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Clarifying the mechanism of effect of the Bionator for treatment of maxillary protrusion: A percentile growth study

ABSTRACT

Aim *The reported effects of Bionator treatment in patients with mandibular retrognathism are conflicting. This study evaluated the changes in craniofacial morphology resulting from treatment with a Bionator, based on measurement percentiles previously reported, to clarify the mechanism of the effect of this commonly used functional device.*

Materials and methods *Study Design: Retrospective. Setting: A private orthodontic clinic. Participants: Forty-two children (mean age, 10.13 years) requiring treatment with a Bionator for Class II malocclusion (mandibular retrognathism). Children were randomly assigned to a Bionator group with or without an expansion screw. Measurements on lateral cephalometric radiographs were taken before and upon completion of Bionator treatment. All parameters measured were characterised according to the measurement percentiles previously reported. Each parameter was compared before and after treatment for all patients and for each treatment group using Wilcoxon's test.*

Results *No significant differences in cranial length or mandibular body length were seen in any of the 3 groups, but anterior cranial base length and maxillary length were significantly decreased while mandibular ramus height and mandibular length were significantly increased after treatment in the Bionator with expansion screw group and in the all-patient group.*

Conclusions *The findings suggest that treatment with a Bionator with expansion screw during the growth and development stage results in increased mandible length and ramus height and inhibits the growth of the maxilla and anterior cranial base bone.*

Keywords *Bionator, Bionator with expansion screw, Class II, Craniofacial growth, Percentiles*

Introduction

Among the aetiological possibilities of Class II malocclusion are nasomaxillary complex, maxillary dentoalveolar protrusion, mandibular retrognathism, and even disharmony between vertical components. According to McNamara [1981], the most common characteristic of Class II cases is mandibular skeletal retrusion, with only a small percentage of cases exhibiting maxillary skeletal protrusion. The most frequent approach to growth modification is the use of functional appliances that restrict the forward growth of the maxilla as well as stimulate mandibular growth. Such modification also aims at dentoalveolar change of the maxillary and mandibular anterior teeth, normalising neuromuscular activity, and achieving harmonious anatomical relations. One such functional appliance, the Bionator, which was developed by Balter in 1964 [Graber and Neumann, 1984], is considerably less bulky than the Andresen-Häupl activator. The appliance was intended primarily for use during growth in cases of Class II malocclusion with a retrognathic mandible. The extent and effectiveness of changes in Class II malocclusion resulting from treatment with either the Bionator or other functional appliances remain controversial, with several investigators claiming that the treatment effect is limited mainly to the dentoalveolar region [Calvert, 1982; Chen et al., 2002]. Several clinical studies have expressed divergent opinions on the mechanism of effect of such treatment, with some proposing that the treatment causes growth restriction of the maxilla [Harvold and Vargervik, 1971] and others that the mandible exhibits growth acceleration [Reey and Eastwood, 1978; Luder, 1982; McNamara et al., 1985; Almeida et al., 2002].

Against such a background, this study sought to assess how the Bionator alters craniofacial morphology in the growth and development stage for Class II patients with mandibular retrognathism by comparing measurements on lateral cephalometric radiographs taken before and upon completion of treatment.

Materials and methods

For this study 42 children were retrospectively evaluated. Subjects were 9 boys (mean age 10.58±1.16 years) and 33 girls (mean age 10.01±1.36 years) diagnosed with maxillary protrusion (Class II malocclusion) at an orthodontic clinic. Patients were randomised for phase I (early) treatment with a Bionator into one of the following two treatment groups: Bionator without expansion screw (n=12), or Bionator with expansion screw (n=30). All patients had Class II malocclusion due to mandibular retrognathism. The following selection criteria were used: overjet >5 mm; Class II molar relationship with at least half a cusp width distal molar relationship; skeletal Class II malocclusion with ANB >5 degrees; retrognathic mandible with SNB <73 degrees; and no history of previous medical or dental therapy. Use of the appliance was discontinued when the mandible was advanced from a Class II to a Class I relationship and the overjet was reduced. The Bionator we used is shown in Figure 1A–C and consists of a labial wire, palatal arch, and screw for dentoalveolar expansion.

The acrylic in the Bionator appliance was extended to cover the lower incisal edges only, but was trimmed in the posterior region to ensure no contact with the posterior teeth. All the Bionators for mandibular advancement were fabricated to obtain an edge-to-edge incisor relationship with a 2–3 mm bite opening between the central incisors while aligning the maxillary and mandibular midline as far as possible. Patients were instructed to initially wear the appliances for 18 hours every day. After the overjet was reduced and the mandible was brought forward to a Class I relationship, the appliance was worn only during sleeping hours. When dentoalveolar expansion occurred at a rate of 1 mm per month, the labial wire was removed when necessary. Table 1 shows the age of the subjects before and upon completion of treatment (hereafter referred to as "after treatment"), duration of the Bionator treatment, and duration of dentoalveolar expansion (mean 5.38±3.29 months) (Table 1).

Reference points

Two lateral head films taken before and after treatment were available for each subject. Tracings of the cephalograms were made with acetate tracing films. In addition to the most commonly used terms in orthodontic diagnosis, the following 5 terms were used primarily in

Case	Sex	Age before treatment	Age after treatment	Treatment time (months)	Expansion time (months)
1	F	12y5m	13y6m	11	6
2	F	10y8m	12y5m	13	4
3	F	11y6m	12y8m	14	4
4	F	11y1m	12y9m	11	10
5	F	9y4m	11y10m	12	6
6	F	10y11m	12y5m	18	7
7	F	12y8m	14y6m	17	6
8	F	9y1m	11y6m	16	6
9	F	11y10m	13y4m	14	3
10	F	10y1m	13y8m	14	4
11	F	8y7m	11y6m	20	0
12	F	9y4m	12y2m	13	4
13	F	8y7m	9y6m	11	0
14	F	9y1m	10y0m	9	0
15	F	8y3m	9y11m	15	0
16	F	9y5m	11y1m	3	0
17	F	10y1m	12y7m	11	3
18	F	12y5m	14y8m	24	2
19	F	13y1m	14y2m	9	6
20	F	11y0m	13y6m	15	15
21	F	10y7m	11y4m	4	3
22	F	11y1m	12y6m	15	3
23	F	8y11m	12y4m	37	2
24	F	8y11m	11y8m	27	8
25	F	8y8m	10y7m	5	4
26	F	8y10m	11y0m	27	15
27	F	10y2m	11y4m	10	0
28	F	9y6m	11y3m	5	4
29	F	9y5m	10y5m	9	6
30	F	9y0m	11y7m	12	3
31	F	9y5m	11y5m	8	4
32	F	7y5m	10y11m	35	7
33	F	9y7m	10y4m	5	0
34	M	11y10m	13y1m	14	0
35	M	8y6m	12y11m	33	8
36	M	12y11m	14y11m	12	2
37	M	10y3m	13y7m	30	0
38	M	9y10m	14y0m	25	0
39	M	11y5m	12y9m	14	0
40	M	9y5m	12y8m	11	3
41	M	11y0m	13y6m	25	0
42	M	11y1m	13y3m	7	6

TABLE 1 Age of subjects, treatment time, and dentoalveolar expansion time.



FIG. 1 The Bionator used in this study (A) consisted of a labial wire, palatal arch and screw for dentoalveolar expansion. (B, C).

relation to the landmarks we used in a previous study [Oda et al., 2002] (Fig. 2):

a) Glabella (Gl): The ridge between the eyebrows, just above the nasal bone.
b) Opisthocranion (Op): The point in the midline of the cranium that projects farthest backwards.
c) A': The intersection point of plane FH and a line passing through point A which is perpendicular to the plane.
d) Ptm': The intersection point of plane FH and a line passing through the pterygomaxillary fissure which is perpendicular to the plane.
e) Condyle (Cd): A point on the upper contour of the condyle.

Measurement method

The reference points described above were drawn by extending a line through and connecting two points separately, and the following cephalometric measurements were obtained to evaluate distance before and after treatment (Fig. 2): cranial length (Gl-Op), anterior cranial base length (S-N), maxillary length (A'-ptm'), mandibular ramus height (Cd-Go), mandibular body length (Go-Pog), and mandibular length (Cd-Gn). All were characterised using the measurement percentiles we reported previously [Oda et al., 2002]. The present analysis was performed using longitudinal cephalograms (frontal and lateral) which were taken in 1965–1974 from 47 boys and 40 girls ranging from first-year elementary school to third-year junior high school children. The mean age of the first graders was 6.9 years (6.3–7.2 years).

We selected subjects without orthodontic treatment or abnormalities of the anterior tooth overjet-overbite or posterior tooth occlusion. In Japan, we employ standard facial growth charts for practical use [Oda et al., 2000; Yamauchi et al., 2010], based on the hypothesis that relative values such as standard deviation (SD) score or percentile value of the present dimension correspond to the present age. Treatment effects were determined to be significant at $P<0.05$ by the Wilcoxon test for each corresponding percentile for all patients in each treatment group. Analysis was performed in StatView for Windows Version 5.0.

Results

The cephalometric data taken before and after treatment and the corresponding percentile values are shown in Tables 2–7 for Gl-Op, S-N, A'-ptm', Cd-Go, Go-Pog, and Cd-Gn, respectively. Phase I (early) treatment with the Bionator had a mean duration of 15.24 months. Table 8 shows the effects of Bionator treatment for each facial measurement, through a comparison of each parameter value with the corresponding percentile, as determined by the Wilcoxon test. Because they were discrete data, the Wilcoxon signed rank test was used for the analysis, although the results from the Bionator without screw group were analysed using the critical t value table because of the small sample number (<25). The results showed no significant differences in Gl-Op before or after treatment in the 3 groups. The group without expansion screw showed no significant differences in any of the measured cephalometric variables, whereas the group with expansion screw showed significantly restricted growth of S-N and A'-ptm' (both $P<0.05$). Furthermore, there was no evidence of change in Go-Pog resulting from treatment in any of the 3 groups, but there was a significant acceleration in growth of Cd-Go ($P<0.05$) and Cd-Gn ($P<0.01$) in the group with expansion screw and in all patients (Tables 1–8).

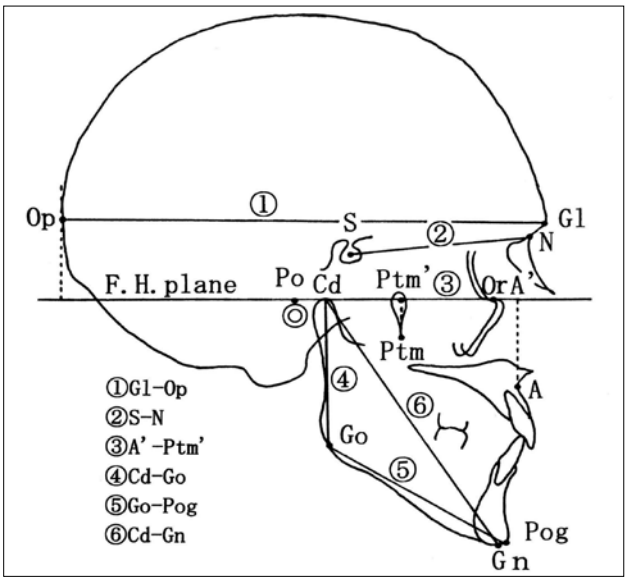


FIG. 2 Cephalometric measurements obtained for distance evaluation before and after treatment.

Discussion

Data and measurement errors

Skeletal, dentoalveolar, and neuromuscular changes in the craniofacial regions could be achieved by forward positioning of the mandible when treated with the Bionator. Generally, it is necessary for treatment to start before the prepubertal growth spurt. In our study, the mean age for starting treatment was 10.13 years and thus constituted early treatment of Class II malocclusion from which we anticipated optimal outcome. Too large of a measurement error in analysis of a head cephalogram means that the measurement value is no longer reliable; therefore, it is necessary to know the magnitude of the measurement error. In this study, we applied our previously reported measurement model [Oda, 1982; Oda et al., 1982] for linear measurement to determine the measurement error. In this method, a tracing of identifiable anatomic landmarks is made on transparent acetate paper with a thin pointed pencil of 0.3 mm diameter, while taking into account the maximum diameter size of up to 0.6 mm. The average of three measurement values is taken as the result, and the

upper bound on the error is consequently inferred to be around 0.35 mm (0.6/√3).

Treatment effect on the mandibular skeletal component

It is widely reported that functional appliances like the Bionator are capable of stimulating mandibular growth [Nelson et al., 1993; Almeida et al., 2004; Türkkahraman and Sayin, 2006]. Nelson et al. [1993] reported that after 18 months of treatment using either the Harvold activator or the Fränkel activator, a significant increase was seen in the articulare-pogonion length. Almeida et al. [2004] concluded that the Bionator appliance did not produce any significant restriction of forward maxillary growth, but the measurements of mandibular body length (Go-Pog) and mandibular length (Cd-Gn) showed a significant increase in growth acceleration. The present data showed that after treatment with a Bionator with expansion screw both mandibular ramus height (Cd-Go) and mandibular length (Cd-Gn) were significantly increased. However, the mandibular body length (Go-Pog) remained unchanged.

Using Macaca mulatta as an animal model, McNamara et al. [1987] found a forward alteration in the mandibular postural position following functional protrusion; this

Pt	Basel. (mm)	Perc.	After (mm)	Perc.
1	187,0	44,7	189,1	50,0
2	190,3	82,8	193,9	86,4
3	177,5	13,8	179,6	11,8
4	188,1	66,0	191,6	72,8
5	189,5	85,5	193,8	91,1
6	195,4	97,0	195,4	92,2
7	190,4	63,1	191,3	53,6
8	176,3	19,8	176,3	8,9
9	195,2	95,9	195,2	85,7
10	188,7	78,8	189,7	56,7
11	186,0	73,4	189,4	73,3
12	181,6	41,1	187,9	52,9
13	195,7	97,0	196,5	97,0
14	174,3	11,2	177,0	17,6
15	192,8	97,0	193,7	97,0
16	186,9	75,0	189,7	77,9
17	192,2	91,8	199,1	97,0
18	174,1	3,0	174,8	3,0
19	187,0	39,4	189,3	47,3
20	183,3	35,7	185,8	32,5
21	180,6	28,1	182,2	31,6
22	184,5	43,0	189,0	55,4
23	187,4	79,6	193,1	83,4
24	179,1	32,0	184,8	43,4
25	178,1	29,2	180,9	28,8
26	189,8	90,0	193,1	88,1
27	191,8	90,0	194,3	95,4
28	181,9	41,5	182,7	34,6
29	189,3	84,8	190,3	84,1
30	182,9	49,5	184,0	39,5
31	185,0	59,7	189,6	75,0
32	183,6	65,4	189,1	75,5
33	188,6	80,9	188,6	77,4
34	199,0	91,3	202,0	89,3
35	192,5	90,0	194,0	65,7
36	180,5	7,8	184,5	6,5
37	205,5	97,0	209,0	97,0
38	212,5	97,0	215,5	97,0
39	194,5	81,6	197,0	75,0
40	189,5	69,7	192,0	61,1
41	202,5	95,5	204,5	92,2
42	183,5	59,7	192,0	56,9

TABLE 2 Measurements and corresponding percentiles (Perc.) for G1-0p before (Basel.) and after treatment (After).

Pt	Basel. (mm)	Perc.	After (mm)	Perc.
1	69,7	77,8	71,2	81,8
2	66,6	50,0	67,7	45,6
3	66,1	46,7	66,8	27,3
4	67,7	65,4	69,0	57,5
5	67,8	88,2	68,9	77,0
6	73,4	97,0	72,0	97,0
7	73,4	97,0	73,0	93,3
8	68,0	91,3	68,9	78,4
9	69,6	83,9	68,8	50,0
10	68,1	84,9	69,7	64,0
11	66,2	78,4	67,7	58,5
12	66,7	77,3	69,4	78,4
13	67,3	83,8	68,6	92,4
14	65,2	55,8	66,4	58,6
15	72,0	97,0	7,7	97,0
16	67,0	78,9	67,8	69,4
17	67,5	77,3	69,3	72,9
18	65,9	22,8	67,2	25,0
19	66,1	19,4	67,9	35,9
20	65,2	28,2	67,7	33,3
21	65,7	40,2	65,7	30,0
22	71,4	97,0	71,4	90,0
23	68,4	92,9	69,1	73,5
24	69,1	96,0	69,0	80,2
25	69,2	97,0	69,2	91,4
26	64,0	41,0	66,4	34,1
27	67,5	77,3	68,6	78,2
28	65,1	46,1	66,4	40,9
29	70,0	97,0	71,1	97,0
30	67,5	90,7	69,9	86,5
31	67,5	84,2	73,5	97,0
32	68,8	97,0	71,2	97,0
33	68,7	92,3	69,3	92,6
34	73,9	94,9	76,5	97,0
35	62,7	19,5	64,4	10,7
36	68,4	34,2	70,8	37,2
37	68,3	69,3	68,2	25,0
38	69,4	84,2	72,3	66,8
39	71,0	86,0	73,0	88,5
40	70,8	93,7	71,8	79,9
41	71,4	91,3	73,6	83,3
42	69,6	77,7	74,2	90,0

TABLE 3 Measurements and corresponding percentiles (Perc.) for S-N before (Basel.) and after treatment (After).

Pt	Basel. (mm)	Perc.	After (mm)	Perc.
1	51,7	97,0	52,8	95,2
2	45,6	37,3	45,6	19,9
3	44,3	16,2	44,3	7,5
4	47,4	58,6	49,4	67,9
5	45,4	54,4	45,8	25,0
6	50,3	97,0	50,3	82,5
7	49,6	72,3	48,8	47,4
8	48,4	97,0	49,4	79,3
9	47,9	54,6	48,9	54,7
10	49,8	97,0	50,6	81,0
11	48,3	97,0	53,4	97,0
12	48,7	97,0	53,8	97,0
13	48,0	97,0	48,3	92,2
14	46,6	76,0	47,3	59,3
15	49,6	97,0	50,5	97,0
16	44,2	33,2	48,0	70,5
17	47,0	67,3	50,0	83,3
18	47,9	46,5	49,2	52,7
19	46,1	20,9	47,0	26,5
20	48,6	78,6	50,0	75,0
21	45,0	28,8	46,7	44,0
22	47,1	55,1	49,0	63,1
23	49,7	97,0	50,0	79,5
24	39,1	3,0	42,8	3,0
25	48,5	97,0	49,6	93,5
26	45,1	57,4	47,6	50,0
27	50,3	97,0	49,8	86,3
28	45,8	57,6	47,5	56,8
29	47,4	82,8	48,1	79,3
30	46,5	75,0	49,1	76,1
31	46,7	71,6	48,5	73,4
32	47,3	97,0	48,0	72,4
33	46,5	67,2	46,5	56,8
34	46,3	40,6	47,9	38,2
35	44,5	52,9	44,9	8,1
36	41,6	3,0	47,4	13,5
37	49,1	91,6	49,1	45,6
38	51,3	97,0	52,2	81,0
39	50,4	91,5	52,7	93,5
40	47,4	84,4	48,7	58,3
41	53,1	97,0	55,8	97,0
42	48,7	77,7	50,4	80,0

TABLE 4 Measurements and corresponding percentiles (Perc.) for A'-Ptm' before (Basel.) and after treatment (After).

adaptation response was most pronounced in the growth acceleration seen in the postero-superior region of the condyle. Mandibular remodeling associated with Bionator therapy is based primarily on condylar growth. Our findings are in good agreement. Using metallic implants in a clinical study, Araujo et al. [2004] found significant growth in the posterior direction of the condyle with Bionator therapy. Similar findings were observed in the present study, where mandibular length (Cd-Gn) was significantly increased after treatment with a Bionator with an expansion screw. Araujo et al. [2004] also described that the Bionator appliance reduced condylar growth change in the upper direction, but showed predominately greater posterior growth in the gonial region. These results are not consistent with those of the present study in which we found that mandibular ramus height (Cd-Go) was significantly increased following treatment with a Bionator with expansion screw.

Annual cephalometric data have been extensively investigated in recent years. The results of studies indicate that not only whole body but also functional occlusal change is closely correlated with craniofacial growth, providing us with a better understanding of the morphology of mandibular growth. Such investigations [Miyagawa, 1988; Kuroki, 1991; Ueda, 1991] have

Pt	Basel. (mm)	Perc.	After (mm)	Perc.
1	53,7	27,5	57,7	55,7
2	48,3	12,6	53,4	24,7
3	51,3	22,9	58,4	65,3
4	52,2	41,2	57,1	56,7
5	50,1	45,7	53,1	38,8
6	60,7	97,0	64,3	97,0
7	51,8	14,6	60,2	68,1
8	53,2	77,5	61,2	96,8
9	56,3	63,0	60,4	75,0
10	57,0	83,5	66,3	97,0
11	54,3	90,0	62,3	97,0
12	55,1	86,8	64,4	97,0
13	52,9	80,1	52,9	69,8
14	44,3	3,0	48,0	16,2
15	61,1	97,0	67,5	97,0
16	56,5	95,8	59,5	92,8
17	51,8	52,4	59,1	70,4
18	58,0	66,0	65,4	97,0
19	59,4	69,9	60,7	74,2
20	55,2	76,2	62,0	88,4
21	50,4	29,1	55,0	60,8
22	61,5	97,0	65,2	97,0
23	57,5	97,0	64,8	97,0
24	47,4	23,1	51,6	23,3
25	54,7	91,2	58,5	91,8
26	57,2	97,0	61,0	93,8
27	52,1	54,2	60,5	95,0
28	54,7	95,6	61,6	97,0
29	57,5	97,0	57,9	90,0
30	51,1	59,1	62,8	97,0
31	52,6	68,1	54,3	57,1
32	51,3	86,9	52,4	48,2
33	55,5	86,5	55,0	77,6
34	56,7	82	64,3	92,9
35	46,9	21,5	49,0	3,0
36	54,9	35,8	58,0	22,0
37	52,9	66,4	60,3	75,0
38	53,5	79,5	62,4	81,0
39	55,8	79,5	62,2	91,8
40	54,8	90,1	59,3	82,5
41	60,1	87,9	64,6	61,5
42	60,5	97	66,6	95,3

TABLE 5 Measurements and corresponding percentiles (Perc.) for Cd-Go before (Basel.) and after treatment (After).

Pt	Basel. (mm)	Perc.	After (mm)	Perc.
1	73,7	50,0	73,7	36,9
2	68,4	31,8	71,1	29,1
3	71,3	36,5	75,2	56,8
4	68,2	22,3	71,2	26,3
5	64,1	12,8	67,1	3,0
6	74,0	71,5	77,7	78,1
7	74,7	51,5	77,2	56,4
8	71,6	86,7	70,4	42,0
9	71,8	43,6	72,0	25,0
10	72,0	72,3	76,7	57,0
11	64,8	34,6	69,6	28,3
12	74,6	97,0	84,0	97,0
13	68,0	62,9	71,5	79,5
14	75,0	97,0	75,0	93,6
15	83,9	97,0	87,0	97,0
16	70,3	70,5	76,0	83,7
17	73,2	82,3	75,0	56,5
18	72,4	39,9	70,6	18,5
19	71,1	21,5	74,1	60,1
20	73,4	67,0	80,4	84,3
21	67,4	24,3	68,5	21,7
22	73,1	64,3	76,4	69,2
23	75,9	97,0	81,8	97,0
24	64,9	30,0	68,3	14,7
25	67,0	54,2	70,9	55,7
26	63,0	10,0	66,9	3,0
27	68,7	45,1	69,8	34,5
28	77,2	97,0	80,9	97,0
29	73,7	95,3	79,1	97,0
30	77,9	97,0	82,0	97,0
31	63,4	6,8	70,5	39,2
32	69,8	97,0	78,7	97,0
33	69,4	62,6	69,4	69,4
34	80,4	97,0	84,5	96,0
35	64,2	18,1	73,9	25,0
36	72,4	14,5	75,3	9,7
37	74,5	90,0	78,2	56,3
38	76,1	97,0	81,0	75,0
39	71,4	37,0	74,7	25,0
40	71,6	81,4	77,0	68,2
41	75,7	87,9	78,6	61,5
42	70,4	35,0	78,9	72,5

TABLE 6 Measurements and corresponding percentiles (Perc.) for Go-Pog before (Basel.) and after treatment (After).

Pt	Basel. (mm)	Perc.	After (mm)	Perc.
1	108,8	59,2	113,8	75,0
2	104,8	73,5	112,3	83,0
3	107,3	70,0	118,8	97,0
4	105,6	68,3	113,0	77,9
5	100,9	75,7	106,6	58,7
6	114,7	97,0	121,1	97,0
7	112,6	78,2	117,4	91,0
8	108,5	97,0	117,5	97,0
9	110,3	77,2	114,3	81,2
10	109,9	95,0	124,8	97,0
11	104,8	94,6	116,3	97,0
12	113,4	97,0	129,2	97,0
13	106,1	96,5	109,2	97,0
14	106,3	94,5	109,3	94,6
15	111,5	97,0	122,0	97,0
16	109,8	97,0	119,4	97,0
17	108,9	93,8	119,5	97,0
18	113,3	85,4	120,7	96,6
19	113,1	76,2	117,1	91,4
20	107,1	86,2	117,8	94,0
21	102,0	47,5	106,5	67,8
22	116,4	97,0	124,9	97,0
23	112,7	97,0	123,4	97,0
24	95,9	37,8	105,3	53,8
25	104,3	93,5	110,6	93,9
26	103,5	90,0	111,3	91,1
27	105,1	82,8	113,2	96,2
28	109,5	94,8	118,5	97,0
29	109,0	97,0	113,6	97,0
30	107,7	97,0	122,7	97,0
31	103,1	84,2	109,5	83,8
32	105,2	97,0	116,0	97,0
33	105,0	69,4	107,0	87,0
34	114,6	71,1	124,4	88,3
35	94,9	3	107,4	7,6
36	102,5	3	110,8	3,0
37	110,2	71,1	120,0	61,4
38	111,4	86,3	125,3	81,8
39	111,3	57,5	121,9	85,5
40	106,6	57,9	114,3	47,5
41	120,3	97	127,0	93,0
42	113,8	85	125,9	92,0

TABLE 7 Measurements and corresponding percentiles (Perc.) for Cd-Gn before (Basel.) and after treatment (After).

Parameter	All patients	P-value	Without screw group	P-value	With screw group	P-value
	N=42		n=12		n=30	
G1- 0p	0,940	NS	0,779	NS	0,940	NS
S - N	0,003	**	0,328	NS	0,009	**
A' - Ptm'	0,024	*	0,110	NS	0,050	*
Cd - Go	0,025	*	0,374	NS	0,041	*
Go - Pog	0,304	NS	0,213	NS	0,677	NS
Cd - Gn	0,002	**	0,203	NS	0,004	**
Wilcoxon's test: NS: Not significant, *: P<0.05, **: P<0.01						

TABLE 8 Effects of treatment with a bionator without or with expansion screw on facial measurements.

illustrated that functional change due to eruption of the molars can induce growth acceleration of mandibular length (Cd-Gn) and mandibular ramus height (Cd-Go). Furthermore, the change in mandibular body length (Go-Pog) and its relationship with somatic growth in the adolescent stage were also demonstrated. Such biological phenomena correspond well with the outcomes of our treatment with a Bionator with expansion screw (Table 8).

Treatment effect in the maxillary skeletal component

Many researchers [Harvold and Vargervik, 1971; McNamura et al., 1985; Jakobsson and Paulin, 1990; Lange et al., 1995; Cozza et al., 2004] assert that functional appliances like the Bionator restrict the development of maxillary structures. As with headgear, Jakobsson and Pulin [1990] reported that activators do not produce any growth acceleration in the mandible beyond that which would have occurred without treatment, but do reduce forward growth of the maxilla. Harvold and Vargervik [1971] found that patients instructed to wear the activator 14 hours per day for 6 months showed significantly reduced forward growth of the entire maxilla; however, growth acceleration of the mandible remained unaffected by the use of the appliance. Furthermore, Cozza et al. [2004] reported that functional therapy with activators restricts the growth of maxilla.

Many studies [Ruf et al. 2001; Almeida et al., 2004; Türkkahraman and Sayin, 2006;] have reported that functional orthopedic appliances produce an increase in mandibular length while not restricting the forward growth of the maxilla. However, other reports [Calvert, 1982; Chen et al., 2002; Jena et al., 2006; Almeida-Pedrin et al., 2007] have claimed that treatment with a functional appliance offered little or no change in mandibular bone growth. Calvert [1982] does not support the opinion that the Anderson appliance can produce any alterations in mandibular form, but he did find that overjet was reduced by lingual tipping of the maxillary incisors and labial tipping of the mandibular incisors, and that overbite was reduced by elongation of both the maxillary and mandibular molars. Another study on Bionator treatment by Almeida-Pedrin et al. [2007] indicated no significant forward growth acceleration in the mandible or forward growth restriction in the maxilla, but treatment clearly accounted for dentoalveolar changes. In the present study, cranial length (Gl-Op) did not show a significant difference before or after Bionator treatment, but both anterior cranial base length (S-N) and maxillary length (A'-ptm') did show a significant difference before and after treatment with a Bionator with expansion screw (P<0.05). These findings indicate that growth restriction of the maxillary complex can be achieved through certain Bionator treatment. We intend to investigate dentoalveolar changes in future studies.

Using the Bionator

Our data clearly demonstrates that treatment with a Bionator with expansion screw does enhance mandibular forward growth and restricts maxillary forward growth. All of the subjects enrolled in this study were instructed to wear the appliance for 18 hours rather than 14 hours a day, optimising the opportunity to achieve correction. Furthermore, measurements were converted to a form of percentile data, and the corresponding percentile data before and after Bionator treatment were examined using the Wilcoxon test. Therefore, the method we employed provided a detailed and optimised evaluation of the effects of growth changes. McNamara and Brudon [1993] stated that when a set of study models of Class II malocclusion patients are "hand-articulated", it becomes obvious that when the dental casts are placed with the posterior dentition in a Class I relationship, a unilateral or bilateral crossbite is produced. This indicates the presence of maxillary constriction as a component of Class II malocclusion. Therefore, in the treatment of Class II malocclusion characterised by mandibular retrusion and maxillary constriction, widening of the maxilla often leads to spontaneous correction. When Bionators are constructed to displace the mandible anteriorly during the growth and development stage, we can expect that adaptations will occur in the cartilage of the mandibular condyle and its associated periosteum. In expansion procedures employing palatal bar or screw appliances, lateral dentition is uprighted in the palato-buccal direction, which may effectively increase alveolar bone width. Moreover, eliminating the disharmony between the tongue and circumoral muscles following expansion and uprighting of the alveolar bone consistently induces elongation of the lateral dentition and increased vertical dimension, and the results often lead to better paralleling of the occlusal plane relative to the palatal plane. The consequent improvement facilitates the mandible to function in an anterior position in the construction bite. Therefore, significant intra-arch expansion in the maxilla is necessary. A midline screw or open spring is incorporated into functional appliances for transverse maxillary expansion. The most commonly recognised indication for maxillary expansion is an increase in total arch length that will accommodate crowding teeth

into the dental arch. However, the purpose of the present study was to evaluate the treatment effects of the Bionator with a maxillary expansion appliance in individuals with a maxillary constriction. There are many cases of dental arch expansion in a definite age range clearly having a characteristic effect on the growing craniofacial complex. As seen in Case No.11 in Table 1, Bionator treatment without expansion took as long as 20 months to improve the overjet, despite the patient being the youngest of the subjects. While some authors have reported no actual treatment effect of Bionator therapy, many of the patients treated in the present study completed the expansion treatment procedures and a significant effect of the appliances on maxillary expansion was demonstrated. Uysal et al. [2005] reported that the maxillary interpremolar width, maxillary canine, premolar and molar alveolar widths, and mandibular premolar and molar alveolar widths were significantly narrower in subjects with Class II Division 1 malocclusion than in the normal occlusion sample. For this reason, the use of a Bionator with an expansion screw, rather than without, should be considered before or during the treatment of Class II Division 1 patients.

Conclusions

- No significant differences were seen in Gl-Op or Go-Pog in either the Bionator with expansion screw group or the Bionator without expansion screw group.
- The length of S-N and A'-Ptm' was significantly decreased, and the length of Cd-Go and Cd-Gn was significantly increased, following treatment with a Bionator with expansion screw.
- These findings suggest that, if used properly during the growth and development stage, a Bionator with expansion screw can be effective for the treatment of Class II malocclusions by increasing mandible length and ramus height as well as inhibiting growth of the maxilla and anterior cranial base bone.

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