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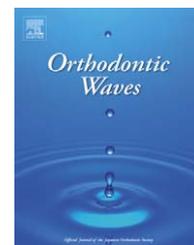
Research paper

The aggressive chin cup protocol (14 h/day for 2 years with excellent compliance) depends on commitment to overcorrection of the skeletal Class III malocclusion

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ABSTRACT

The effects of 2-year orthopedic treatment with a chin cup appliance were compared between: Group 1, 35 female patients from a private clinic who showed excellent compliance; Group 2, 31 female patients from a dental hospital, whose compliance ranged from good to fair; Group 3, an untreated control sample of similar female patients. All patients had anterior cross-bite and a negative ANB angle of at least $-2°$. The first group was treated with an aggressive protocol: 14 h a day for 2 years, force of 250–300 g, frequent monitoring to ensure compliance for the full 2 years and commitment to overtreatment of skeletal Class III malocclusion to improve stability. The second group was treated with a more routine protocol: night-time wear for 2 years, force of 500 g, commitment to correcting the anterior cross-bite (year one) with compliance tapering off in the second year. The third group was a cross-sectional sample of untreated females with similar Class III malocclusions. Group 1 showed significantly more skeletal correction. It was concluded that an aggressive protocol of chin cup therapy for 2 years is an orthopedic solution for developing Class III malocclusions.

1. Introduction

In general, the variables related to orthodontic/orthopedic treatment are: (1) the number of hours of wear/day, (2) the duration of treatment and (3) the magnitude of the orthopedic force applied. Because of compliance problems, fixed orthopedic appliances, such as a rapid palatal expansion appliance, are expected to be more effective than removable appliances, such as a chin cup or a face mask. In particular, the extent of patient compliance with removable appliances is usually the critical issue in determining the effectiveness of treatment.

Methods are available for determining the accuracy of a patient's report on appliance wear; headgear cooperation can be measured with an incorporated timer [1,2]. Cureton et al. [1]

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noted a poor correlation between a patient's report and the actual number of hours worn. Cole [2] indicated that one-third of the patients gave inaccurate reports of headgear use: reports of 69% of the patients were accurate at least 84% or the time, but 31% of the reports were accurate for 58% of the time or less. In the initial chin cup study [3], chin cup cooperation was tried to measure with a fixed timer but failed in several months because of quality of the timer. Recognizing limitations in reports on compliance, cooperation for aggressive chin cup therapy is reinforced by informing parents and patients about: (1) treatment benefits (goals), (2) pain expected in the treatment process and (3) potential problems at each therapeutic step [4]. Also immediate short-term rewards are helpful, and frequent monitoring of appliance comfort is essential.

The duration of chin cup use for mild discrepancies (ANB angle of about −2°) is usually approximately 2 years assuming adequate patient compliance [3]. Based on the above findings, two hypotheses were formulated. Hypothesis 1: patient compliance and commitment to overtreatment affects the outcome with chin cup therapy. Hypothesis 2: 2 years of chin cup wear with excellent compliance is sufficient to improve skeletal Class III abnormalities.

2. Materials and methods

2.1. Population sample

The chin cup treated patients were from a carefully controlled private clinic (Group 1) [5,6] and an institutional setting, dental hospital (Group 2) [3,5,7]. All the patients showed anterior cross-bite that was well corrected at the end of active treatment. Patient compliance was defined as excellent if the appliance was worn 80% or more of the prescribed time for the full 2-year treatment period (Group 1). Compliance was defined as fair–good (Group 2) if the chin cup was worn 80% of the prescribed time or more during the first year with a tapering off to 70% or less in the second year of treatment. Group 1 patients demonstrated excellent compliance in wearing a chin cup appliance for a minimum of 14 h/day for the full 2 years. The total force at the center of chin was 250–300 g. Group 2 patients had fair–good compliance in wearing a chin cup during a night-time wear (the minimum of 10 h) for 2 years; the average force at the center of chin was 500 g.

Group 1 consisted of 35 female patients with an average age of 9 years 5 months at the start of treatment (T0) and 11 years 6 months at the end of active treatment (T1). Group 2 consisted of 31 female patients with an average age of 8 years 9 months

at T0 and 11 years 4 months at T1 (Table 1). Although the authors recognize the importance of developmental age, chronological age was applied for the chin cup treated subjects in the present study. All treated cases at T0 showed −2° < ANB angle, negative overjet and positive overbite; and T1 dental casts showed a normal incisor relationship and an acceptable posterior occlusion in the treatment progress. All cases in both Groups 1 and 2 were randomly selected from the chin cup research project cases (roughly 400 well treated cases with full records at post-retention) with two sets of head films at T0 and T1.

The lateral head films at T1 were taken at the time stopping a chin cup use in the treated groups. However, Group 2 showed 2 years 7 months active use of chin cup, longer than that of Group 1 (2 years 1 month). In Group 1, 12 patients had all four bicuspids extracted and four had rapid palatal expansion (RPE), but none were treated with anterior protraction of the maxilla. In Group 2, four patients had bicuspid extractions and none had RPE. The timing of bicuspid extraction was different in the individuals, according to the degree of anterior crowding and first or second bicuspid extraction. The principal distinction for Group 2 was that most of the patients showed declining compliance in the second year of chin cup use, because the anterior cross-bite (chief complaint) was corrected at the first year. As evidence for the committed approach for Group 1, the head cup and hooks were changed two or three times to ensure patient comfort and reinforce compliance (Fig. 1A and B). The patients in Group 2 used the same (initial) head cup throughout the 2-year chin cup treatment. To evaluate the extent of monitoring patient comfort and compliance in Group 2, the treatment records in the dental hospital were reviewed but there was no clear pattern of patient monitoring as noted for Group 1. The excellent compliance group (Group 1) was well managed and carefully observed by the dental staff of the private clinic. The dental hospital provided an acceptable standard of care but the private clinic was more dedicated to ensuring patient comfort and compliance.

2.2. Cephalometric analysis

The reference lines (abscissa and ordinate) consisted of the reference FH line and a line perpendicular to the reference FH line passing through a point Sella. A computerized x–y coordinate program (Win Ceph, Rise Co., Japan) was used to identify and digitize the landmarks (Fig. 2). Cephalometric linear and angular measurements were analyzed statistically to elucidate the differences between the initial (T0) and second year (T1) of treatment in Groups 1 and 2, using the

Table 1 – Sample classification depending on patient compliance of chin cup treated groups.						
	T0		**T1**		**Ext.**	**RPE**
	n	Mean age (years)	*n*	Mean age (years)		
Group 1 (excellent compliance)	35	9.39	35	11.52	12	4
Group 2 (good to fair compliance)	31	8.73	31	11.12	4	0
Untreated skeletal Class III	325	10.08	283	12.00		
Total	391	9.40	349	11.55	16	4

Fig. 1 – (A) Shows an occipital-pull chin cup in Group 1. Note a patch work-head cup. (B) Shows a high-pull chin cup design in Group 1. Arrows indicate some of hooks changed.
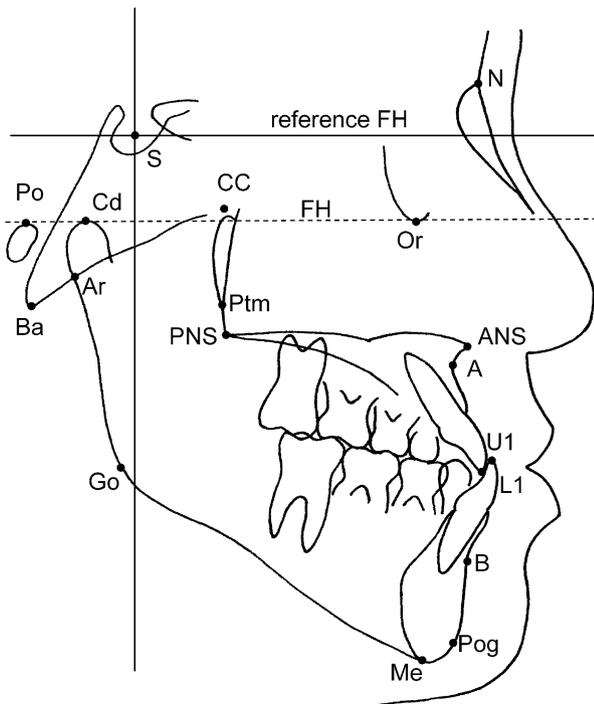

Fig. 2 – Landmarks used in cephalometric analysis.

unpaired Student's and Welch's t-tests (Table 2). A p-value less than 0.05 indicates a statistically significant difference. Measurements with statistically significant differences between the two groups are shown in the form of bar graphs (Figs. 3 and 4). Cephalometric measurements were achieved by well trained two orthodontists who were trained and worked at the same Facility, Department of Orthodontics. All cephalometric variables were measured twice and calculated carefully for statistical analysis.

The landmarks were obtained and analyzed using the X and Y values of the reference lines for constructing a skeletal framework (Fig. 5). Superimposition of the frameworks of Groups 1 (blue line), 2 (red line) and untreated Class III (black line) group [5] at T0 and T1 is shown in Figs. 6 and 7.

3. Results

There was no significant difference in the cranial base for the three groups at T0 and T1. Compared to Group 2 at T0, Group 1 showed a dolichofacial skeletal Class III pattern, associated with a larger discrepancy in the ANB angle, Wits appraisal and IMPA, but a smaller mandibular length (Table 2). The T0 – T1 difference in nasal floor inclination (NF to FH) revealed the

Table 2 – Cephalometric angular and linear measuerements in Groups 1 and 2															
	Group 1						Group 2						Group 1 × Group 2		
	T0 (n = 35)		T1 (n = 35)		T0 − T1 (n = 35)		T0 (n = 31)		T1 (n = 31)		T0 − T1 (n = 31)		T0	T1	T0 − T1
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	p-Value	p-Value	p-Value
Cranial base															
N-S	65.23	2.87	67.10	3.05	1.87	1.05	64.60	2.91	66.48	3.05	1.88	1.08	0.383	0.411	0.991
N-Ba	98.43	5.38	101.90	5.03	3.47	2.80	99.04	3.63	102.54	3.82	3.50	2.55	0.594	0.564	0.962
N-CC	52.40	3.17	54.36	2.68	1.96	1.92	52.48	2.73	54.06	2.90	1.59	1.86	0.916	0.669	0.427
CC-Ba	46.04	3.26	47.55	3.40	1.51	2.98	46.56	2.82	48.47	3.14	1.91	2.17	0.488	0.258	0.544
NSBa	131.33	4.72	131.45	4.84	0.12	1.48	130.05	4.73	130.65	5.21	0.60	2.05	0.276	0.517	0.281
NSAr	124.47	4.79	125.45	4.89	0.98	1.77	125.00	5.72	125.40	6.16	0.40	2.25	0.683	0.971	0.246
FH to SN	7.96	2.69	8.01	2.74	0.05	1.39	7.26	3.17	8.01	2.74	0.75	1.73	0.336	0.995	0.072
Maxilla and mandible															
SNA	78.84	2.73	79.11	2.87	0.27	1.01	80.27	4.22	80.73	4.05	0.46	1.10	0.102	0.064	0.482
SNB	78.11	2.51	76.21	2.39	−1.91	1.40	80.95	4.42	79.82	4.19	−1.13	1.72	0.002**	0.000***	0.047*
ANB	0.73	1.59	2.91	1.66	2.18	1.20	−0.68	2.08	0.92	1.82	1.59	1.70	0.003**	0.000***	0.107
Wits appraisal	−6.87	3.07	−2.29	2.28	4.24	2.88	−8.58	2.40	−5.14	3.36	3.45	3.03	0.015*	0.000***	0.286
SNP	77.03	2.53	75.72	2.36	−1.31	1.40	80.44	4.36	79.74	4.27	−0.70	1.71	0.000***	0.000***	0.117
ArGoMe	133.36	5.30	130.74	5.21	−2.63	2.14	131.25	4.50	130.32	4.82	−0.93	2.02	0.087	0.735	0.002**
Ar-Me	96.05	6.19	98.39	6.34	2.35	2.21	100.66	5.03	106.01	5.75	5.35	3.65	0.002**	0.000***	0.000***
Ar-Go	39.09	4.22	40.13	4.52	1.04	1.76	41.33	3.12	43.42	3.44	2.09	2.56	0.018*	0.002**	0.055
Go-Me	65.07	4.36	67.55	4.72	2.48	1.47	68.59	4.56	72.74	4.84	4.15	2.97	0.002**	0.000***	0.004**
Gn-Cd	104.29	6.59	107.24	6.64	2.95	2.34	109.17	5.50	115.01	6.31	5.84	4.01	0.002**	0.000***	0.001***
Facial height															
N-ANS	49.53	2.94	52.46	2.91	2.93	1.38	49.88	3.34	52.95	3.52	3.06	1.85	0.648	0.542	0.745
ANS-Me	60.50	4.15	62.18	4.82	1.68	1.98	61.71	3.79	66.41	3.99	4.70	2.85	0.223	0.000***	0.000***
NF to FH Pl.	1.05	2.61	1.79	2.76	0.74	1.51	1.81	3.17	1.15	2.67	−0.66	1.94	0.289	0.346	0.002**
FMA	31.73	5.62	31.69	5.38	−0.03	2.18	28.86	5.70	29.37	5.51	0.51	2.23	0.044*	0.088	0.323
Ramus A.	82.59	4.48	85.45	4.82	2.87	3.44	81.85	5.17	83.30	4.14	1.45	3.12	0.539	0.058	0.086
Dental															
FOP	15.24	4.56	13.38	4.42	−1.86	3.19	13.68	4.45	10.55	4.99	−3.13	4.15	0.167	0.017*	0.165
U-1 to FH Pl.	109.70	6.98	112.95	6.41	3.25	6.80	112.22	6.69	118.15	5.77	5.94	6.67	0.141	0.001***	0.111
L-1 to Mand.	92.31	5.31	87.51	6.09	−4.80	5.47	87.07	6.43	85.18	6.86	−1.89	5.31	0.001***	0.149	0.032*
Interincisal	126.26	8.84	127.86	9.28	1.60	10.53	131.85	8.14	127.29	9.42	−4.55	8.41	0.010**	0.806	0.012*

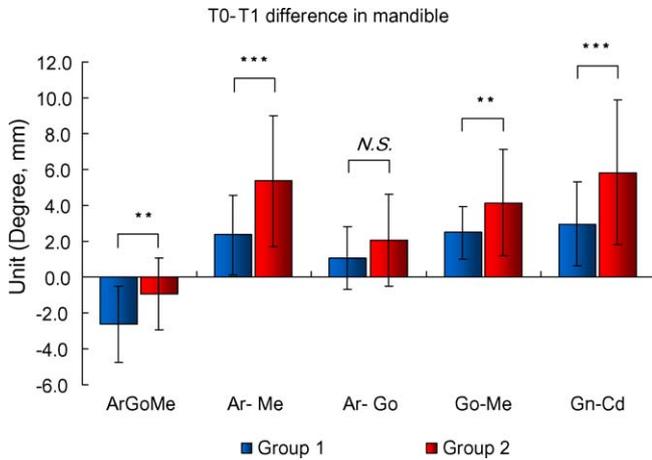Symbols indicate the level of significance; $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Fig. 3 – Cephalometric values of the mandible with significant differences between the two groups are shown as a bar graph.

opposite rotational direction: an increase of 0.74° in Group 1 and a decrease of 0.66° in Group 2.

The direction of pull of the chin cup tended to increase the lower anterior facial height (ANS-Me) because of a backward rotation of the mandible (Ramus pl to FH). The T0 − T1 difference in the anterior vertical height (ANS-Me) in Group 1 indicated that there was significantly ($p < 0.001$) less vertical growth and more backward rotation of the mandible than observed in Group 2 (Table 2; Fig. 4).

The T0 − T1 difference in the results of cephalometric measurements is shown as a bar graph (Figs. 3 and 4). Group 1 patients showed a significant inhibition of growth in the values of mandibular length to compare with those of Group 2, except for ramus height. The obtuse gonial angle (ArGoMe) in Group 1 was significantly ($p < 0.01$) decreased compared with that in Group 2, which contributed to the vertical correction of the initial dolichofacial abnormality (Fig. 3). The skeletal framework illustrations (profilograms) showed the overall differences in the extent of the orthopedic effects among Groups 1 and 2 compared with the untreated Class III group.
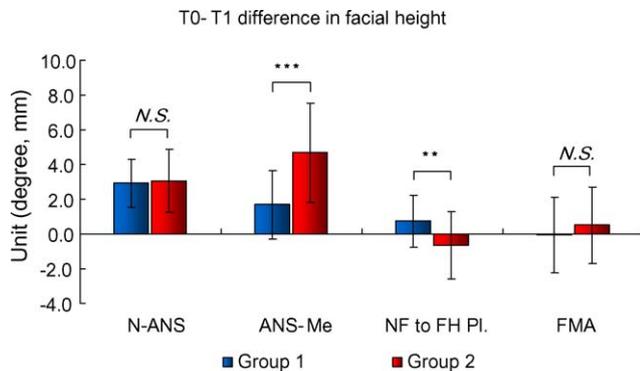

Fig. 4 – Measurements related to the anterior or vertical facial height with significant differences between the two groups are shown as a bar graph.
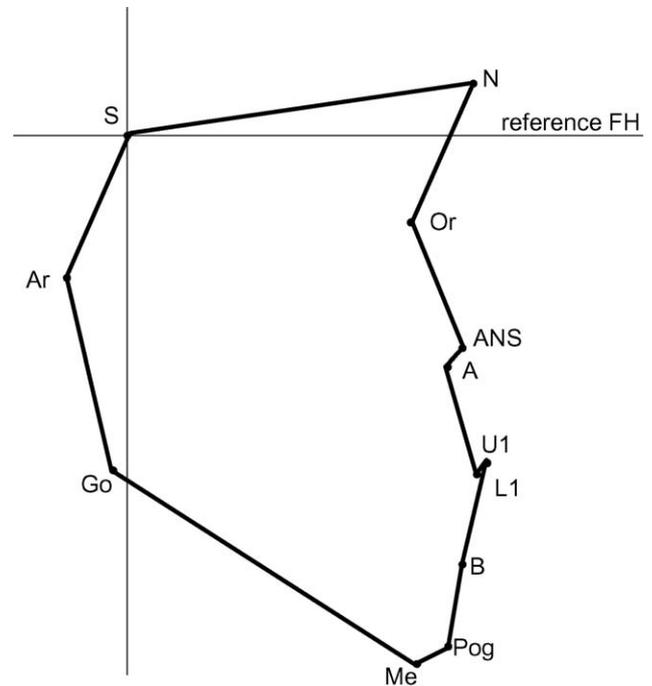

Fig. 5 – Landmarks used for skeletal framework (profilogram) composite.

4. Discussion

Previous studies of chin cup therapy have focused on 5-year treatment outcome and 5-year retention follow-up [5,6]. Studies of the skeletal framework as well as 4.5- [8] or 5-year [5] chin cup follow-up data showed positive improvement of skeletal Class III pattern or aggressive treatment outcome [5] of skeletal Class III malocclusion. However, a smaller degree of skeletal relapse (<25% of the active treatment change) was observed during the post-treatment period for the aggressive protocol. For instance, the post-treatment frameworks of Sugawara et al. [8] and Deguchi et al. [5] are quite different in terms of their effects on the mandible, although the treatment approaches (14 h/day) were similar. A long period of chin cup use (4–5 years) may be effective but it would be exceedingly difficult for a patient to comply. An effective 2-year treatment protocol is needed for the orthopedic approach to be a viable option. Data analysis for the present study has indicated that 2 years of chin cup use with excellent compliance and an aggressive monitoring approach is sufficient to correct skeletal Class III malocclusion. It has been reported that the aggressive protocol produces a more desirable and stable result, but it was not clear why. The present study compared active treatment effects for an aggressive versus a more typical 2-year treatment protocol, to elucidate the therapeutic differences associated with each approach. Group 2 patients were instructed to be less aggressive in promoting chin cup therapy after the anterior cross-bite was corrected because the correction of anterior cross-bite would lead to natural improvement of skeletal Class III malocclusion. On the other hand, the private orthodontist treating Group 1 patients believed that aggressive overtreatment of skeletal Class III malocclusion was necessary for a full 2 years to achieve a more stable result [5]. Thus, the different treatment philosophies
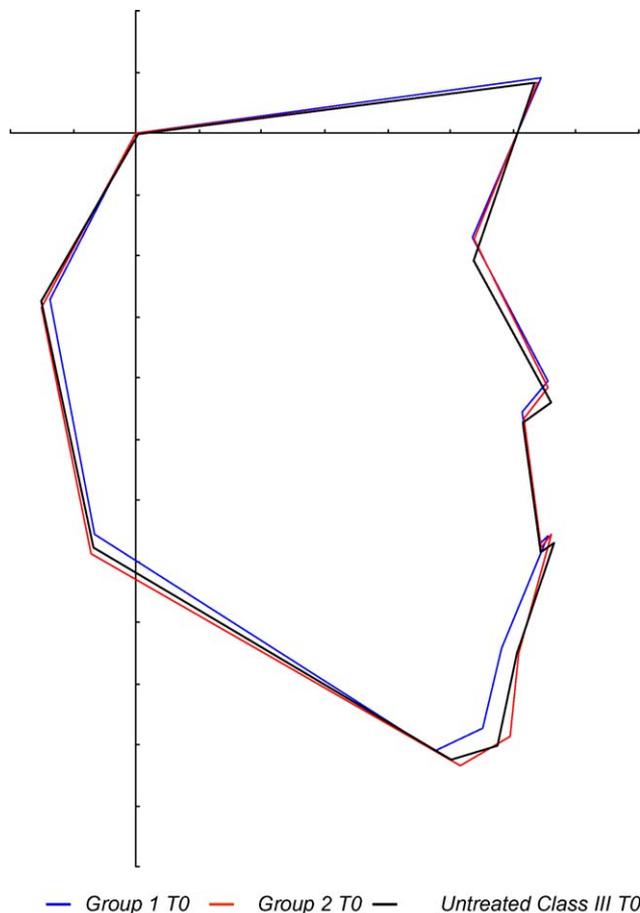
Fig. 6 – Superimposed skeletal frameworks of Groups 1 and 2 patients and untreated Class III group before treatment at T0. Blue line, Group 1; red line, Group 2; black line, untreated Class III group. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)
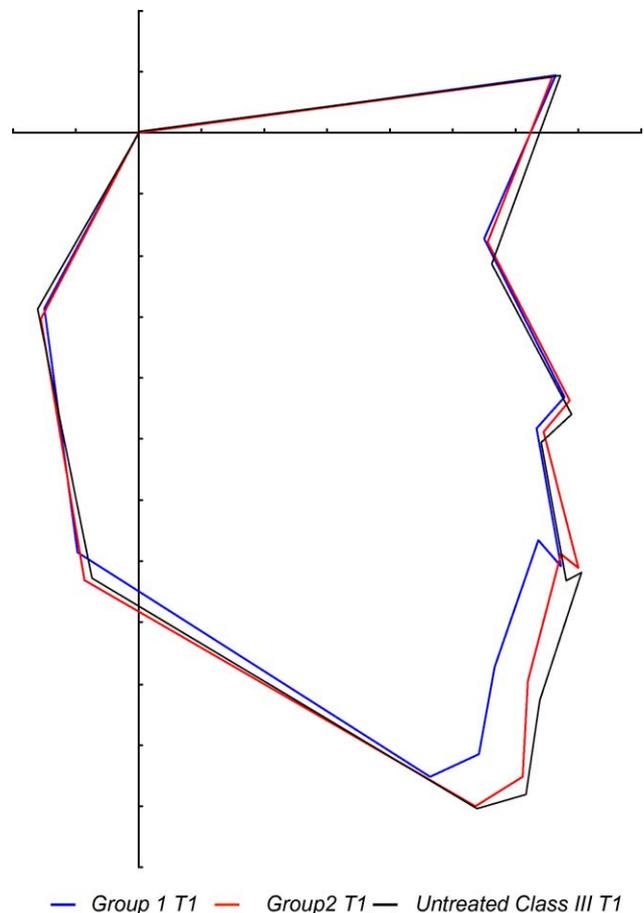
Fig. 7 – Superimposed skeletal frameworks of the two treated groups and the untreated Class III group at T1. Note the aggressive correction of skeletal Class III abnormalities in Group 1. Blue line, Group 1; red line, Group 2; black line, untreated Class III group. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

between the clinics appeared to be important in eliciting patient compliance.

Westwood et al. [9] reported that significant favorable changes in sagittal jaw relation were obtained after 10 months of active face mask therapy with RPE. They recommended aggressive overtreatment of Class III skeletal malocclusion to insure long-term stability of desired dental–skeletal relationships.

In the present study, Group II and the untreated skeletal Class III malocclusion data were applied comparable to the 2 years total changes of Group 1 subjects. Group II subjects at T0 showed more severe mandibular protrusion with mesiofacial pattern and chin cup treatment time was 6 months longer than those of Group 1, which may bring an average error at T0 – T1 differences in both chin cup groups. Although untreated skeletal Class III data was shown as a skeletal framework, statistical analysis of the cephalometric values was not calculated. Ref. [5] could be useful for understanding the details of chin cup treatment effects.

Previous studies [3,5] analyzed pretreatment (T0) to 5-year post-treatment (T1) differences for both short- and long-term

chin cup therapy. The Group 1 patients in the present 2-year study showed a 75% change in SNB angle, an 80% change in ANB angle and an increase in Wits appraisal compared with those observed in the 5-year study [5], which was sampled from the same private clinic. The Group 2 patients in the present study showed similar decrease of SNB angle, increase of ANB angle and decreased gonial angles compared with those of a 5-year study [3]. The unsuccessful treatment of early Class III malocclusion with a protraction face mask is associated with a more forward position of the mandible, a decreased ramal length, an increased mandibular length and more obtuse gonial angle [10]. Based on these published results, it is concluded that the control of mandible growth is the key to stability in skeletal Class III treatment. The application of a positive orthopedic force to the chin (mandible) with a face mask appliance is suggested for closing the obtuse gonial angle.

Recent reports have indicated only minor differences [11] or the same treatment effects [12] between a compliance-free and a compliance-dependent appliance. It is generally believed by most clinicians that a removable appliance is likely to be less

effective than a fixed one. Furthermore, moving molars distally with a compliance-free appliance may exert an adverse effect when attempting to move the anterior segments forward [13–15].

The tapering off and discontinuation of chin cup treatment is often an subjective factor. The majority of female patients, who were correctly diagnosed and treated with a chin cup, achieve correction of anterior cross-bite and acceptable posterior occlusion within 1 year. On the other hand, a more severe problem, with either negative ANB angle >−2° [16] and/or a dolichofacial Class III pattern, particularly in the case of a male patient [6], is more challenging. If an acceptable occlusion (anterior cross-bite correction) is not achieved after 1 year of chin cup therapy with good compliance, treatment is unlikely to be successful and should be stopped. The surgical option, which should have been explained before treatment as part of the letter of informed consent, should be pursued.

Non-compliance in chin cup therapy results in a longer treatment time, additional extraction of teeth, collapse or relapse of nicely treated malocclusion and frustration in the young patient [17]. To avoid those problems, the extent of mutual understanding between the orthodontist and the patient, as well as the personality of the patient are very important for predicting compliance [18–20]. Well-known psychological scales and tests could be used for predicting patient compliance [21]. The orthodontist must appear confident in the effectiveness of chin cup treatment and be prepared to carefully explain the diagnosis, treatment outcome, results and potential retention problems. Only then can the patient and parents understand the importance of compliance. If the orthodontist him/herself does not appear confident in the positive effects of chin cup therapy, the patient and his/her parents are unlikely to have the necessary commitment for successful treatment.

The importance of the present study was to document the greater correction of the skeletal deficit with an aggressive approach to treatment compared to a typical protocol.

5.   Conclusions

1. Hypothesis 1 is accepted. The extent of patient compliance and the commitment to overtreatment affects significantly the treatment outcomes of the 2-year chin cup therapy.
2. Hypothesis 2 is accepted. Combining the present results with our previous data [5,6], it is suggested that active 2-year application of a chin cup with excellent compliance (14 h/day, 300 g) improves the level of stability in skeletal Class III malocclusion.

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