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A comparison of chincap and maxillary protraction appliances in the treatment of skeletal Class III malocclusions

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SUMMARY The purpose of this retrospective investigation was to compare cephalometrically the treatment effects of chincap and maxillary protraction appliances in subjects with a Class III skeletal malocclusion with a combination of an underdeveloped maxilla and prominent mandible. Twenty-four patients were divided into two groups according to the treatment type; the chincap group (mean age 11.03 years, $n = 12$) and the Delaire type maxillary protraction appliance group (mean age 10.72 years, $n = 12$). In both groups, a significant increase in ANB, molar relationship, and overjet showed the effect of the appliances in the treatment of Class III malocclusions. In comparing the two groups, the maxilla was displaced more anteriorly and the molar relationship correction was greater in the maxillary protraction appliance group ($P < 0.05$). Angular and dimensional parameters for lower incisor/NB and nasolabial angle showed significant differences between the groups ($P < 0.05$).

Introduction

Subjects with Class III malocclusions are among the most difficult to treat. These can present with various combinations of underlying skeletal and dental components, the differentiation of the various types is important for the success of treatment (Graber *et al.*, 1985; Guyer *et al.*, 1986; Staggers *et al.*, 1992; McNamara and Brudon, 1993).

Williams and Andersen (1986) demonstrated, by linear analysis, that the development of the maxilla both in size and position could be an aetiological factor in Class III development. They pointed out that mandibular prognathism was the result of an increase in the ratio between mandibular length and the dorsal position of the glenoid fossa. Droel and Isaacson (1972) suggested that increased vertical development between the sella and glenoid fossa could be an aetiological contributor to the skeletal Class III pattern. Chang *et al.* (1992) found greater mandibular length and forward mandibular position, a slightly backward positioned and shorter maxilla in a Class III deciduous dentition group. This study also indicated that Class III subjects in the primary dentition have significantly greater mandibular length, because of an increased gonial angle. Guyer *et al.* (1986) reported that Class III subjects showed larger mandibular plane angles, larger gonial angles, longer mandibles, and compensation of the dentition including maxillary dentoalveolar protrusion and mandibular dento-alveolar retrusion. Chang *et al.* (1992) found that the maxillary incisors were tipped lingually by the retroclined mandibular incisors in a Class III deciduous dentition group.

Graber *et al.* (1985) categorized the following possibilities for a sagittal Class III relationship:

1. Class III malocclusion due to a dentoalveolar malrelationship.
2. Class III malocclusion with a long mandibular base.
3. Class III malocclusion with an under-developed maxilla.

4. Class III malocclusion with a combination of an underdeveloped maxilla and prominent mandible.
5. Class III skeletal malocclusion with tooth guidance.

Analysis of 302 adult Class III individuals showed that one-third of the sample had a combination of maxillary retrusion and mandibular protrusion. Maxillary skeletal retrusion was only found in 19.5 per cent of the sample and mandibular protrusion in 19.1 per cent (Ellis and McNamara, 1984).

There are several treatment choices for use in specific types of Class III malocclusion during the growth period. The chincap is an appliance that has been the treatment choice for mandibular prognathism (Graber *et al.*, 1967; Sakamoto *et al.*, 1984; Sugawaro *et al.*, 1990). A reverse activator can also be used to exert a retrusive force on the mandible (Graber *et al.*, 1985; McNamara and Brudon, 1993) and the orthopaedic face mask has been used in cases of maxillary skeletal retrusion. Several appliances were designed to protract the maxilla by changing the extra- and intra-oral anchorage units (Delaire *et al.*, 1976; Nanda, 1980; Takada *et al.*, 1993). More recently, it is believed that maxillary protraction can be applied to most developing Class III cases regardless of the specific aetiology (McNamara and Brudon, 1993; Chong *et al.*, 1996). The purpose of this study was to evaluate and compare the treatment effects of a maxillary protraction appliance and chincap on subjects with a Class III skeletal malocclusion with a combination of an underdeveloped maxilla and a prominent mandible.

Materials and methods

Lateral cephalometric radiographs of 168 previously treated skeletal Class III malocclusion patients were traced and digitized. They were evaluated with the JOE program (Rocky Mountain Orthodontics JOE Version 5.0/Denver, USA). This program makes considerations about the malocclusion type and its origin by analysis of several cephalometric parameters. Sagittal considerations made by this program are based on facial depth (NPg/Frankfort horizontal), maxillary depth (NA/Frankfort horizontal) and corpus length (Xi–Pg). After the evaluation of the 168 cases, the considerations in the program showed that only 24 cases had a skeletal Class III malocclusion with a combination of maxillary retrusion and mandibular protrusion. Others were either maxillary retrusion or mandibular protrusion cases.

When the treatment types of the 24 skeletal Class III cases with a combination of maxillary retrusion and mandibular protrusion were investigated, it was found that 12 subjects were treated with chincap appliances and 12 with a maxillary protraction appliance.

The first group of 12 patients (six girls and six boys) with a mean age of 11.03 years were treated with a chincap and mandibular occlusal biteplate (Figure 1). The chincap applied a total force of 600 *g*. The patients were instructed to wear the appliance for at least 14–16 hours a day.

The second group comprised 12 children (seven girls and five boys) with a mean age 10.72 years. Maxillary protraction therapy was applied in this group. They were treated by using a Delaire type orthopaedic facemask and a removable intra-oral appliance with an anterior point

Figure 1 Chincap appliance.

application (Figure 2). The total force applied was 600 *g* and the patients were instructed to wear the appliance for approximately 16 hours a day.

When a normal dental relationship was obtained with a 2–3 mm overjet, lateral cephalometric radiographs were taken in both groups. The treatment time was 10.0 months for the chincap group and 11.7 months for the maxillary protraction group.

All radiographs were traced, digitized, and evaluated with the RMO JOE program. Sixteen linear and 17 angular cephalometric measurements were determined. The measurements are shown in Figure 3a–b. All cephalometric radiographs were retraced and redigitized after 15 days. Method error coefficients for all measurements were calculated and found to be within acceptable limits (range 0.91–0.99; Winner, 1971).

For statistical analysis, the program SPSS for Windows version 6.0/Chicago, USA was used and non-parametric tests were applied. Wilcoxon

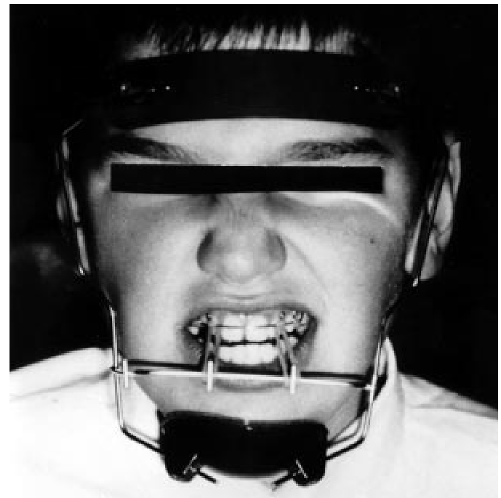
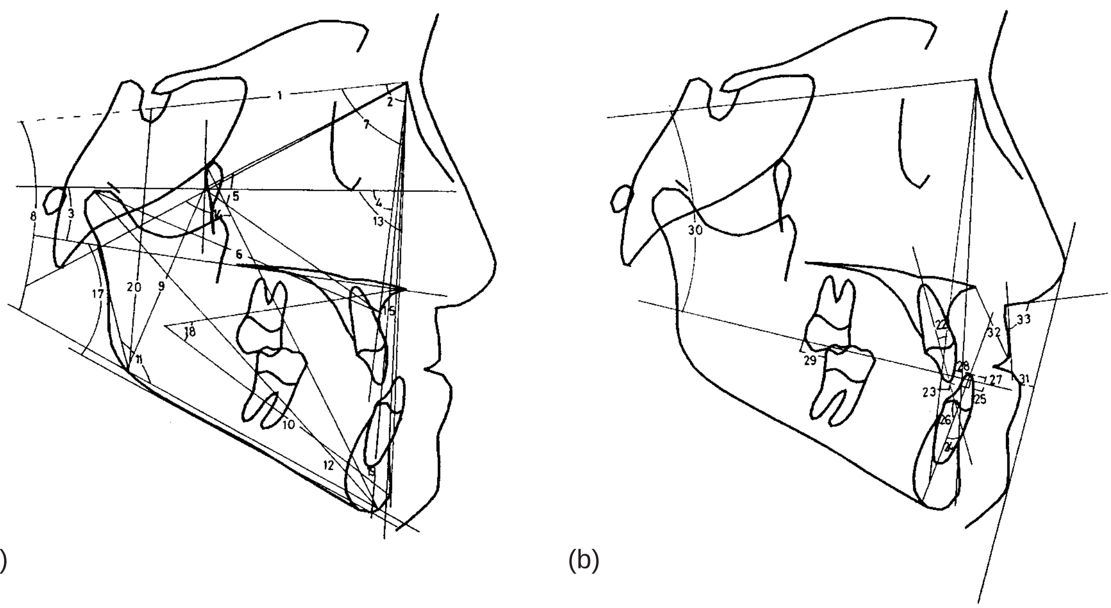


Figure 2 Maxillary protraction appliance.



(a) (b)

Figure 3 (a) Skeletal angular and dimensional measurements. (1) S–N; (2) SNA; (3) palatal/FH plane; (4) maxillary depth (NA/FH); (5) maxillary height (N–CF/CF–A); (6) Co–A; (7) SNB; (8) SN/GoGn; (9) ramus height (CF–Go); (10) corpus length (Xi–Pg); (11) Gn–Go–Ar; (12) Co–Gn; (13) facial depth (N–Pg/FH); (14) facial axis (N–Ba/CC–Gn); (15) ANB; (16) max–mand differential (Co–Gn)–(Co–A); (17) palatal plane/mandibular plane; (18) lower face height (Xi–ANS/Xi–Pg); (19) anterior face height (N–Me); (20) posterior face height (S–Go); (21) posterior/anterior ratio (20/19 × 100). (b) Dental and soft tissue angular, and dimensional measurements; (22) Upper incisor/NA(°); (23) upper incisor–NA (mm); (24) lower incisor/NB (°); (25) lower incisor–NB (mm); (26) inter-incisal angle; (27) overbite; (28) overjet; (29) molar relationship; (30) SN/occlusal plane; (31) lower lip–aesthetic plane; (32) upper lip length; (33) nasolabial angle.

Table 1 Pre-treatment mean (x) values, standard error of the mean (Sx), and statistical differences (P).

		Chincap		Maxillary protraction		
		x	Sx	x	Sx	P
1.	S–N	66.89	0.89	67.07	0.90	0.821
2.	S–N–A	78.25	0.68	76.23	0.07	0.076
3.	Palatal/FH plane	–3.09	0.77	–0.66	1.00	0.061
4.	Maxillary depth	86.52	0.39	85.02	0.40	0.059
5.	Maxillary height	61.73	0.81	61.32	1.13	0.705
6.	Co–A	78.92	1.06	79.01	1.67	0.969
7.	S–N–B	80.22	0.95	80.52	0.66	0.650
8.	SN/GoGn	35.08	0.95	32.78	1.77	0.226
9.	Ramus height	53.99	0.97	58.88	1.80	0.075
10.	Corpus length	67.93	1.18	71.87	1.47	0.065
11.	Gn–Go–Ar	129.20	1.78	123.13	2.31	0.054
12.	Co–Gn	108.30	1.28	113.46	1.70	0.089
13.	Facial depth	88.71	0.61	90.45	0.59	0.098
14.	Facial axis	90.33	0.73	91.47	1.40	0.545
15.	A–N–B	–2.09	0.81	–4.28	0.34	0.078
16.	Max–Mand differential	29.34	1.21	34.46	0.85	0.059
17.	Palatal pl/mandibular pl	23.68	1.15	23.37	1.53	0.307
18.	Lower face height	43.01	1.34	43.83	1.22	0.622
19.	Anterior face height	110.90	0.92	113.93	1.77	0.096
20.	Posterior face height	70.53	1.39	74.39	1.62	0.121
21.	Posterior/anterior ratio	63.56	1.01	65.35	1.31	0.384
22.	U1/NA (°)	19.79	1.22	25.36	1.67	0.015*
23.	U1–NA (mm)	3.78	0.44	5.49	0.51	0.025*
24.	L1/NB (°)	18.17	1.13	16.35	1.77	0.405
25.	L1–NB (mm)	3.97	0.34	3.09	0.43	0.239
26.	Inter-incisal angle	144.20	2.35	142.58	2.81	0.649
27.	Overbite	4.69	0.89	3.71	0.61	0.364
28.	Overjet	–2.73	0.64	–2.46	0.50	0.705
29.	Molar relation	–4.13	0.91	–4.43	0.86	0.733
30.	SN/occlusal pl.	17.60	1.11	17.84	1.48	0.969
31.	Lower lip–aesthetic pl.	–2.01	0.57	–2.79	0.25	0.212
32.	Upper lip length	23.17	0.83	24.59	0.87	0.384
33.	Nasolabial angle	109.49	5.36	109.53	4.76	0.762
34.	Chronological age	11.03	0.55	10.72	0.54	0.384
35.	Skeletal age	11.12	0.57	10.81	0.48	0.307

*$P < 0.05$.

test was used to determine the difference of the mean changes within each treatment group. For comparison of the differences between the groups, the Mann–Whitney U-test was used.

Results

The statistical comparison of the pre-treatment values between the groups showed significant differences in upper incisor/NA relations (degree-mm; Table l).

Chincap group

SNB and facial axis showed significant decreases in the chincap group. There was a statistically significant increase in this group in Co–A, ramus height, ANB, lower face height and anterior and posterior face heights. Evaluation of dental relationships during chincap therapy showed significant increases in upper incisor–NA(mm) and overjet. Angular and dimensional parameters for lower incisor–NB and molar relationship

Table 2 Treatment effects of chincap and maxillary protraction therapy and comparison of the groups.

		Chincap			Maxillary protraction			Comparison
		D	SD	*P*	D	SD	*P*	*P*
1.	S–N	0.39	0.31	0.241	1.10	0.30	0.009*	0.161
2.	S–N–A	0.39	0.47	0.610	2.17	0.53	0.007**	0.028*
3.	Palatal/FH plane	0.27	0.56	0.952	–0.58	0.70	0.515	0.733
4.	Maxillary depth	–1.60	0.48	0.066	1.14	0.61	0.093	0.255
5.	Maxillary height	–0.96	0.49	0.051	–0.01	0.73	0.959	0.596
6.	Co–A	3.23	0.85	0.008**	4.39	0.80	0.005**	0.257
7.	S–N–B	–1.95	0.56	0.012*	–1.52	0.57	0.028*	0.791
8.	SN/GoGn	1.52	0.71	0.092	1.75	0.70	0.038*	0.850
9.	Ramus height	2.45	0.49	0.007**	2.97	0.60	0.007**	0.596
10.	Corpus length	0.40	0.69	0.515	0.68	0.69	0.441	0.910
11.	Gn–Go–Ar	–1.00	0.46	0.075	–0.09	0.68	0.879	0.325
12.	Co–Gn	2.60	0.92	0.076	2.24	0.83	0.017*	0.939
13.	Facial depth	–1.17	0.48	0.051	–2.52	0.66	0.013*	0.151
14.	Facial axis	–1.60	0.48	0.008**	–1.80	0.76	0.047*	0.705
15.	A–N–B	2.45	0.41	0.005**	3.69	0.44	0.005**	0.069
16.	Max–Mand differential	–0.57	0.45	0.262	–2.17	0.76	0.025*	0.140
17.	Palatal pl/mandibular pl	1.43	1.00	0.093	2.13	1.01	0.059	0.969
18.	Lower facial height	2.43	0.71	0.014*	2.11	0.63	0.019*	0.910
19.	Anterior face height	4.10	0.88	0.012*	4.44	0.93	0.009**	0.850
20.	Posterior face height	1.84	0.43	0.007**	1.70	0.74	0.028*	0.520
21.	Posterior/anterior ratio	–0.53	0.55	0.284	–0.96	0.53	0.087	0.791
22.	U1/NA (°)	5.43	2.26	0.067	3.73	2.20	0.114	0.427
23.	U1–NA (mm)	1.24	0.39	0.025*	0.44	0.56	0.515	0.289
24.	L1/NB (°)	–4.67	1.46	0.013*	0.40	1.25	0.959	0.015*
25.	L1–NB (mm)	–1.01	0.26	0.018*	–0.07	0.19	0.759	0.015*
26.	Inter-incisal angle	–3.04	2.71	0.203	–7.81	3.03	0.047*	0.226
27.	Overbite	–1.94	0.96	0.114	–3.09	0.71	0.009**	0.471
28.	Overjet	5.75	0.77	0.005**	5.53	0.45	0.005**	0.623
29.	Molar relation	1.67	0.60	0.021*	4.87	0.94	0.005**	0.038*
30.	SN/occlusal pl.	0.41	1.02	0.575	0.43	1.18	0.684	0.879
31.	Lower lip–aesthetic pl.	0.16	0.72	0.959	–0.22	0.53	0.594	0.734
32.	Upper lip length	2.46	0.84	0.037*	2.18	0.56	0.013*	0.405
33.	Nasolabial angle	–9.94	2.45	0.007**	0.83	2.10	0.647	0.017*
34.	Chronological age	0.83	0.11	0.008**	0.98	0.26	0.007**	0.733
35.	Skeletal age	0.85	0.39	0.008**	0.97	0.34	0.008**	0.879

$^*P < 0.05$; $^{**}P < 0.01$.

showed a significant decrease in this group. Soft tissue analysis demonstrated a significant increase in upper lip length and a significant decrease in nasolabial length (Table 2).

Face mask group

S–N length, SNA, Co–A, SN/GoGn, ramus height, Co–Gn, ANB, lower face height, and anterior and posterior face heights showed a significant increase at the end of the orthopaedic face mask therapy. Significant decreases were observed in SNB, facial depth, facial axis, and maxillo-mandibular differential. The inter-incisal angle significantly decreased. There was a significant increase in overjet, and significant decreases in overbite and molar relationship in the maxillary protraction group. Evaluation of the soft tissues demonstrated a significant increase in upper lip length (Table 2).

Comparison of chincap and face mask therapy

The SNA angle increased significantly more in the maxillary protraction group compared with the chincap group. Angular and dimensional parameters for lower incisor–NB showed significant differences between the groups. There was a significantly greater increase in the molar relationship in the maxillary protraction group than in the chincap group. While the nasolabial angle significantly decreased in the chincap group, there was a non-significant increase in the maxillary protraction group and the difference between the groups was statistically significant (Table 2).

Discussion

A Class III malocclusion is easily identified at a very early age, most typically evidenced clinically by the appearance of an edge-to-edge incisor relationship or an anterior crossbite (McNamara and Brudon, 1993). At this point, diagnosis is important for the selection of the treatment type, as individuals who exhibit a Class III malocclusion present a spectrum of abnormalities. Class III malocclusions with a combination of maxillary and mandibular aetiology require special consideration as the final correction may entail the use of orthognathic surgery.

Treatment effects of chincap therapy

The treatment effects of chincap therapy were seen as a significant decrease in SNB and an increase in ANB. It has been shown through several clinical (Suzuki, 1972; Irie and Nakamura, 1975; Üner *et al.*, 1995; Chong *et al.*, 1996) and experimental studies (Joho, 1973; de Albay Levy *et al.*, 1976; Asona, 1986) that chincap force is effective on the growing mandible. Sakamoto *et al.* (1984) pointed out that the improvement in the mesiodistal relationship of the maxilla and mandible seemed to be produced by a combination of the restraint of the expected annual increase in mandibular length, in addition to the distal displacement and rotation of the mandible. Mitani and Fukazawo (1986) believed that growth inhibition might take place in the mandibular body length, when such restriction was maintained for a long period. In the present study, no significant decrease was observed in mandibular body length (Co–Gn) over the treatment period.

Several investigators have found that vertical ramal growth is inhibited (Graber, 1977; Ritucci and Nanda, 1986). This suggests that the force transmitted through the mandible places pressure on the condyle and causes diminution in the ramus height in addition to a significant increase in posterior face height. Mitani and Fukazawo (1986) found a significant increase in condylion–gonion believed that this was responsible for bone apposition at the inferior border of the gonial angle. The non-significant decrease in Gn–Go–Ar found in this study is in agreement with the investigations of Sakamoto *et al.* (1984) and Graber (1977). Some investigators (Allen *et al*, 1993; Mimura and Deguchi, 1996) reported a slight increase of the gonial angle resulting in an increase in lower face height. The present study demonstrated a statistically significant increase in both anterior, posterior, and lower face heights, confirming previous findings.

As indicated in several studies (Sakamoto *et al.*, 1984; de Albay Levy *et al.*, 1976; Ritucci and Nanda, 1986; Allen *et al.*, 1993), the chincap in this investigation was not found to have a significant effect on the anteroposterior growth of the maxilla. Upper incisor protrusion, lower incisor retrusion, and reduction of the overjet are in agreement with the other chincap studies (Thilander, 1965; Ritucci and Nanda, 1986; Allen *et al.*, 1993; Üner *et al.*, 1995).

Treatment effects of face mask therapy

In keeping with previous studies (Ishii *et al.*, 1987; Mermigos *et al.*, 1990; Takada *et al.*, 1993; Ngan *et al.*, 1996a) a significant amount of maxillary forward movement represented by an increase in the SNA angle was found with the maxillary protraction appliance. Maxillary expansion and protraction resulting in maxillary forward movement, has been found to be stable 2 years after removal of the appliances (Ngan *et al.*, 1996b, 1998). The significant increase in

Co–A is in agreement with Mermigos *et al.* (1990). In an experimental study, Tanne and Sakuda (1991), pointed out that the maxillary complex exhibited tensile stresses in an anterior direction. Chong *et al*. (1996) reported that forward translation of the maxilla was greater in the treated patients compared with control groups. However, the inter-group differences were not statistically significant due to the limited maxillary advancement needed because repositioning of the mandible aided in the relatively rapid establishment of a positive overjet (Chong *et al*., 1996).

In this study significant increases in ANB and overjet and decreases in maxillomandibular difference [(Co–Gn)–(Co–A)] and molar relationship showed that Class III correction was achieved with the maxillary protraction appliance. These results are in accordance with several studies (Ishii *et al.*, 1987; Mermigos *et al.*, 1990; Takada *et al.*, 1993; Ngan *et al.*, 1996a,b; Chong *et al.*, 1996; Chen and So, 1996).

Many case reports and animal experiments concerning the effects of the maxillary protraction appliance have shown a downward movement with a backward rotation of the mandible (Dellinger, 1973; Ishii *et al.*, 1987; Tanne and Sakuda, 1991; Ngan *et al.*, 1996a; Chen and So, 1996). In this study, significant increases in SN/GoGn and lower face height were also observed. Significant decreases in SNB, facial depth and facial axis indicated a backward rotation of the mandible. This is contrary to Mermigos *et al.* (1990), who found no significant change in the anteroposterior position of the mandible, but a tendency for the mandibular plane and gonial angle to decrease through the maxillary protraction therapy. Chong *et al.* (1996), and Chen and So (1996) stated that backward repositioning of the mandible was greater than forward movement of the maxilla, while Ishii *et al*. (1987) reported that changes in the maxilla and mandible almost equally contribute to the correction of the anteroposterior jaw relationship when a combined chincap and maxillary protraction appliance is used.

Ishii *et al*. (1987) and Takada *et al.* (1993) believed that maxillary posterior tooth eruption resulted in a downward and backward rotation of the mandible. In this study, anterior and posterior face heights increased significantly, while no significant change was observed in the posterior/anterior ratio through the maxillary protraction therapy. These results agree with those of Mermigos *et al*. (1990).

The present study demonstrated significant increases in mandibular body length (Co–Gn). Chong *et al.* (1996) reported that mandibular length increased less in treated patients compared with controls. Mermigos *et al.* (1990) suggest that this linear increase is a reflection of growth rather than a direct result of therapy.

Evaluation of dentoalveolar parameters showed that there was a significant decrease in interincisal angle. Some investigators (Chong *et al.*, 1996; Ngan *et al.*, 1996a,b) reported significant retroclination of the mandibular incisors. In this study no significant change was observed. This contradiction might be as a result of different chincap forces in several protraction appliances.

Comparison of chincap and face mask therapy

The statistical comparison of chincap and maxillary protraction appliances showed that the protraction appliance had a significantly greater effect on the maxilla. Parallel to this finding, the correction in molar relationship was also significantly greater in this group. The decrease in angular and dimensional measurements of lower incisor–NB in the chincap group showed significant difference compared with the face mask group. This was an expected result since the force on the lower incisor region was greater in this group.

Conclusions

1. Both appliances were effective in the treatment of subjects with Class III malocclusions.
2. SNA angle, molar, and NB to lower incisor relationships, and nasolabial angle showed significant differences between chincap and maxillary protraction appliances. In addition to the aetiological aspect of the malocclusion these differences should be taken into consideration during treatment planning.

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