ORIGINAL ARTICLE

Skeletal and dental components of Class II correction with the bionator and removable headgear splint appliances

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Introduction: The purpose of this study was to differentiate the dentoalveolar and skeletal effects to better understand orthodontic treatment. We evaluated the treatment changes associated with the bionator and the removable headgear splint (RHS). **Methods:** The sample comprised 51 consecutively treated Class II patients from 1 office who had all been successfully treated with either a bionator (n = 17) or an RHS appliance (n = 17). Class II patients waiting to start treatment later served as controls (n = 17). A modified version of the Johnston pitchfork analysis was used to quantify the dentoalveolar and skeletal contributions to the anteroposterior correction at the levels of the molars and the incisors. **Results:** Both appliances significantly improved anteroposterior molar relationships (2.15 mm for the bionator, 2.27 mm for the RHS), primarily by dentoalveolar modifications (1.49 and 2.36 mm for the bionator and the RHS, respectively), with greater maxillary molar distalization in the RHS group. Overjet relationships also improved significantly compared with the controls (3.11 and 2.12 mm for the bionator and the RHS, respectively), due primarily to retroclination of the maxillary incisors (2.2 and 2.38 mm for the bionator and the RHS, respectively). The differences between overall corrections and dentoalveolar modifications for both molar and overjet relationships were explained by skeletal responses, with the bionator group showing significantly greater anterior mandibular displacement than the RHS group. **Conclusions:** The bionator and the RHS effectively corrected the molar relationships and overjets of Class II patients primarily by dentoalveolar changes. (Am J Orthod Dentofacial Orthop 2008;134:732-41)

Early Class II treatment is typically accomplished by using either headgear or functional appliances.[1-16] Functional appliances, which focus treatment on the mandible, are based on the premise that mandibular deficiency is responsible for the malocclusion.[17] Headgear treatments aim to redirect maxillary growth, assuming that therapeutic control of the maxilla is easier and more predictable than that of the mandible.[18,19] Independently of the way they act on the jaws, both approaches should produce dentoalveolar effects because the appliances are supported by teeth, rather than bone. Their actual effects remain controversial because studies typically do not distinguish between dental and skeletal components of the correction. Although it was originally thought that mandibular growth was enhanced by treatment with activators,[20,21] more current reports support substantial dentoalveolar effects and redirection of condyle growth.[3,10,22] In spite of increases in overall mandibular length, the chin is usually not displaced anteriorly more with functional appliances than without treatment.[23] Whereas headgears reportedly hold the maxillary base in place as the mandible grows anteriorly,[5,6,8,12,13,16,24,25] predominantly dentoalveolar effects have also been reported.[26,27] Investigations specifically designed to compare the skeletal and dental effects of headgears and bionators are limited and controversial, reporting both differences[8] and similarities.[27]

To date, the relative dental and skeletal effects of the removable headgear splint (RHS) and the bionator have not been compared. Removable splints, which distribute the headgear force over many teeth, have hygienic and biomechanical advantages. They facilitate cleaning by eliminating bands and prevent spaces, which typically occur when headgear forces are applied to the molars only. The use of a splint rather than bands connected to the molars was originally suggested by

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Table I. Sample characteristics

Group	Boys (n)	Girls (n)	Age at T1 (y)		Age at T2 (y)		Interval (T2-T1) (y)	
			Average	Range	Average	Range	Average	Range
Controls	8	9	8.90	6.67-12.30	10.30	7.84-12.72	1.40	0.42-3.55
Bionator	8	9	8.22	6.46-10.56	9.87	7.62-13.88	1.65	0.95-3.32
RHS	4	13	8.61	6.91-10.31	10.31	8.61-12.46	1.70	0.90-2.94

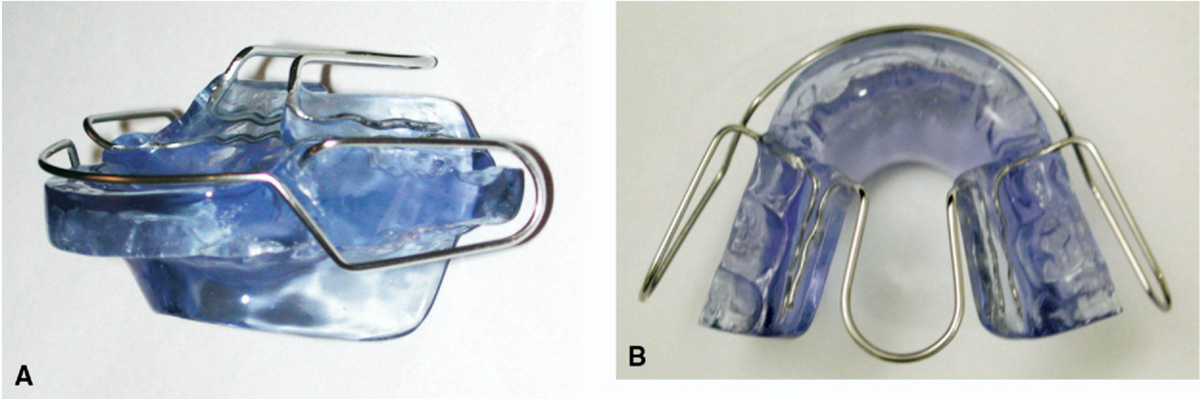

Fig 1. Bionator used in this investigation.

Thurow[18]; the original appliance was shown to restrain maxillary growth, distally tip and displace the maxillary teeth, and restrain the eruption of the posterior maxillary teeth.[2,28]

The RHS was fashioned after the appliance introduced by Joffe and Jacobson[19] and takes advantage of some features of the original Thurow appliance. It also has additional options, including a lingual shield for tongue thrust and a screw for expansion. The RHS was designed to be used for vertical and anteroposterior (AP) control of the maxilla and the maxillary molars. It is thought to more easily adapt to occlusal changes than the Thurow appliance because it does not cover the anterior teeth with acrylic.

A major limitation of traditional cephalometric studies has been their inability to determine the relative skeletal and dental contributions to Class II correction. For example, studies using A-point to measure maxillary position and displacement can be misleading (ie, overestimate true orthopedic effects) because A-point is modified by changes of incisor position.[26,29] Composite measures such as the SNA and SNB angles, which are typically used for quantifying maxillary and mandibular treatment changes, include both dental and skeletal effects. In addition, these measurements summarize the movements of at least 3 landmarks; this could mask actual maxillary and mandibular changes.[30] The Johnston[30] pitchfork analysis is perhaps best known for quantifying relative treatment changes. More recently, a modified version of this analysis has been used to compare treatment effects.[26] The modifications were deemed necessary because the occlusal plane, used for orientation in the original analysis, often changes during treatment, and the pterygomaxillary fissure, used to quantify maxillary changes, is not truly a stable reference structure.[31]

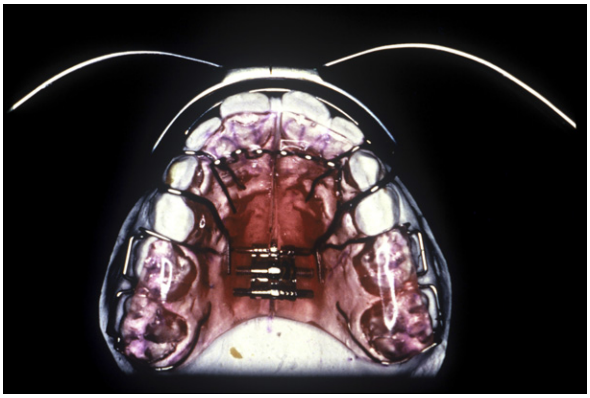

Fig 2. RHS used in this investigation.

Using the modified pitchfork analysis, we designed this investigation to compare the treatment changes associated with the bionator and the RHS

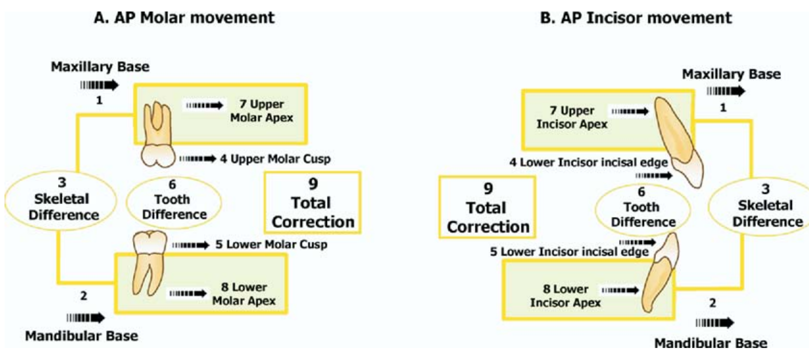

Fig 3. Modified pitchforks for the molar and incisor regions: *upper box* symbolizes the maxilla and *lower box* the mandible.

appliances, and compare them with untreated Class II controls.

MATERIAL AND METHODS

A sample of 51 consecutive patients (Table I) was selected from the private office of 2 authors (J.C.R.M. and L.P.M.). The patients had Class II Division 1 malocclusions before treatment, were treated without extractions, and had good treatment results. Seventeen patients (8 boys, 9 girls), who decided for various reasons to postpone treatment, were used as controls. Seventeen patients (8 boys, 9 girls) were treated with a bionator, and the remaining 17 (4 boys, 13 girls) were treated with the RHS appliance. All patients were treated before their growth spurts.

The bionator appliance (Fig 1), based on that described by Balters[32] and adapted by Ascher,[33] had the lingual portion of the acrylic in the mandibular arch extended apically 2 to 3 mm more than originally recommended to provide a better skeletal effect. Anteriorly, the acrylic touched the alveolar process and extended over the edges of the incisors, covering a small portion of the labial surface. The buccal shield served as an active element if needed. The construction bite was taken into an edge-to-edge relationship of the maxillary and mandibular incisors, regardless of the amount of overjet. The patients were instructed to use the device for at least 16 to 18 hours a day. Once correction was achieved and confirmed by mandibular manipulation, they used the bionator only during sleep, 8 to 10 hours a day. Patients were seen monthly for any necessary adjustments.

The RHS group was treated with an appliance composed of an acrylic plate, 2 double Adams clasps, a vestibular arch (both made with 0.7-mm stainless steel wires), an extraoral arch fixed to the acrylic, and an expansion screw at the level of the second deciduous molars (Fig 2). The acrylic plate extended laterally and occlusally, covering the cusps and approximately one-third of the molars' buccal surfaces. Anteriorly, it extended to the lingual aspect of the incisors, leaving the incisal edges free. The acrylic was 1 to 1.5 mm deep (Fig 2). It was based on the appliances introduced by Joffe and Jacobson[19] and was similar to the one described by Castanha Henriques et al.[4] If expansion was needed, the screw was activated twice a week (0.5 mm of expansion) during the first month and once a week (0.25 mm) thereafter for as long as needed. The buccal arch was used to correct mild diastemas or inclinations when needed. The outer bow of the extraoral arch was adjusted so that the elastics' line of force passed through the first and second deciduous molars anteroposteriorly and between the lower margin of the orbitale and the apex of the first molar vertically, which is thought to be the maxilla's center of resistance.[34,35] This high-pull headgear delivered approximately 300 to 400 g of force per side and was worn 16 to 18 hours a day (removed only during school). When correction was achieved, the patients used the headgear for 8 to 10 hours during sleep. They were seen monthly so that the splints could be adjusted and ground for retention and stability as needed.

Cephalometric method

Standardized lateral cephalograms were taken at the beginning of treatment (T1) and the end of treatment (T2). Each radiograph was traced twice, on different occasions, by the same examiner (J.C.R.M.) using Dentofacial Planner Plus software (Dentofacial Planner, Toronto, Ontario, Canada). For the modified pitchfork analysis, 14 cephalometric landmarks were digitized twice on each tracing. Six landmarks represented the anterior and posterior fiducial registrations of the cranial base, the maxilla, and the mandible. The other 8 landmarks described the positions of the maxillary and mandibular molars and incisors, including cusps and apices. Eight dentoalveolar measurements were calculated from the landmarks, including SNA, SNB, ANB, mandibular plane angle (MPA), Wits appraisal, interincisal angulation (U1/L1), maxillary incisor to palatal plane (U1/PP), and mandibular incisor to mandibular plane (L1/MP). Replicate analysis showed that systematic errors were 0.04 to 0.84 mm; random method errors[36] were 0.23 to 0.52 mm for the digitations and 0.09 to 0.44 mm for the tracings.

All the changes were oriented parallel to a reference line at –7° from the sella-nasion plane. Overall tooth movements were calculated based on the tracings superimposed on the stable cranial base structures, as described by Björk and Skieller.[37] To determine the actual movements of the incisors and the molars, maxillary and mandibular superimpositions were performed as described by Björk and Skieller.[37,38] Tooth movements were subtracted from the overall tooth movements to estimate the movements of the skeletal bases.

A modified version of the Johnston pitchfork diagram was used to analyze tooth and skeletal movements (Fig 3). Components 1 and 2 described the AP movement of the maxillary and mandibular skeletal bases, respectively, and component 3 described their differences. Similarly, components 4 and 5 described AP tooth movements in the maxilla and the mandible, respectively (molar cusps or incisors' incisal edge), and component 6 described their differences. Components 7 and 8 described the AP movements of the apices in the maxilla and the mandible, respectively. The total correction was represented by component 9, calculated as the sum of components 3 and 6. Changes in position favorable to the correction of a Class II malocclusion were given positive signs, and changes that worsened the malocclusion were given negative signs.

The measures were transferred to SPSS software (version 12.0, SPSS, Chicago, Ill) for evaluation. Preliminary tests showed that some variables were not normally distributed. Thus, medians and interquartile ranges were used to describe some variables. Group comparisons were made by using analysis of variance (ANOVA) when the variables were normally distributed, and the Kruskal-Wallis test when they were not Changes of time were evaluated with paired *t* tests (for normal distributions) and Wilcoxon tests (not normally distributed). A probability level of 0.05 was used to determine statistical significance.

RESULTS

In terms of the group comparisons at T1, even though SNA, SNB, Wits appraisal, and U1/L1 were similar among the 3 groups, ANB ($P = 0.03$) and MPA ($P < 0.001$) showed between-group differences (Table II). ANB was comparable for the control and the RHS groups; both differed significantly ($P = 0.03$) from the bionator group. The MPA of the RHS and the bionator groups also differed significantly ($P < 0.001$). The treatment changes showed significant group differences for all variables except for MPA and L1/U1. The ANB angle and Wits appraisal decreased similarly for the 2 treatment groups; both were significantly different from the controls ($P = 0.006$ and $P < 0.001$, respectively). The RHS group showed significantly different changes for SNA, whereas the bionator group had a significantly different pattern of change for SNB. The bionator group also demonstrated significantly greater increases in L1/MP than did the other groups. Both treatment groups had decreases in U1/PP that were significantly different from the controls.

The bionator produced an overall 2.41-mm correction of molar relationships (Fig 4, Table III). Basal bone modifications were responsible for 0.82 mm (34%) of the total correction, with the maxilla and the mandible moving forward 0.65 and 1.47 mm, respectively. Dentoalveolar movements accounted for 1.59 mm, or 66%, of the correction. Although maxillary molar movement was not statistically significant ($P > 0.05$), the mandibular molar moved mesially by 1.18 mm. Compared with the untreated controls, bionator treatment produced a significant ($P < 0.001$) 2.15-mm overall correction of the molar relationship, due primarily to dentoalveolar changes (1.49 mm, or 69%). The maxillary molars moved distally 0.9 mm, and the mandibular molars tended to move mesially slightly more than expected (0.59 mm), although these differences were not statistically significant. The 0.66-mm (31%) correction of the basal bone relationships was small and statistically insignificant.

The RHS and the bionator produced similar amounts of overall correction (2.53 vs 2.41 mm) of the molar relationships (Fig 5; Table III). Basal bone modifications accounted for an insignificant 3% of the RHS correction. Ninety-seven percent of the correction was due to dentoalveolar movements (2.46 mm). The maxillary molar moved distally 1.65 mm; this was significantly ($P < 0.001$) more than the distal movement produced by the bionator, and the mandibular molar moved mesially 0.81 mm. Compared with the untreated controls, RHS treatment produced a signifi-

Table II. Descriptive statistics and group comparisons at T1 and from T1 to T2

	T1						
	Controls		*Bionator*		*RHS*		
Variable	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	P
SNA (°)	82.67	2.01	82.28	2.08	82.03	4.47	0.85
SNB (°)	76.31	2.72	77.17	3.48	75.17	4.14	0.25
ANB (°)	6.37	1.59	5.11	2.34	6.85	1.75	0.03*
Wits (mm)	3.59	2.01	4.22	2.28	3.64	2.20	0.64
MPA (°)	34.78	4.46	29.79	6.18	36.54	3.98	<0.001*
L1/U1 (°)	113.87†	110/118	116.25†	110/119	112.50†	104/119	0.67
L1/MP (°)	97.27	4.86	98.27	5.00	97.91	7.83	0.89
U1/PP (°)	119.55	4.48	122.60	5.19	120.71	4.33	0.17

*Significant group differences; †medians and interquartile ranges.

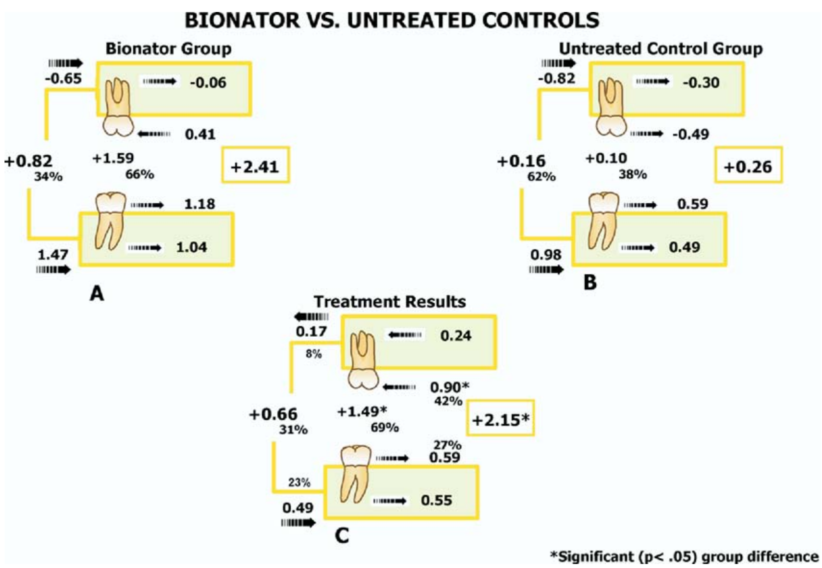

Fig 4. Modified pitchforks of the posterior region for **A,** bionator; **B,** controls; **C,** treatment changes.

cant (2.27 mm) correction of the molar relationships, due primarily to dentoalveolar changes (2.36 mm). The maxillary molar crowns moved distally 2.14 mm, accounting for 94% of the dentoalveolar correction. The maxillary molar apex was also displaced distally 0.73 mm. The mandibular molars moved mesially, with the apex displaced mesially (0.56 mm) significantly more than the cusp (0.22 mm).

The bionator produced an overall overjet change of 3.63 mm, with approximately 25% (0.92 mm) of the correction due to basal bone modifications (Table III and Fig 6). Dentoalveolar movements accounted for 2.71 mm, or 75%, of the correction. The maxillary incisors were retroclined (1.56 mm) significantly, and the mandibular incisors were proclined 1.15 mm, but this change was not statistically significant. Compared with the controls, bionator treatment produced a significant 3.11 mm of overjet correction, due primarily to dentoalveolar changes (2.70 mm, or 87%). The maxillary incisors were retroclined 2.20 mm (71% of the total treatment effect). The 0.41 mm of basal bone correction was small and statistically insignificant.

Overjet was corrected by 2.64 mm with the RHS. Basal bone modifications were responsible for only 0.22 mm, or 8%, of the correction; this was insignificant. The mandible moved anteriorly only 0.62 mm with the RHS; this was significantly (P = 0.025) less than the anterior movement produced by the bionator. Dentoalveolar changes accounted for 2.42 mm (92%) of the correction. The maxillary incisors were retroclined 1.74 mm, and the mandibular incisors were proclined 0.68 mm. Compared with the controls, the RHS produced a significant 2.12 mm of correction of the incisal relationship because of the dentoalveolar

Table II. Continued

T1-T2						
Controls		Bionator		RHS		
Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	P
0.00	0.88	−0.32	0.61	−0.86	0.64	0.004*
0.29†	0.07/0.57	0.76†	0.19/0.99	0.36†	0.33/0.70	0.03*
−0.30	0.65	−1.19	0.92	−1.01	0.83	0.006*
0.04†	−1.17/0.79	−2.19†	−3.00/−1.39	−1.33†	−2.99/−0.15	<0.001*
−0.24	0.82	0.39	1.13	−0.03	1.28	0.23
0.48†	−1.91/2.57	4.12†	2.07/5.13	6.72†	2.02/14.27	0.29
0.73	2.42	1.56	2.15	0.99	2.67	0.01*
0.07†	−2.23/1.05	−5.08†	−6.63/−3.00	−4.44†	−10.59/−1.45	<0.001*

Table III. Skeletal and dental changes in molar relationships and positions in patients treated with the bionator and the RHS and the untreated controls

	Bionator		RHS		Control		Bionator vs control	RHS vs control	Bionator vs RHS
Variable	*Average*	*SD*	*Average*	*SD*	*Average*	*SD*	*Significance*		
Molars									
Maxillary									
Osseous base	−0.65	0.71	−0.42‡	1.29	−0.82	0.64	0.462	0.236	0.513
Apex	−0.06‡	1.01	0.43	0.91	−0.30‡	0.80	0.448	0.011*	0.115
Cusp	0.41‡	1.08	1.65†	1.86	−0.49	0.81	0.008*	<0.001*	0.004*
Mandibular									
Osseous base	1.47	1.21	0.49‡	1.40	0.98	0.97	0.196	0.213	0.027*
Apex	1.04	1.29	1.05	0.81	0.49	0.77	0.136	0.030*	0.983
Cusp	1.18	1.02	0.81	0.62	0.59	0.81	0.066	0.340	0.159
Incisors									
Maxillary									
Osseous base	−0.67	0.77	−0.40‡	1.11	−0.56	0.81	0.682	0.618	0.399
Apex	−0.81	0.97	−0.55	0.78	−0.77	0.63	0.882	0.325	0.342
Incisal Edge	1.56	1.04	1.74†	1.93	−0.64†	0.89	<0.001*	<0.001*	0.318
Mandibular									
Osseous base	1.59	1.19	0.62	1.38	1.07	1.12	0.191	0.265	0.025*
Apex	0.20‡	0.55	0.60	0.70	0.42	0.41	0.183	0.328	0.054
Incisal Edge	1.15	0.74	0.68†	0.68	0.65	0.72	0.053	0.660	0.098

*Significant group differences; †median; ‡no significant changes over time.

changes (2.41 mm). The maxillary incisors were retroclined significantly by 2.38 mm (controlled tipping), and the mandibular incisors maintained their position (Figs 7 and 8; Table III).

DISCUSSION

Compared with the controls, the RHS did not produce a significant orthopedic effect. A lack of orthopedic effects with headgear treatment has been previously reported.[26,27] Orthopedic effects have also been reported with headgear splints[2,28,39] and headgears connected to banded molars.[5,6,8,12,13,16,24,25] However, most studies reporting orthopedic effects used A-point to measure maxillary position; this can be misleading.[26,29] Our data support this notion because the SNA difference identified between the RHS and the control groups (Table II) was actually dentoalveolar rather than skeletal (Fig 5 and Table III). This emphasizes the importance of using methods that distinguish between dental and skeletal components of correction. The lack of difference in skeletal effects between our RHS and control groups might have been due to small treatment effects associated with the lack of power. Post-hoc analyses showed that our power was insufficient to rule out type II errors. Differences across studies could also be explained by the timing of intervention,[40] biomechanical factors such as the line of action of the headgear force,[12,24,41] and the headgear

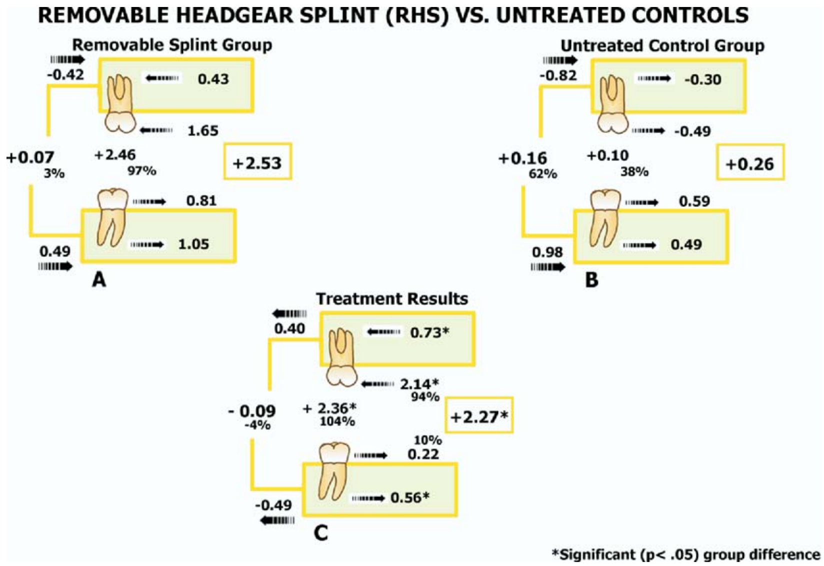

Fig 5. Modified pitchforks of the posterior region for **A,** RHS; **B,** controls; **C,** treatment changes.

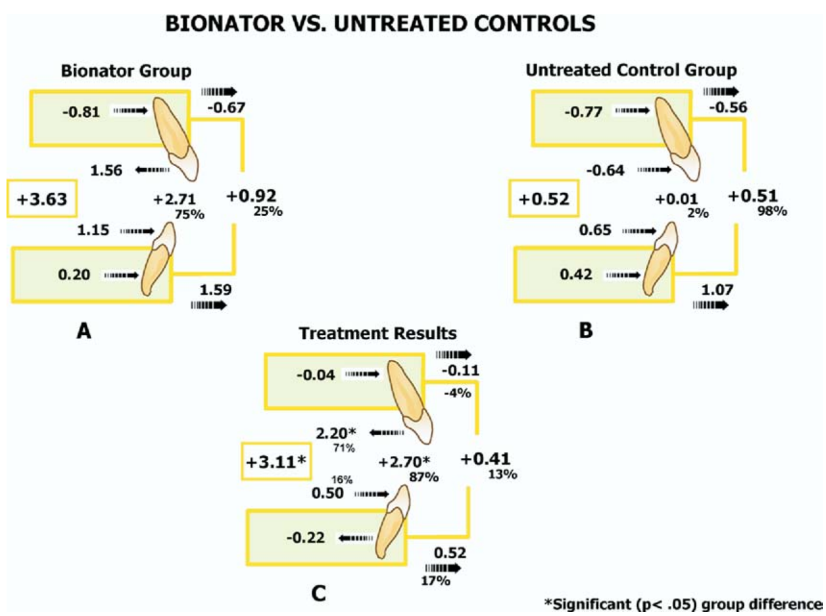

Fig 6. Modified pitchforks of the anterior region for **A,** bionator; **B,** controls; **C,** treatment changes.

attachments (connected to the molars alone vs splints vs archwires). Even if orthopedic effects were produced by the RHS, they were small.

The bionator also did not produce significant orthopedic effects. This is consistent with randomized clinical trials showing no clinically significant mandibular orthopedic effects with functional appliances.[6,10,11,42] Although elongation of the mandible was previously reported with various functional appliances,[1,14-16,27,43] anterior repositioning of the mandible remains controversial (systematic review of Cozza et al[3]). Elongation does not necessarily produce AP corrections because functional appliances tend to rotate the mandible downward.[14,21,44] When orthopedic effects were reported with functional appliances, they have been small and often confounded by tooth movements.[10,21,27] Although our results show a difference between the bionator and the control groups for the SNB angle, there actually were no differences in basal bone movements based on the modified pitchfork analysis. The implications are

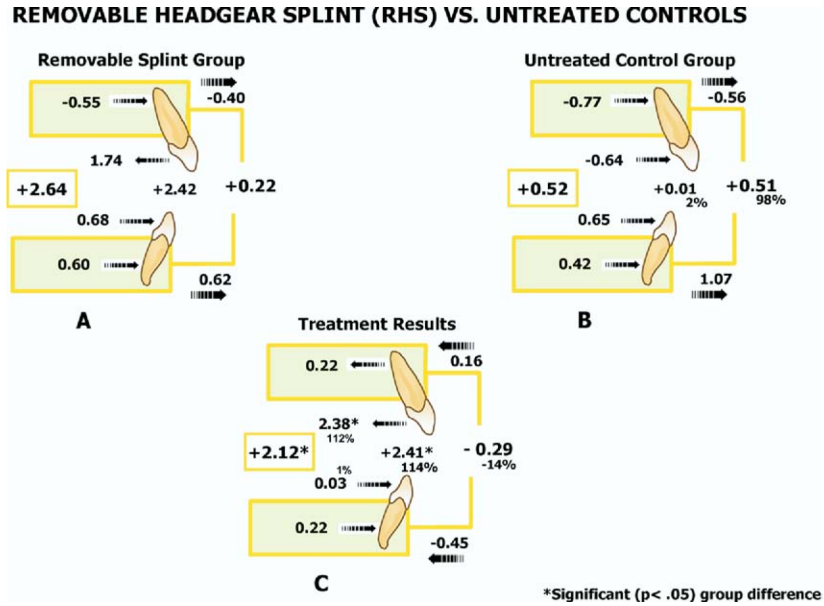

Fig 7. Modified pitchforks of the anterior region for **A,** RHS; **B,** controls; **C,** treatment changes.

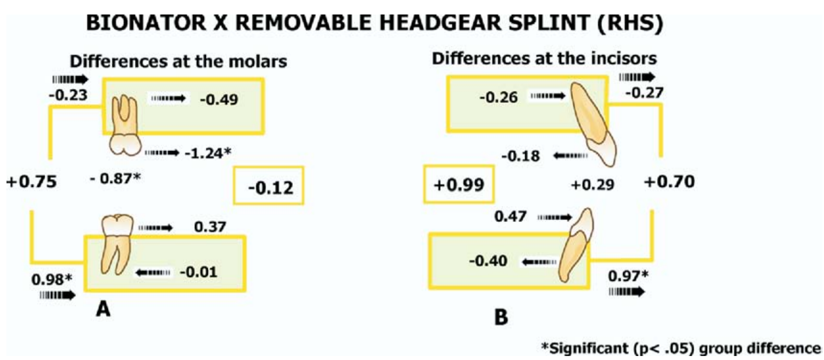

Fig 8. Modified pitchforks of **A,** posterior and **B,** anterior region treatment-change differences between the bionator and the RHS.

that growth redirection or stimulation with functional appliances is also very limited.

Although the treatment effects in each group were small and insignificant compared with the controls, the bionator produced slightly greater forward repositioning of the mandible than the RHS, because the mandible came forward in the bionator group and went back in the RHS group. This could be explained because the 2 treatment groups had different growth patterns. However, Keeling et al[27] reported no differences between bionator and headgear/biteplane treatment for either jaw, whereas Haralabakis et al[8] showed orthopedic differences between headgear and activator treatment in both jaws. Randomized prospective clinical trials that distinguish between dental and skeletal effects are necessary to resolve this controversy.

Although both appliances successfully corrected molar relationships, their effects were primarily dental and distinctly different. The RHS improved the AP dental relationships at the levels of both molars and incisors by dentoalveolar changes. Ninety-one percent of the correction of molar relationship was accomplished by distal movement, associated with some tipping, of the maxillary molars. A predominantly dentoalveolar effect was previously associated with Class II correction with headgear,[26,27] although more limited dentoalveolar effects were also described.[2,8,28,39] Interestingly, all of the studies separating the dental and skeletal components of correction reported predominantly dentoalveolar effects, again emphasizing the influence of the methodology on the interpretation of the results. The RHS corrected overjet by controlled tipping of the maxillary incisors, with no contribution from the mandibular incisors. The original Thurow appliance retroclined the maxillary incisors even more than the RHS because the acrylic maintained the positions of the anterior teeth.[2,28] When the headgear force is oriented anterior to the dentition's center of resistance, the maxillary incisors become proclined.[39] Lack of mandibular incisor proclination was demonstrated with the Thurow headgear splint and other headgear appliances, suggesting that the action of the RHS is limited to the maxillary molars when correcting Class II relationships and to the maxillary incisors when correcting overjet.[2,6,27,28]

Compared with the controls, the bionator also corrected the Class II molar relationship and overjet predominantly by dentoalveolar changes. The maxillary molars were tipped distally, and the mandibular molars tended to be mesially displaced. Dentoalveolar changes accounted for 70% of the correction, two thirds of which was due to the maxillary molars. Bionators have been reported to distalize the maxillary molars,[24] although lack of AP movements have also been reported.[27] Most studies do not provide comparative information because they do not distinguish between the AP skeletal and dentoalveolar changes of the molar. The maxillary incisors were retroclined, accounting for most of the overjet correction (71%). There was also a tendency, albeit insignificant, for some proclination of the mandibular incisors. L1/MPA showed slightly greater proclination in the bionator than in the other groups. Retroclination of the maxillary incisors with bionator/activator therapy was previously established[1,7,14]; most studies also showed mandibular incisor proclination.[1,6,7,11,14,21,45] Because the magnitudes of changes are comparable and our comparisons are based on relatively small sample sizes, the lack of significant retroclination could have been due to lack of power. Since the lingual acrylic extends down farther and covers a third of the buccal surface of the mandibular incisor, the bionator we used might provide better control of mandibular incisor proclination.

Although the RHS had a greater effect on the maxillary molars, the bionator tended to have a greater dentoalveolar effect on the mandibular incisors. The maxillary molars cusps were distalized 4 times as much with the RHS than with the bionator. Although no direct comparisons have been made with the RHS, it has been shown that bionators/activators have less distalizing effect on the maxillary molars than do headgears.[8,24,27] The apices of the maxillary molars also appeared to have moved distally more in the RHS group, indicating translation and possibly greater stability.[9]

Both appliances improved the overjet mainly by lingual tipping of the maxillary incisors. The mandibular incisor edges were proclined approximately twice as much with the bionator than with the RHS. Keeling et al[27] also showed that headgear corrections were due to retroclination of the maxillary incisors and approximately twice as much proclination of the mandibular incisors with the bionator. Importantly, this suggests that bionators could limit molar correction when the proclined mandibular incisors contact the retroclined maxillary incisors.

CONCLUSIONS

1. The bionator corrected the molar relationships and the overjet of Class II patients mostly by dentoalveolar changes.
2. The RHS was successful in correcting the molar relationships and the overjet of Class II patients compared with the controls. The correction was due almost entirely to dentoalveolar changes.
3. The bionator showed significantly greater amounts of anterior mandibular displacement than the RHS group.
4. There was greater maxillary molar distalization in the RHS group than in the bionator group.

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