1-PP showed that the MA group intrudes the upper frontal teeth while the HA group does not (P<0.001). Regarding the mandible, there were no significant differences in SNB and L1-MP (°); however, L1-MP (mm), NP_FH (°) and LL-Eline (mm) showed significant differences (P<0.001). The MA group intruded the frontal teeth and rotated the mandible anticlockwise, which was also confirmed by the changes of the OP-SN (°), MP-SN (°), and np-fh (°) (P<0.001). Compared to the headgear activator, the modified activator can level the frontal teeth, decrease the angle of the MP-SN and MP-FH, and rotate the mandible counterclockwise, which could achieve a better chin and lip outline.

Keywords: Activator, J hook, headgear, hyperdivergent

Introduction

The activator was invented by Dr. Andrensen [1], and is a functional appliance to correct Angle's class II malocclusion during the late mixed teeth period. An activator consists of an acrylic oral part and a few wire elements that move the mandible forward and inhibit the maxilla in the opposite direction. In recent years, it has some modification called Bionater [2] and Kinetor [3] by Balters and Stockfisch, respectively. Pfeiffer combined the activator with headgear to reduce the duration of treatment [4]. Teuscher [5] and Thurow [6] modified the combination of the activator and headgear. They primarily emphasized the importance of the traction force direction regarding the center of resistance of teeth and maxilla. The J hook headgear is one of the characteristics of the Tweed-Merrifield Edgewise technique [7, 8]. The function of the J hook headgear is to intrude and retract the upper frontal teeth while inclining the upper molars distally. The aim of the present study was to investigate the combined effect of the activator and the J hook headgear in the treatment of hyperdivergent Class II malocclusion during the late mixed teeth period.

Material and methods

Total sixty-eight cases (34 boys and 34 girls) aged from 9 to 12 years old (the average age was 10.2 years old) at the late mixed teeth period were recruited for this study. All patients agreed to sign the informed consent and the research was approved by the ethics committee of Stomatological Hospital affiliated to Medical College of Zhejiang University. All patients had Class II molar relationship without severe crowding, deep incisor overjet, hyperdivergent

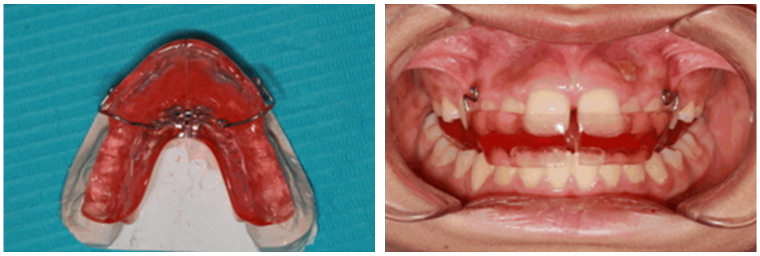

Figure 1. The view of the modified activator.

At each appointment, the appliance was adjusted approximately 0.5-1 mm by trimming the acrylic of the lingual side of the upper anterior teeth. When the upper anterior teeth reached the ideal place, the doctor inspected whether the molars touched each other. If not, the occlusal side of the upper molars was trimmed. Then, the first stage of the treatment was completed.

Class II skeletal pattern (MP-SN>36°, ANB>4°), and had no history of orthodontic therapy. First, the patients were divided into two groups based on sex. Then, 17 cases were selected from the two groups respectively as the experiment group (Group MA: modified activator and J hook headgear group) and the control group (Group HA: headgear-activator combination group). Group MA used the modified activator. The primary difference between the modified and the traditional appliance was that the former connected two hooks with the J Hook headgear mesial to the upper canine for extraoral traction without the labial arch. The lower part of the modified activator covers half of the labial surface of the lower frontal teeth with no connection with the lingual surfaces of the lower incisors. The upper part of the modified appliance covers half of the crown in the anterior teeth on both labial and palatal sides. There is a screw in the middle of the palatal parts to widen the arch for the narrow arch cases (**Figure 1**).

In the cases of the overjet less than 6 mm, the mandible was positioned forward with the upper and lower incisor edge to edge. In the other hand, a two-step activation was suggested when overjet exceed 10 mm due to the temporomandibular joint (TMJ) condyle did not adapt to the upper and lower incisor edge to edge position.

There should be a 2-mm distance between the edge of the upper and lower incisors, and 4-5 mm distance in the posterior area. Two hooks mesial to the upper canines were used to ligate to the J hook and the headgear. The angle of the high pull traction was directed through the center of resistance of the upper arch and the maxilla. Each side of the J hook uses approximately 500 g force. The patients were instructed to wear the activator and the J Hook headgear for more than 12 hours a day.

Group HA used the activator combined with a high-pull headgear as Weiland's described [9], containing tubes that are embedded in the acrylic, which are then used to insert a conventional headgear bow at the level of the second premolars. 500 g was applied in each side, and the point of force application on the headgear bow was more backward than that in the MA group. In addition, the construction bite of the molars left sufficient interocclusal space to allow the lower premolars and molars to erupt, which was different from the MA group.

The goal of the two approaches was to correct the deep overjet and the canine relationship, level the excessive curve of Spee, inhibit the growth of the maxilla forward, and strengthen the tension of the lips' muscle. The treatment duration ranged from 0.5 to 1 year.

Lateral standardized cephalograms were obtained from all patients before and after the functional treatment and then measured by the same doctor with the Dolphin software (GAC International, Inc., Bohemia, New York, USA). The results were repeated twice to determine the measurement error, which was supposed to be 0.994 or above for all of the parameters. Finally, a paired-sample *t* test was performed to evaluate the treatment results for the groups and intergroup comparison. The treatment changes included the following four groups: the maxilla, the mandible, the maxilla-mandible relationship, and the soft tissue changes. The measurements of the cephalograms were shown in **Figure 2**. Definitions relating to the angular and linear measurements are listed as follows:

Angular measurements (in degrees): SNA: angle of the nasion-sella line (S-N) and the nasion-subspinale line (N-A); SNB: angle of the nasion-

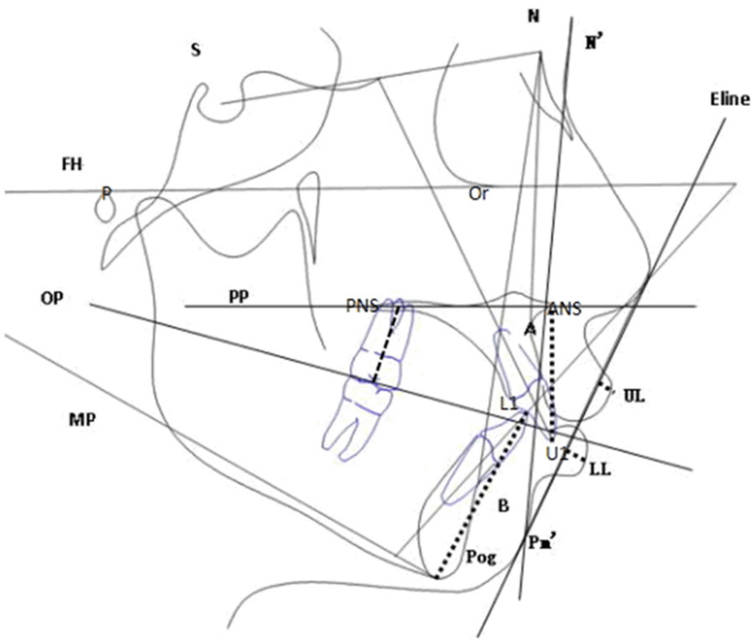

Figure 2. The measurements of the cephalograms.

Table 1. Treatment changes of selected cephalometric variables in the MA group

Variables	Pre-Treatment		Post-Treatmen		Difference		P
	Mean	SD	Mean	SD	Mean	SD	
SNA (°)	79.71	3.11	79.5	2.94	-0.21	0.71	0.16
SNB (°)	74.2	2.79	75.98	2.66	1.78	0.89	<0.001
ANB (°)	5.51	0.96	3.51	1.04	-2	0.86	<0.001
U1-NA (mm)	6.09	0.73	3.49	1.4	-2.6	1.5	<0.001
U1-SN (°)	107.91	3.95	99.51	2.86	-8.4	2.94	<0.001
U1-PP (mm)	32.35	1.47	31.83	1.55	-0.52	0.65	0.00077
U6-PP (°)	110.39	2.52	116.77	2.77	6.32	2.67	<0.001
OP-SN (°)	25.05	2.64	23.43	2.2	-1.62	1.44	<0.001
L1-MP (°)	99.8	2.35	99.39	1.91	-0.43	1	0.047
L1-MP (mm)	42.73	1.58	42.05	1.66	-0.68	0.84	<0.001
MP-SN (°)	36.71	3.15	35.38	3.01	-1.34	1.18	<0.001
MP-FH (°)	29.06	2.51	28.42	2.46	-0.64	0.75	<0.001
NP_FH (°)	80.78	1.27	82.57	1.3	1.78	0.41	<0.001
U-Eline (mm)	4.63	0.64	2.03	1.02	-2.6	1.12	<0.001
L-Eline (mm)	5.77	1	2.81	1.21	-2.96	1.02	<0.001
np-fh (°)	83.63	1.64	86.21	1.62	2.59	0.86	<0.001

sella line (S-N) and the nasion-supramental line (N-B); ANB: angle of the nasion-subspinale line (N-A) and the nasion-supramental line (N-B); U1-SN: infero-posterior angle of the upper incisor long axis and the nasion-sella line; U6-PP: infero-anterior angle of the upper first molar long axis and the PP plane (ANS-PNS); OP-SN: anterior angle of the occlusal plane and the nasion-sella line (S-N); L1-MP: supero-posterior angle of the lower incisor long axis and mandibular plane (Go-Gn); MP-SN: anterior angle of the mandibular plane (Go-Gn) and the nasion-sella line (S-N); MP-FH: anterior angle of the mandibular plane (Go-Gn) and the Frankfort horizontal plane (P-Or); NP-FH: infero-posterior angle of the nasion-pogonion(N-Pog) line and the Frankfort horizontal plane (P-Or); np-FH: infero-posterior angle of the nasion of soft tissue-pogonion of soft tissue(N'-Pm') line and the Frankfort horizontal plane (P-Or); Linear measurements (in millimeters): U1-NA: the vertical distance from U1 to the nasion-subspinale line (N-A); U1-PP: the vertical distance from U1 to the PP plane (ANS-PNS); L1-MP: the vertical distance from L1 to the mandibular plane (Go-Gn); UL-Eline: the vertical distance from UL to the Eline; LL-Eline: the vertical distance from LL to the Eline.

Results

Statistical analysis of the pre-treatment and the post-treatment of the two groups and intergroup comparison are presented in **Tables 1-3**. The cephalogram's comparison before and after the treatment in the two groups is shown in **Figure 3**.

Maxilla changes

In the MA group, the angle of the SNA did not increase (*P*=0.16), the distances of U1 to NA and U1-PP decreased (*P*<0.001), and the axis angle of the molars (U6-PP) increased (*P*<0.001).

In the HA group, the angle of the SNA also did not increase (P=0.16), the distance of U1 to NA decreased (P≤0.001), and the distance of U1 to PP did not change significantly (P=0.7). The axis

Table 2. Treatment changes of selected cephalometric variables in the HA group

Variables	Pre-Treatment		Post-Treatment		Difference		P
	Mean	SD	Mean	SD	Mean	SD	
SNA (°)	79.15	2.62	79	2.72	-0.15	0.41	0.08
SNB (°)	74.21	2.56	75.38	2.57	1.17	0.52	<0.001
ANB (°)	4.95	0.5	3.63	0.56	-1.32	0.65	<0.001
U1-NA (mm)	5.85	0.65	2.97	0.92	-2.89	1.34	<0.001
U1-SN (°)	107.69	2.72	99.84	2.25	-7.85	3.2	<0.001
U1-PP (mm)	32.35	1.47	32.56	1.19	0.02	0.21	0.7
U6-PP (°)	110.25	2.41	115.29	2.7	5.05	2.75	<0.001
OP-SN (°)	24.68	1.96	28.7	1.75	4.01	0.56	<0.001
L1-MP (°)	99.55	1.84	99.58	1.81	0.03	0.2	0.048
L1-MP (mm)	42.21	1.32	42.25	1.3	0.03	0.16	0.38
MP-SN (°)	36.62	2.8	36.74	2.81	0.02	0.16	0.004
MP-FH (°)	29.05	2.09	29.12	2.07	0.21	0.13	0.006
NP_FH (°)	82.78	1.6	83.21	1.62	1.03	0.2	<0.001
U-Eline (mm)	4.58	0.63	3.07	0.68	-1.51	0.46	<0.001
L-Eline (mm)	5.78	1.09	4.60	0.95	-1.18	0.31	<0.001
np-fh (°)	84.13	1.48	85.32	1.6	1.19	0.35	<0.001

Table 3. Intergroup comparison of the mean differences

Variables	MA Group		HA Group		P
	Mean	SD	Mean	SD	
SNA (°)	-0.21	0.71	-0.15	0.41	0.7
SNB (°)	1.78	0.89	1.38	0.57	0.06
ANB (°)	-2	0.86	-1.53	0.65	0.04
U1-NA (mm)	-2.6	1.5	-2.89	1.34	0.49
U1-SN (°)	-8.4	2.94	-7.85	3.2	0.53
U1-PP (mm)	-0.52	0.65	0.02	0.21	<0.001
U6-PP (°)	6.32	2.67	5.05	2.75	0.14
OP-SN (°)	-1.62	1.44	4.01	0.56	<0.001
L1-MP (°)	-0.43	1	0.03	0.2	0.04
L1-MP (mm)	-0.68	0.84	0.03	0.16	<0.001
MP-SN (°)	-1.34	1.18	0.13	0.28	<0.001
MP-FH (°)	-0.64	0.75	0.21	0.13	<0.001
NP_FH (°)	1.78	0.41	1.03	0.2	<0.001
UL-Eline (mm)	-2.6	1.12	-2.43	1.06	0.67
LL-Eline (mm)	-2.96	1.02	-2.67	0.94	<0.001
np-fh (°)	2.59	0.86	1.19	0.35	<0.001

angle of the molars (U6-PP) increased ($P<0.001$) as well.

Mandibular changes

In the MA group, the angle of the SNB increased ($P<0.001$), the facial angle increased (NP-FH° $P<0.001$), and the mandible was growing forward after the treatment. The lower incisors were intruded (L1-MP mm $P<0.001$) while remained in the same position (L1-MP° $P<0.05$). Therefore, the overjet reduction appeared to be primarily achievement by retraction of the upper incisors.

In the HA group, the angle of the SNB and the facial angle increased (NP-FH° $P<0.001$). The lower incisors were not intruded (L1-MP mm $P=0.38$) while remained in the same position (L1-MP° $P<0.05$).

The maxilla-mandible changes

In the MA group, the angle of the ANB decreased ($P<0.001$) and the mandibular plane angle (MP-SN and MP-FH) decreased ($P<0.001$). In addition, a significant anticlockwise rotation of the occlusal plane occurred (OP-SN, $P<0.001$).

In the HA group, the angle of the ANB decreased ($P<0.001$). The mandibular plane angle (MP-SN and MP-FH) increased ($p<0.01$). In contrast to the MA group, the occlusal plane rotated clockwise ($P<0.001$).

The soft tissue changes

In the MA group, the upper and lower tips were both retracted (UL-Eline, LL-Eline, $P<0.001$), and the facial angle of the soft tissue increased (FH-N'Pm' $P<0.001$).

In the HA group, the upper and lower tips were also both retracted (UL-Eline, LL-Eline, $P<0.001$), and the facial angle of the soft tissue also increased (FH-N'Pm' $P<0.001$).

Intergroup contrast

In the maxilla, there was no significant difference in the changes of SNA, U1-NA (mm), U1-SN, and U6-PP between the two groups. However, the changes in U1-PP showed that the MA intervention can intrude the upper frontal teeth while the HA intervention cannot ($P<0.001$). In the mandible, there was no significant difference in the changes of SNB, but the variables L1-MP (mm) and NP_FH (°) LL-Eline

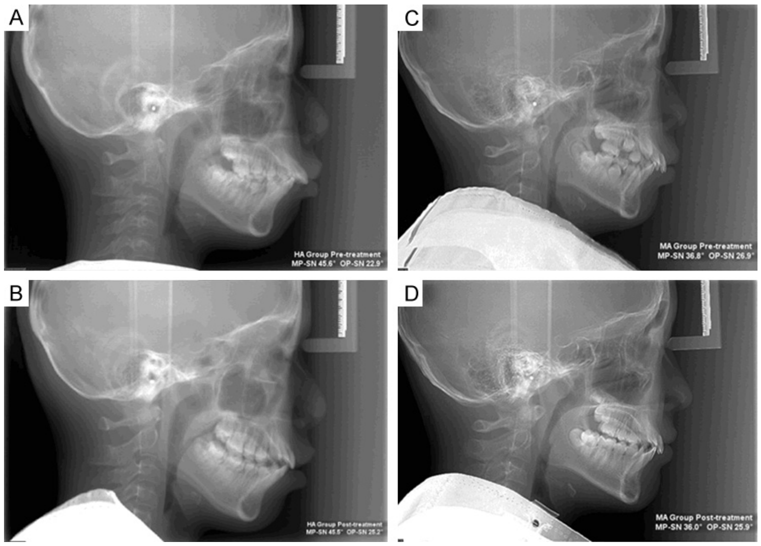

Figure 3. The comparison of the cephalograms before and after the treatment in the Two groups (A and B is the MA Group; C and D is the HA Group).

(mm) showed the significant differences (P<0.001). The MA intervention can intrude the frontal teeth and rotate the mandible anticlockwise, which was also confirmed by the changes of the OP-SN (°), MP-SN (°), and FH-N'Pm' (°) (P<0.001).

Discussion

Maxilla prognathic and/or retrognathic mandible may contribute to the class II malocclusion, but the most common reason is mandibular skeletal retrusion [10, 11]. Therefore, counterclockwise rotation of the mandible is a desired way to solve both the vertical and the sagittal problems.

In the two groups, the angle of the SNA did not change, indicating that both approaches can inhibit the growth of the maxilla to a certain degree with 500 g orthopedic force on each side that crossed through the resistance center of the maxilla. The outcome is similar to the other studies [12-15], although some other scholars have found little or no orthopedic effect from an activator [16, 17] and activator headgear treatment [18].

Both approaches could retract the maxillary frontal teeth, and no statistically significant difference was found between them. However, we found that the frontal teeth of the maxilla (U1-pp, mm) were intruded (P<0.001) after the treatment in the MA group, but not in the HA group. The finding was contrary to the results of Altenburger's study [19]. We assumed that the discrepancy was due to the different ligated position of the extraoral force. With the assistant of the J hook of the modified activator, the frontal teeth of the MA group were retracted and intruded, and then the pendulum-like effect was controlled. While in the HA group, the tubes connected to headgear bow were embedded at the level of the second premolars, far away from the frontal teeth, so there was no intrusion. The space of the retraction came from the leeway space and the distal-inclination of the molars.

After the treatment, the angle SNB of the two groups increased (P<0.001), and no statistically significant difference was found between two groups. Unlike maxillary growth, the scholars agreed that the activator may promote mandibular growth [20, 21].

In the MA group, the lower incisors were intruded (L1-MP mm P<0.001). Some other studies have reported that the mandibular incisors protruded after the activator headgear treatment [22, 23]. The variable L1-MP° (P<*0.05*) showed that the lower incisors stayed in the same position on the whole. The modified appliance covered half of the labial surface of the lower incisors with no connection to the lingual surfaces of the lower incisors. Therefore, the lower frontal teeth could be leveled vertically without protruding. The space of the leveling originated at the leeway space.

The most important aspect of the treatment of hyperdivergent class II malocclusion is vertical control. Fushima and his coworkers [24] proposed that the retruded mandible with backward rotation was accompanied by steep cant of the posterior occlusal plane and short vertical height of the upper molars. But Ye and his coworkers [25] pointed out that the steeper cant of the occlusal plane was contributed to an excessive height of the maxillary incisors. In this study, we found that the angles MP-SN and MP-FH of the MA group were both reduced after the treatment (P<0.001), and the inclination of the occlusal plane (OP-SN) was decreased (*P*<0.001). This means that the mandible had rotated forward and upward in the desired way. In contrast, the angles MP-SN and FH-SN of the HA group were increased, which finding was contrary to the results of previous studies [9, 12]. Furthermore, the inclination of the occlusal plane (OP-SN) in the HA group turned out to be steeper (*P*<0.001), which was similar to Türkkahraman's research [26]. The difference is due to the varied method of the construction bite. In the MA group, with the intrusion of the frontal teeth and/or the elongation of the upper molars, occlusal plane turned to be flat. In the HA group, the construction bite of the molars was affected by the erupt of the lower molars, so the occlusal plane rotated clockwise. Ye and his coworkers [25] interpreted the association between counterclockwise rotation of the mandible and reduction of occlusal plane canting by the hinge structure of the temporomandibular complex. The intrusion of the anterior teeth provided the space for the mandible rotation. Lamarque [27] emphasized the importance of the controlling of the occlusal plane to enhance the response of the mandible to the treatment. If the occlusal plane was turned to be flat, the vertical component of the growth vector was reduced, while the forward part (mandible response [28]) was increased, which facilitated facial balance and harmony.

After the treatment, the profiles of all patients were improved in both groups. In cephalometries, improvements in the soft tissue profile manifested as the distance of the UL-Eline and LL-Eline decreased (*P*<0.001). This was in part due to the retraction of the upper frontal incisors. We also found that patients in the MA group had a better chin and lip outline than the patients in the HA group because of the anticlockwise rotation of the mandible and the occlusal plane (UL-Eline, LL-Eline, FH-N'Pm', *P*<0.001).

Conclusions

The results of this study indicated that therapy with a combination of activator and J hook headgear is effective in treating the hyperdivergent class II malocclusions during the late mixed teeth period. Compared to the headgear activator, the modified one had the following advantages:

1. Both the frontal teeth can be leveled, which was very useful in the treatment of hyperdivergent class II malocclusion, especially in cases with excessive growth of the frontal maxilla. 2. The mandible can be motivated to rotate forward and upward. 3. Achieve a better chin and lip outline.

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Disclosure of conflict of interest

None.

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