Original Article

A comparison of two different techniques for early correction of Class III malocclusion

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ABSTRACT

Objective: To compare the effectiveness of Reverse Twin-Block therapy (RTB) and protraction face mask treatment (PFM) with respect to an untreated control in the correction of developing Class III malocclusion.

Materials and Methods: A retrospective comparative study of subjects treated cases with either PFM (n = 9) or RTB (n = 13) and untreated matched controls (n = 10) was performed. Both the PFM and control group samples were derived from a previously conducted clinical trial, and the RTB group was formed of consecutively treated cases. The main outcome variables assessed were skeletal and dental changes. Lateral cephalograms were taken at the start and end of treatment or during the observation period. Analysis of variance was used to compare changes in cephalometric variables arising during the study period in the lateral group. Linear regression analysis and an unpaired *t*-test were used to determine the impacts of treatment duration and gender, respectively.

Results: Significantly greater skeletal changes arose with PFM therapy than with RTB therapy or in the control group (SNA, SNB, and ANB; $P < .001$). The dentoalveolar effects of RTB therapy exceeded those of PFM treatment, with significantly more maxillary incisor proclination ($P < .001$) and mandibular incisor retroclination ($P < .006$) arising with treatment.

Conclusions: Both appliances are capable of correction of Class III dental relationships; however, the relative skeletal and dental contributions differ. Skeletal effects, chiefly anterior maxillary translation, predominated with PFM therapy. The RTB appliance induced Class III correction, primarily as a result of dentoalveolar effects. (*Angle Orthod.* 2012;82:96–101.)

KEY WORDS: Class III; Protraction face mask; Reverse Twin-Block appliance

INTRODUCTION

Early correction of a developing Class III malocclusion remains a complex challenge. Interceptive approaches include fixed appliances,[1] removable appliances,[2] removable functional appliances,[3–5] chin cup,[6,7] protraction headgear,[8,9] and skeletal anchorage systems.[10]

Encouraging outcomes have been reported[3–5] with use of reverse functional appliances, including the FR-III and Reverse Twin-Block (RTB) appliances in cases involving Class III malocclusion. Loh and Kerr[4] reported the successful correction of a developing Class III malocclusion with the FR-III appliance. The treatment effects reported included the following: mean upper incisor proclination of 1.8°, retroinclination of the lower incisors of 2.3°, and a mean change in ANB of 2°. Significantly, no increase in maxillary length was reported, indicating that treatment success relies on favorable dentoalveolar changes and the rotational effects of the mandible. Kidner et al.[5] demonstrated that the majority of changes induced by the RTB appliance are dentoalveolar changes, with upper incisor proclination of 5.5° and lower incisor retroclination of 4.5° reported. The mean change in ANB was 1.3°.

Protraction headgear has proven popular as the result of a perceived ability to modify dentofacial

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Figure 1. Reverse Twin-Block appliance in situ.

growth associated with this device. In a prospective follow-up study, Ngan et al.[9] reported a mean increase in overjet of 5.5 mm and an increase in maxillary protraction of 2.1 mm, on average. Correction of the incisor relationship was sustained in 90% of subjects 12 months after treatment. Similarly, Westwood et al.[11] reported a mean advancement of A-point of 1.5 mm and a mean increase in overjet of 4.6 mm. Interestingly, these treatment effects were stable over an observation period of 5 years and were generally unaffected by continued growth.

Long-term stability of these treated cases relies on the presence of continued favorable growth. In untreated Class III samples there is a tendency for this type of malocclusion to worsen with increasing age and following the postpubertal growth phase. In addition, ''catch-up'' growth of the skeletal bases has been reported following treatment with chin cup appliances[7] and protraction headgear.[12] Cephalometric variables associated with unfavorable long-term outcome following protraction therapy include increased mandibular length,[13] an obtuse gonial angle,[13] and a steep mandibular plane angle.[14]

It appears that early use of both intraoral and extraoral appliances in the mixed to late dentition can result in both positive skeletal and dental effects to a varying degree. A meta-analysis by Kim et al.[15] reported a greater skeletal contribution to the overall effect when protraction therapy was commenced before the age of 10 years. However, patients in the late mixed dentition have been reported[16,17] to benefit from treatment.

The aim of this research was to compare the dentoalveolar and skeletal changes occurring with a functional appliance (the RTB), protraction face mask treatment (PFM), and untreated controls.

MATERIALS AND METHODS

The clinical notes and hard-film cephalometric radiographs of subjects having RTB and PFM therapy and untreated subjects were obtained. All subjects were treated in Kent and Canterbury Hospital (UK) from 2002 to 2008. The study was granted institutional approval by the Research and Development Department, East Kent University NHS Foundation Trust. The PFM and untreated subjects were derived from a previous prospective investigation[18] conducted by two of the authors (MREC reference: 03/8/2).

The exclusion criteria included patients with a Class III malocclusion not amenable to interceptive correction; craniofacial syndromes, including cleft lip and palate; repeated histories of broken appliances and failed appointments; and unavailability of adequate records, including complete diagnostic records, treatment notes, and pre- and posttreatment lateral cephalograms. The inclusion criteria for the RTB group included the following: growing patients, anterior crossbite involving three to four incisors in ICP, and edge-edge incisor relationship in RCP with minimal dental decompensation of the upper and lower incisors. Both the PFM and untreated controls were part of a larger multicenter randomized clinical trial, and both the inclusion criteria and treatment protocol are described elsewhere.[18] A sample size calculation was performed based on the understanding that a change in ANB of 2.48° (standard deviation [SD], 3°) would be clinically significant. It was calculated that a sample size of at least eight subjects per group would guarantee a power of 80% at the 5% significance level, allowing detection of significant differences among the three groups. The quality of the radiographs was assessed by a single researcher.

Thirteen consecutively treated patients (six males and seven females) were included in the RTB group being treated by three operators. Adams cribs on molars or premolars and interproximal ball-ended claps were utilized for retention. A midline expansion screw was incorporated into the upper component to permit arch coordination. Upper and lower inclined bite planes at 70° to the occlusal plane and of a minimum height of 5 mm were placed bilaterally (Figure 1). A recurved spring was placed palatal to the upper incisors, and a lower labial bow was used to control the position of the lower labial segment.[19] Subjects were encouraged to wear the appliances on a full-time basis, with removal for toothbrushing, eating, and engaging in contact sports. Subjects were reviewed on a 4-week to 6-week basis; the appliance was discontinued following establishment of a positive overjet and overbite. Nine consecutively treated patients (two males and seven females) were included

Table 1. Pretreatment (T1) Clinical Characteristics[a]

Variable	Control, Mean (SD)	PFM, Mean (SD)	RTB, Mean (SD)	*P*-Value
SNA, °	80.8 (2.8)	81.2 (4.0)	80.0 (3.4)	.69
SNB, °	82.7 (3.2)	83.7 (3.2)	81.8 (3.8)	.49
ANB, °	−1.9 (1.4)	−2.4 (2.8)	−1.8 (1.8)	.76
Upper incisor to palatal plane, °	109.4 (7.1)	109.3 (5.3)	108.5 (5.8)	.92
Lower incisor to mandibular plane, °	91.0 (5.5)	91.1 (5.0)	87.8 (5.8)	.27
MMPA, °	24.2 (4.2)	24.1 (3.1)	23.3 (3.6)	.81
UFH, mm	46.5 (3.0)	47.3 (1.6)	48.2 (3.5)	.39
LFH, mm	57.2 (5.5)	59.4 (4.2)	57.8 (4.8)	.60
LAFH, %	55.0 (3.1)	55.4 (1.7)	54.4 (1.9)	.56

[a] PFM indicates protraction face mask treatment; RTB, Reverse Twin-Block treatment; SD, standard deviation.

in the PFM group. All patients were treated by a single operator (ATD). The control group consisted of 10 patients (three males and seven females) who were randomized to an untreated control group as part of a randomized controlled trial.[18]

Lateral cephalograms were taken at the start and end of the treatment (RTB group) or following the 15-month observation period (PFM and control groups)[18] using the same cephalostat in each group. All radiographs were hand-traced under optimal conditions, which consisted of the following: use of 4H lead pencil, high-quality tracing paper, and a well-lit light box.[20] Cephalometric analyses were performed to assess both dental and skeletal changes.

Overall 32 participants were included in the study. The mean overall age of participants was 9.2 years. Within each group the mean age was 8.5 (SD, 0.50) years, 8.8 (SD, 0.56) years, and 9.9 (SD, 0.99) years in the control, PFM, and RTB groups, respectively. The majority of participants were female (66%), with even gender distributions in the respective groups ($P = .48$). The three groups were also comparable with respect to pretreatment clinical parameters ($P > .05$; Table 1). The average treatment time and observation period for the RTB, PFM, and control groups was 9.23 months, 9.46 months, and 17.1 months, respectively.

Table 2. Intraexaminer Reliability for Angular and Linear Cephalometric Measurements

Variable	Mean Difference	95% Limits of Agreement
SNA, °	−0.10	(−1.33, 1.13)
SNB, °	−0.15	(−1.72, 1.42)
ANB, °	0.15	(−1.10, 1.40)
Upper incisor to palatal plane, °	0.30	(−0.54, 1.14)
Lower incisor to mandibular plane, °	−0.05	(−1.96, 1.86)
MMPA, °	−0.10	(−1.13, 0.93)
UFH, mm	−0.05	(−0.79, 0.69)
LFH, mm	0.05	(−0.27, 0.37)
LAFH, %	0.20	(−0.64, 1.04)

Statistical Analysis

Analysis of variance (ANOVA) was used to compare treatment effects between the three groups. Differences between individual groups were assessed by post hoc analysis. The effects of treatment duration and gender were assessed using linear regression analysis and an unpaired *t*-test, respectively. All data analysis was performed with the Statistical Package for the Social Sciences (SPSS Inc, version 13.0, Chicago, Ill) with a pre-specified level of statistical significance of $P < .05$.

The intraexaminer reproducibility of the cephalometric analysis was determined by retracing 10 randomly selected lateral cephalograms on two separate occasions by a single operator (JS) at an interval of 4 weeks. The level of agreement between the two sets of tracing was assessed using the Bland-Altman method.[21] An acceptable limit of agreement was demonstrated for each radiographic measurement (Table 2).

RESULTS

Pretreatment (T1) - Post treatment (T2)

All outcomes were measured on a continuous scale, and an examination of the distribution of the values indicated that all were approximately normally distributed. ANOVA was used to compare differences arising during the study period (Table 3). The greatest change in SNA occurred in the PFM group (mean 2.1°); this change was significantly greater than the results from the RTB group ($P < .001$), with little change arising in the control group. There was an overall mean reduction for SNB in both of the treatment groups ($P < .001$), although there was no significant difference between these two groups. The greatest mean change in ANB arose in the PFM group (3.8°); this change was also significantly greater than that arising with RTB therapy ($P < .001$).

A significant increase ($P < .001$) in maxillary incisor inclination in both treatment groups arose, with significantly more proclination arising with RTB therapy

Table 3. Changes Occurring in Each Group During the Study Period (T1–T2)[a]

Variable	Control, Mean (SD)	PFM, Mean (SD)	RTB, Mean (SD)	Overall *P*-Value	PFM vs CTB *P*-Value
SNA, °	−0.3 (0.8)	2.1 (0.9)	1.2 (0.7)	<.001	<.001
SNB, °	0.7 (0.8)	−1.7 (2.0)	−2.1 (1.2)	<.001	.52
ANB, °	−0.5 (1.1)	3.8 (1.3)	1.0 (1.3)	<.001	<.001
Upper incisor to palatal plane, °	0.3 (1.9)	4.0 (2.4)	9.0 (3.1)	<.001	<.001
Lower incisor to mandibular plane, °	−1.5 (3.0)	−2.2 (2.1)	−5.3 (2.2)	.002	.006
MMPA, °	0.2 (0.4)	2.6 (1.7)	1.7 (1.2)	<.001	.08
UFH, mm	2.2 (1.1)	2.3 (1.2)	1.5 (1.1)	.24	.14
LFH, mm	2.2 (0.9)	3.3 (1.3)	2.8 (1.5)	.17	.38
LAFH, %	0.3 (0.5)	1.4 (1.6)	0.7 (0.8)	.06	.09

[a] PFM indicates protraction face mask treatment; RTB, Reverse Twin-Block treatment; SD, standard deviation.

($P < .001$). Retroclination of the mandibular incisors was evident in all three groups ($P = .002$). Again, the greatest inclination change arose with RTB therapy ($P = .006$). There was a tendency for a significant increase in MMPA ($P < .001$) in both treatment groups, PFM (mean, 2.6°) and RTB (mean, 1.7°), but no difference between the two treatment groups ($P = .08$). Significant increases in overjet were noted in both treatment groups ($P < .001$).

The PFM group showed the largest mean improvement in skeletal discrepancy (4.2°); this change was significantly greater than those observed in both the RTB and control groups ($P < .001$). An unpaired *t*-test confirmed little gender-related difference between the groups (Table 4). There was also no difference in treatment duration between the two groups, PFM (9.46 months; SD, 2.74) compared to RTB (9.2 months; SD, 0.5).

In summary, there were significant overall differences among the three groups for the following variables: SNA ($P < .001$), SNB ($P < .001$), ANB ($P < .001$), upper incisor ($P < .001$), lower incisor ($P = .006$), and MMPA ($P < .001$).

DISCUSSION

It is well established that maxillary protraction may result in significant sagittal skeletal advancement of the maxilla, downward and backward rotation of the mandible, and retroclination of the mandibular incisors.[22] In contrast, the effects of the RTB appliance are primarily limited to the dentition, with resulting rotational effects on the dental bases.[5] This study generally supports these assumptions.

The sample investigated was well matched with respect to demographic and pretreatment clinical characteristics. Consequently, changes arising during the study period can be attributed to appliance therapy rather than being confounded by individual growth characteristics. This concordance may reflect the prospective collection of data in the PFM and control samples.

The primary effects of PFM therapy are skeletal in nature, with the greatest impact on the maxillary position, with significant sagittal advancement with a mean increase in SNA of 2.1°. These changes are in keeping with previous findings.[1,18,22] Mandall et al.[18] and Gallagher et al.[22] reported mean increases in SNA of 1.4° and 2.0°, respectively. With regard to maxillary base position, Ngan et al.[23] reported a mean increase of 2 mm. In addition, there was a significant reduction in SNB (mean, −1.7°; SD, 2.0°) and tendency for an increase in lower anterior facial height. These additive effects culminated in a significant reduction in ANB (3.8°). The vertical and mandibular effects of PFM are attributable to the downward rotation of the maxilla during application of protraction forces.[18] Slightly

Table 4. Effect of Gender on Changes During the Study Period (T1–T2)

Variable	Gender, Mean (SD)		*P*	Regression Coefficient (95% Confidence Interval)
	Female	Male		
SNA, °	0.3 (1.6)	−0.5 (1.5)	.20	−0.2 (−0.6, 0.3)
SNB, °	−1.0 (1.9)	−1.3 (1.9)	.75	−0.3 (−1.1, 0.5)
ANB, °	1.6 (2.2)	0.8 (1.9)	.32	0.0 (−0.8, 0.7)
Upper incisor to palatal plane, °	4.1 (4.6)	6.4 (4.1)	.17	−0.6 (−2.1, 0.9)
Lower incisor to mandibular plane, °	−3.2 (2.9)	−3.3 (3.1)	.94	−0.7 (−2.1, 0.6)
MMPA, °	1.5 (1.8)	1.3 (0.9)	.69	0.2 (−0.5, 0.9)
UFH, mm	2.0 (1.2)	1.9 (1.0)	.88	0.2 (−0.4, 0.9)
LFH, mm	2.8 (1.6)	2.8 (0.6)	.91	0.1 (−0.6, 0.8)
LAFH, %	0.9 (1.2)	0.5 (0.7)	.38	0.0 (−0.6, 0.6)

greater proclination of the maxillary incisors and less retroclination of the mandibular incisors arose in our group compared to those values reported by Mandall et al.,[18] highlighting the variability in response to protraction forces.[23]

A minimal effect on SNA (mean, 1.2°) arose with RTB therapy. These minor changes were analogous to those arising in the untreated control groups and may purely reflect continued maxillary growth during treatment. The effect on SNB (mean, −2.1°; SD, 1.2°) was greater than that arising with PFM therapy, indicating a greater downward and backward rotational effect. However, skeletal changes were slightly lower than those reported by Kidner et al.[5] Correction of the incisor relationship arose predominantly as a result of dentoalveolar effects. More significant dental changes were reported in the present study than in a previous case series,[5] with almost 4° more maxillary incisor proclination in the present sample. This finding may reflect activation of the palatal spring used in the design of the RTB appliance used in this study. Furthermore, the intersecting 70° occlusal blocks introduce a significant Class III traction effect on both the mandibular and maxillary dentitions. The relative lack of positive skeletal changes with RTB detracts significantly from the value of the appliance. Longitudinal analysis[24] of Class III subjects during adolescence has demonstrated a 6-mm discrepancy in maxilla-mandible growth relative to skeletal Class I controls; consequently, skeletal changes are essential during growth modification to compensate for likely deterioration in the preordained Class III growth pattern.

Both Mandall et al.[18] and Ngan et al.[23] reported increases in overjet (4.4 mm and 6.2 mm, respectively) with PFM therapy. Interestingly, in this study both treatment modalities resulted in similar changes in overjet: PFM (mean, 5.6 mm; SD, 0.5 mm) and RTB (mean, 5.5 mm; SD, 1.1 mm). However, it is important to appreciate the relative contributions of the skeletal and dental changes to the overjet correction. Gu et al.[1] reported the skeletal contribution as a result of protraction forces to measure 40%.

Parallels can be drawn from this study, with the increase in overjet a reflection of greater skeletal than dental contribution with protraction headgear therapy; the reverse applies for the RTB group.

As the PFM and control groups were recruited and observed prospectively, they were unlikely to be the subjects of selection bias. Conversely, the RTB sample was obtained retrospectively. Hence, the beneficial effects of this appliance may be magnified. It should be remembered, however, that participants in the PFM group may have been particularly compliant and motivated as a result of the Hawthorne effect. In addition, as a result of the difference in timing related to when postlateral cephalograms were taken, the effects of the PFM could be slightly underestimated as a result of potential relapse during the observation period. Nevertheless, the design of this study ensures that the benefits of protraction headgear are unlikely to have been overestimated.

While gender-specific Class III growth patterns have been reported,[24] with greater horizontal growth in females and vertical changes in males, no significant differences were reported between males and females in the present study. Treatment length with the RTB appliance was similar to that with PFM. The duration of treatment, however, was still 3 months longer than that reported by Kidner et al.[5] This variation could be related to the period of buccal settling following establishment of a positive overjet and overbite during RTB therapy. Similar skeletal change with PFM therapy has been induced with shorter courses of treatment.[23,25] Nevertheless, more prolonged treatment with PFM may facilitate overcorrection and may favor prolonged stability.

Although there was no significant intergroup difference with respect to age, the mean age of those in the RTB group exceeded that of those in the RTB group by over 1 year. The potential for further mandibular growth could have been assessed with reference to the cervical vertebral maturation technique.[26] However, the repeatability and validity of this technique have been questioned,[27] based on interobserver agreement of no more than 62%. In addition, given that the mean chronological age was less than 10 years, it is likely that both sets of participants were in almost identical developmental stages of the cervical vertebral maturation,[26] primarily stages 1 and 2. Therefore, growth-related changes are unlikely to have led to the improved skeletal changes achieved with PFM compared to RTB.

CONCLUSIONS

- PFM and RTB therapy are effective (compared to effects in untreated controls) in the early treatment of a Class III malocclusion. However, long-term stability of these treatment effects will be influenced by favorable growth.
- The primary effects of the RTB appliance are dental, as characterized by upper incisor proclination and lower incisor retroclination, with minimal skeletal effects.
- In contrast, significant maxillary advancement and less pronounced dental changes occurred with PFM therapy.

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