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Evidence on Early Correction of Class III Malocclusion

Abstract: The presence of high quality evidence on the dentofacial orthopaedic correction of Class III malocclusion is scarce. Long-term follow-up of growth modification has reported mixed results. The aim of this article is to review the literature on the early correction of Class III malocclusion and to provide some clarification on the following important issues: definite types of treatment modalities for treatment of Class III malocclusion; case selection; short-term and long-term effects of different treatment modalities; timing of treatment; success rate and skeletal and dental effect of different treatment modalities.

Clinical Relevance: Early treatment of Class III patients with maxillary deficiency using appliances such as protraction facemasks can be used to maximize maxillary growth potential in appropriate cases. However, correct diagnosis and understanding of the individual growth pattern is imperative in determining the success of early Class III treatment.

Ortho Update 2011; 4: 82–88

Longitudinal data on untreated Class III malocclusions was scarce until the late 1980s,[1,2,3] when compared to the data available on Class I or Class II malocclusions. The factors responsible were the low prevalence of Class III malocclusions in a non-Asian population and the lack of well-designed randomized control trials (RCT) on early intervention for Class III malocclusion. Therefore, it is difficult to propose a definitive management protocol for these patients. Many types of appliances for early correction of Class III malocclusion have been used in the past (Table 1). Some of these appliances have been used solely or in conjunction with other appliances.

Removable and 2 x 4 fixed appliances are generally used for the correction of anterior crossbites of non-skeletal origin. Other appliances, such as chin cups, protraction facemasks (Figure 1) and maxillary expanders (Figure 2, 3 and 4) are used for the correction of skeletal Class III malocclusions. The relative orthopaedic and dento-alveolar effects are shown in Table 2.

Grinding or extraction of Cs
URAs with Z/T springs
2 x 4 appliances
Chin cup therapy (CCT) ■ Vertical pull (for increased anterior LFH) ■ Occipital pull (for prognathic mandible)
Protraction facemask therapy (PFM)/Reverse pull headgear
PFM+ Rapid maxillary expansion (RME)
CCT + PFM + RME
Frankel III (FR 3)
Temporary anchorage device (TAD) + URA + Class III elastics

Table 1. Methods used for correction of Class III malocclusion.

The orthopaedic effects are

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Figure 1. Protraction facemask with anterior hooks to effect downward and forward pull of maxilla with elastics.

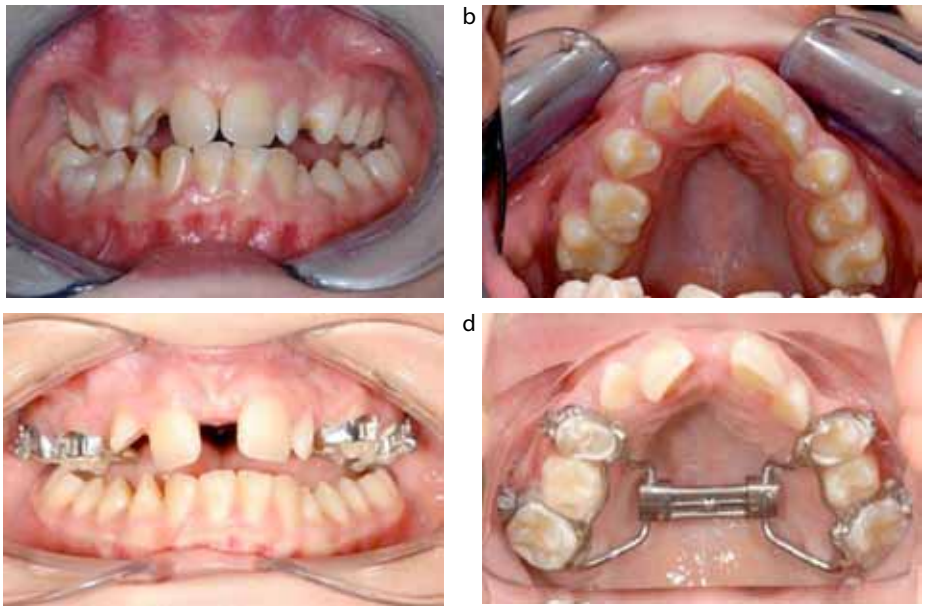

Figure 2. (a, b) Before expansion; **(c, d)** after expansion with RME in a Class III patient.

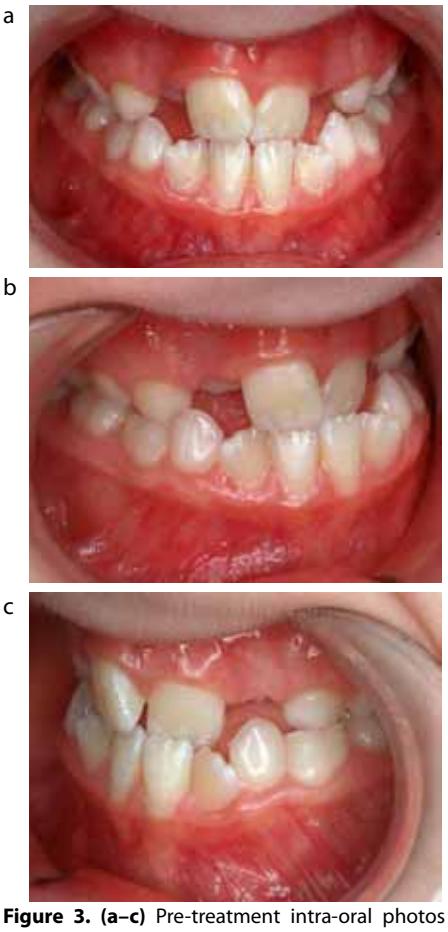

Figure 3. (a–c) Pre-treatment intra-oral photos of an 8-year-old with Class III malocclusion and bilateral posterior crossbites.

Figure 4. (a–c) Near end treatment intra-oral photos showing early correction of Class III malocclusion and posterior crossbites.

subject to considerable controversy:

- Are the orthopaedic effects sustained long-term?;
- The amount of orthopaedic change is much debated in the literature;
- The age of the patient undergoing treatment is important for the most beneficial effects.

We aim to review the recent orthodontic literature to seek answers to the above controversies. In addition, we will review the available evidence as to whether facemask therapy (PFM) is beneficial with or without maxillary expansion.

Protraction facemask therapy (PFM) with or without rapid maxillary expansion (RME)

The use of RME devices have been advocated in the past with PFM,[4] based on the assumption that it disrupts the circum-maxillary sutures and initiates downward and forward movement of the maxillary complex. Other benefits of RME are the transverse expansion of narrow maxilla, correction of buccal crossbite, increase in arch length and reduction of deep bite. The amount of maxillary protraction with PFM and RME was shown to be 2 mm more than in PFM without RME.[4] However, the limitations of this Korean-based study was the absence of a control group or any randomization. Another RCT compared the effects of maxillary protraction with and without RME and found no significant difference between the treatment outcomes.[5] The author recommended that, in the absence of objective reasons (such as buccal crossbite or arch length deficiency) for expansion, it does not aid the correction of Class III malocclusion. Presence of a control group differentiated treatment effects from normal growth in this trial,[5] but for limitations of cranial-base superimpositions, the occlusal-plane analysis was used to assess all the post-treatment changes. Therefore, the use of

Treatment	Skeletal effects	Dental effects	Soft tissue effects
CCT	■ Inhibition of mandibular growth. ■ Backward redirection and posterior positioning of mandible. ■ Inhibits vertical mandibular growth.		
PFM	■ Forward and downward growth of maxilla. ■ Tipping of maxillary plane anteriorly upwards and posteriorly downwards.	■ Proclination of maxillary incisors. ■ Lingual tipping of mandibular incisors.	■ Forward movement of upper lip. ■ Soft pogonion moves backwards. ■ More convex profile with menton moving downwards.
RME (used with PFM)	■ Transverse maxillary expansion. ■ Forward and downward maxillary movement. ■ Downward and backward rotation of mandible and increase in anterior LFH. ■ Widening of alar base width.	■ Midline diastema between I/I. ■ Buccal tipping and extrusion of posterior maxillary teeth.	
Frankel III (FR 3)	■ The lip pads and buccal shields create space for the forward displacement of the maxilla and for bone deposition on the posterior borders of the maxillary tuberosity. ■ Backward and downward rotation of the mandible.	■ Proclination of maxillary incisors. ■ Retroclination of mandibular incisors.	■ Aids in creation of anterior oral seal.

Table 2. Theories on the mode of action of different orthopaedic appliances for the correction of Class III malocclusion.

RME with PFM should be advocated only in the presence of transverse maxillary deficiency, or in those cases with shortened dental arch length.

Measurement of change

The common use of cephalometery for this purpose is widely acknowledged, however, review of the literature indicates some measurement methods are less erroneous than others. This would suggest that linear measurements[6,7,8] (Pancherz's and Pitchfork analysis) are less invalid than the angular measurements (Eastman analysis). Additionally, plaster models have been used for the purpose of assessing the dento-alveolar changes.

Immediate effects

Chin cup therapy (CCT)

The use of CCT decreased the mandibular prominence as an immediate effect with an ANB change of approximately 2° in a non-Caucasian sample with a mean age of 8years.[9] However, the severity of antero-posterior (AP) jaw discrepancy is the key determinant in evaluating the success of CCT. Since there was no power calculation, randomization or presence of a control group, the differentiation of normal growth from treatment effects was not possible here.

A cohort of 24 Japanese female patients who received CCT showed significant improvement in the ANB immediately post-treatment in an older age group (mean age of 10.10 years).[10] Although this study is commonly quoted in many publications, it has multiple fundamental flaws, including:

- Selection bias (only female gender used);
- Reporting bias (the total sample size was 40 whereas only 25 were discussed);
- The study only reported on angular measurements; and finally
- The standard deviations were high (±2.8°), which could lead to the inappropriate interpretation of results.

Additionally, no power calculation or randomization was present. The results of this study should therefore be considered with caution.

The immediate effects of CCT on a non-Caucasian sample are decreased mandibular prominence and significant decrease in ANB. The amount of these changes are, however, unclear from the literature.

Protraction facemask+rapid maxillary expansion (PFM+RME)

A multicentre RCT on a prospective Caucasian (N = 35) and control (N = 38) sample,[11] has reported a positive ANB difference of 2.1° ± 2.3° between the PFM+RME group and the control group. The forward movement of SNA was statistically significant at 1.4° ± 2.1°. There was a small statistically and

Study	Tx Groups	Results: Immediate effect	Result: Long-term effect	Comments
Mandall *et al*[11]	■ PFM+RME ■ RCT ■ Caucasian ■ Tx (N=35) vs Control (N=38) ■ Prospective control ■ No retainer	**ANB (°):** Increased in Tx 2.1° cf control **O/J:** Increased 4.4 mm cf control **PAR:** Improvement in Tx group by 32% **TMJ:** No effect of Tx **Piers-Harris scale:** No difference **OASIS:** No psychological benefit of Tx	Ongoing trial	■ Intention to treat analysis used ■ No confounder/s
Baccetti *et al*[13]	■ PFM+RME ■ Prospective study ■ Caucasian ■ Tx (N=46) vs Control (N=32) ■ Prospective control ■ No retainer	**ANS-Vert Ptm (Mx forward movement):** ■ 2.8mm E Tx gp vs 0.7mm in control ■ L Tx gp vs control NS **Co-A (Mid face length):** ■ 3.8mm E Tx gp vs 2.4mm in control ■ L Tx gp vs control NS **B-VertT (Md Forward movement):** ■ -0.09mm E Tx gp vs 1.9mm control ■ -0.54mm L Tx gp vs control	Not undertaken	■ Early (E) Tx gp mean age at start was 6.9±0.7yrs ■ Late (L) Tx gp mean age at start was 10.3±1yrs ■ Standardized force level for all subjects ■ Most measurements were linear
Westwood *et al*[12]	■ PFM+RME ■ Prospective study ■ Caucasian ■ Tx (N=34) vs control (49) ■ Retrospective control	**ANB (°):** Increased 3.4° in Tx cf control **Mx:** +2.4mm Tx vs +1.3mm control **Md:** -1.7mm Tx vs +1mm control **O/J:** Increased 4.8mm in Tx cf control **O/B:** 1.2mm Tx vs 0mm control	**At 5.5yrs from start of PFM +RME (included fixed appliance phase)** **ANB (°):** Increased 2.9° in Tx cf control **Mx:** +9.2mm Tx vs +7.6mm control **Md:** +3.3mm Tx vs +6.3mm control **O/J:** Increased 4.4mm in Tx than control **O/B:** 0.7mm Tx vs 0.7mm control (same)	■ Does not represent true long-term effects of PFM+RME as it included phase of fixed appliance and retainer used (both confounders)
Hagg *et al*[16]	■ PFM+RME ■ Prospective Tx (N=21) ■ No control ■ Non-Caucasian sample	**Stable (S) vs Relapse (R) group** **O/J:** +5.4mm S vs +3.7mm R **Mx:** +2.1mm S vs +1.8mm R **Md:** +0.6mm S vs +0.4mm **O/B:** 2mm S vs 0.3mm R	**At 8 yrs from starting the PFM+RME (including fixed appliance phase)** **O/J:** +2.8mm S vs -2.6mm R **Mx:** +8mm S vs +5mm R **Md:** +12mm S vs +15mm R **O/B:** 1.8mm S vs 0.5mm R	■ No control group ■ Fixed appliance phase as confounder
Nang *et al*[17]	■ PFM+RME ■ Tx (N=20) vs Control (N=20) ■ Non-caucasian sample ■ Prospective Tx but control? ■ Retainer used	**ANB:** not given **O/J:** +6.1mm Tx vs -1.0mm control **Mx:** +1.9mm Tx vs +0.5mm control **Md:** -1.3mm Tx vs+1.7mm control **O/B:** -1.8mm Tx vs +0.7mm control	**4 yrs post-Tx follow up** **ANB:** not given **O/J:** +5mm in 15/20 Tx vs -0.7mm control **Mx:** +7mm Tx vs +4mm control **Md:** +9mm Tx vs +11.3mm control **O/B:** -1.2mm Tx vs +2.5mm control	■ No data description in tables or graphs ■ No rigorous criteria ■ Confounder as retainer used
Kim *et al*[18]	■ **Meta-analysis** ■ PFM+RME	**PFM with RME** **ANB(°):** +2.9° **SNA(°):** +1.6° **SNB(°):** -1.3°	**PFM without RME** **ANB(°):** +2.7° **SNA(°):** +1.7° **SNB(°):** -1.2°	**G1 (Tx started < 10yrs)** **ANB(°):** +3.8° **SNA(°):** +2.2° **SNB(°):** -1.6° **G2 (Tx started < 15yrs)** **ANB(°):** +2.8° **SNA(°):** +1.6° **SNB(°):** -1.2°
N: number of subjects included Tx: Treatment group, Mx: Maxilla, NS: Not Significant				

Table 3. Summaries of studies investigating the effects PFM±RME.

clinically insignificant increase of 1.8° in the maxillary mandibular plane angle (MMPA) in the PFM+RME group. In addition, the lower incisors were retroclined to the mandibular plane angle by 4.9° compared to the control group at 1.2°. The overjet improvement was statistically significant in the PFM+RME group at 4.4 ± 2.7 mm. The treatment success rate was reported to be 70% (23/33) with the establishment of a positive overjet.

The PAR improvement in the PFM+RME group was 32% as compared to the control group, which deteriorated further by 8%. This PAR improvement was statistically more significant ($p<0.001$) in the PFM+RME group than the controls. The active treatment in the PFM+RME group lasted between 6–12 months and no functional appliance or retainers were used post-treatment to eliminate any confounders.

A temporo-mandibular joint (TMJ) examination was undertaken at the baseline, during the trial and at the end. The main finding was that the PFM+RME sample had elimination of forward mandibular displacement on closure. There was no resultant TMJ problem with this treatment. In contrast, the number of cases exhibiting forward mandibular displacement increased in the control group. A sample size calculation was undertaken and both the treatment and control groups were matched for age (7–9 years), gender, malocclusion (3–4 incisors in crossbite in intercuspal position, skeletal Class III, ANB, overjet and PAR). The intention to treat analysis was carried out, thus reporting on all the sample groups clearly.

Additional measures were undertaken using the self-concept Piers-Harris scale. No statistically significant difference was found between the two groups with the Piers-Harris scale ($p = 0.22$). The treatment group (PFM+RME) were statistically less significantly ($p = 0.003$) concerned by their malocclusion at the end of the trial when measured with OASIS (quality of life influenced by receiving early treatment of Class III malocclusion), which meant there was no psychosocial benefit of this treatment.

Another prospective study showed significant ANB (3.4° ± 1.3°) $p<0.001$ improvement in the treatment group when compared to the control.[12] The SNA showed a net significant increase (1.6°) $p<0.001$ with treatment when compared to the control group. The mandibular plane angle increased by 1°, which was clinically insignificant ($p<0.5$) compared to the control group immediately post-treatment (1 month post-treatment). The overjet improved significantly by 4.8 mm in the treatment group when compared to the controls. All the above findings are comparable with a recent study by Mandall *et al*.[11] However, there were some basic flaws in this study,[12] such as no sample size calculation and there was no indication of the design of the retainer post-maxillary expansion, which could have been the confounder.

Baccetti *et al*[13] noted a significant forward displacement of the maxillary complex (mean annual increment of 2.7 ± 1.1 mm) immediately after PFM+RME therapy (1 month post-treatment) when compared to the control group (0.76 ± 0.79 mm). Additionally, a small annualized increment in mandibular protrusion (-0.09 ± 1.1 mm) was found in treatment cases when compared to the control group (1.98 ± 1.33 mm). All these changes were seen immediately post-treatment in a younger age group with a mean age of 6.9 ± 0.7 years. All the findings were recorded as linear changes rather than angular measurements, therefore comparison between this study[13] and the clinical trial[11] is somewhat difficult. All the effects of PFM+RME in various studies have been listed in Table 3.

It would be fair to conclude that the immediate effects of PFM+RME are the significant improvement of ANB ($p<0.001$), SNA ($p<0.001$) and overjet with a clinically insignificant ($p = 0.004$) increase in MMPA.

Frankel III (FR 3)

A retrospective Caucasian study has demonstrated an increase in AP midface length of 1.3 mm over the control group after treatment with a FR 3.[14] The Wits analysis used in the FR 3 group showed a mean increase of 2.1 ± 1.9 mm compared to the control group with -0.6 ± 2.2 mm. The overjet increased by 3.9 mm in FR 3 treatments when compared to the control group. There was no significant difference ($p<0.01$) in the vertical dimension between the FR 3 and the control group. The mean age at the time of FR 3 treatment was 7 ± 1.4 years. The inclusion criteria of this study was not rigorous in identifying those Class III cases which had undergone FR 3 treatment, as the Wits appraisal and prevention of an anterior crossbite were used as a selection measure. Both the measures can mask the extent of an underlying skeletal pattern.

Long-term effects

No time scale has yet been devised to categorize the effects of an intervention as being long-term or short-term, utilizing evidence-based methodology.

Chin cup therapy (CCT)

Deguchi and Kitsugi[10] reported on the effects of CCT after a retention phase (4 years) and indicated that the post-treatment effects were sustainable in both the pre-pubertal and post-pubertal groups. This study had multiple flaws, which have been discussed under the previous 'immediate effect' sections. The compliance in CCT wear was the variable contributor which may have affected the results. There was some reporting of TMJ pain and difficulty in mouth opening after the wearing of this appliance in the long term but so far no direct link between the two has been established.[15] The long-term effects of this study have to be interpreted with caution; hence there is insufficient evidence to comment upon the long-term effects of CCT.

Protraction face mask + rapid maxillary expansion (PFM+RME)

Westwood and co-workers observed a treatment and control group for a mean period of 6.5 ± 2 years after PFM+RME therapy.[12] Even though there were significant short-term outcomes of PFM+RME (the midface length increased and annual mandibular length was less compared to the control group), the overall craniofacial modifications for the treatment group and the control group were similar in the post-treatment observation period. However, a positive overjet was maintained in 26 out of 34 patients. The post-treatment observation period was misleading as it included the phase of fixed appliance therapy.

Another study[16] assessed a Class III non-Caucasian sample and followed the treatment outcome for the longest period to date (mean follow up 8.1 ± 1.5 years). This study reported a high dropout rate (8 out of 30 subjects) at the 8 years follow-up and had uneven gender distribution (17♀ and 4♂). The implications of having uneven spread of the two genders can be linked to increased mandibular growth for a longer period and therefore low success rate. The long-term results have been interpreted by grouping the sample in stable (14/22) and relapse (8/22) groups, dependent on positive overjet and reverse overjet, respectively, therefore eliminating a reporting bias. The overjet and the jaw base relationship remained statistically significantly improved ($p<0.001$) in the

stable group compared with the relapse group. In the vertical plane there was no difference between stable and relapse groups.

Nang *et al*[17] undertook a prospective study on a sample of 20 non-Caucasians. The cases were control matched in age, gender and the severity of Class III malocclusion. The cases and controls were assessed on lateral cephalograms immediately post-treatment, 2 years after treatment and finally 4 years after treatment. The mean age of the patients was 8.2 ± 1.3 years. The mean improvement in the overjet was 6.1 mm in treated cases as compared to controls, where the overjet deteriorated to -1 mm immediately after treatment. Finally, positive or edge-to-edge overjet was maintained in 15/20 cases at the end of 4 years. The mean annual forward movement of the maxilla was higher (1.9 mm) in the treatment group than control group (0.5 mm). At a 4-year observation period, the maxilla showed a mean forward movement of 3 mm in the treatment group when compared to the control group. The mandible moved distally by a mean value of 1.3 mm in the treatment group when compared to the control group where it moved forwards by a mean value of 1.7 mm immediately after treatment. On the final 4-year post-treatment observation, the mandible on average was 2 mm less prognathic in the treated group than the control group. The lower face height increased and overbite reduced in the treated group compared to the control group at the end of the 4-year post-treatment observation period. The results of this study should be interpreted with caution owing to the complete absence of tabulated or graphic description of the data. All the results were completely descriptive without any standard deviations. Additionally, there was no mention of ethics, randomization, power calculation, statistical tests, consort diagram or rigorous inclusion, exclusion criteria or reporting of error of methods. Finally, some patients, but not all, wore a retainer after the active phase of PFM+RME treatment. This might have introduced a confounder to alter the results of this study.

There is lack of substantial evidence to comment upon the long-term skeletal effects of PFM+RME. However, a positive overjet is maintained in 2/3 of the treated cases but these outcomes may be dependent upon the severity and extent of Class III malocclusion.[18]

Frankel III (FR 3)

The long-term outcome of FR 3 treatment[14] has shown statistically significant intermaxillary changes ($P<0.001$), but not in the AP midface length. Additionally, it failed to inhibit or redirect the forward mandibular growth. The long-term effects are misleading in this study as the 9-year follow-up period is inclusive of the treatment phases (FR 3 + fixed appliance). The mandible in the FR 3 subjects continued to outgrow the maxilla in the sagittal plane by the ratio of 1.8:1 and these increments were much less than the 2.4:1 ratio found in the Class III controls over the same period of time. This ratio for the average Class I controls was found to be 1.5:1.

The long-term effects of FR 3 are open to question in the correction of skeletal III malocclusion. This appliance may, however, be used as a retainer after active PFM therapy.

Potential contributors of success

The potential contributors identified for success in the early treatment of the Class III malocclusion are:

- Early age at the time of treatment;[12]
- Reduced to average lower face height;[13,16]
- Absence of dental compensation;[13, 16] and
- More favourable skeletal pattern.[13,16]

Baccetti[19] and co-workers found that the increased length of ramus was an adverse factor for the success of early Class III treatment.

Age at timing of treatment

The literature would indicate that early intervention in Class III malocclusion has been a key factor in affecting the outcome.[12] The early intervention (mean age early group 6.9 ± 0.7 years and late group 10.3 ± 1 year) with PFM+RME[12] resulted in significantly greater anterior displacement of the maxilla. The annual anterior displacement of the maxilla in the early group was approximately 5 mm, compared to 2 mm in the late group. In contrast, the annual increment of forward maxillary displacement in the control group was 1 mm. Westwood and co-workers found significantly favourable changes in the maxilla and mandible in the pre-pubertal (mean age 8.3 years) treatment group.[12]

Number of skeletal and dento-alveolar changes with early treatment of Class III malocclusion

The number of changes reported varies between different studies. Recent studies[16] use linear measures (such as Pancherz's analysis) as they are more reliable than angular measures used in previous, older studies. The total change with PFM+RME in maxillary advancement and mandibular base has been up to +2 mm and +1 mm, respectively.[16] The dento-alveolar change in maxillary and mandibular incisors has been up to +3.5 mm and -1 mm, respectively.[16] The lower face height increased by a mean value of 2 mm at the end of treatment.[7]

Treatment time

The treatment time with PFM+RME has varied between 9–12 months.[16,17] The total mean treatment time from the start of orthopaedic treatment (PFM+RME) to the end of the fixed appliance therapy was 37 months.[13] The treatment time with CCT and fixed appliance therapy has been reported as between 1–4 years.[9,10] The treatment time with an FR 3 can range from 2–3 years[14] of full-time wear, followed by a retention phase of an additional 3 years.

Relapse rate

The relapse rate has been commonly measured by change in the overjet relationship. The maintenance of a positive overjet has been considered to be a successful outcome post-treatment, whereas edge-to-edge or negative overjet has been labelled as relapse. This is, however, a crude guide in assessing relapse. The reported relapse in the early treatment group is primarily due to deficient maxillary growth. In contrast, significant mandibular rebound has been reported in the late treatment groups. The relapse rate of PFM+RME has consistently been reported to be 33–36% in the literature.[5,12,13,17] The relapse with CCT has not been reported clearly in the literature.

Conclusions

Orthodontists still face an immense challenge in the orthopaedic management of skeletal Class III malocclusion, especially because of the possibility of relapse due to late mandibular growth. Studies show that protraction facemask/expansion therapy can be used to eliminate anterior crossbite of Class III patients with maxillary deficiency. It maximizes the growth potential of the nasomaxillary complex, allows for favourable sutural response and improves facial profile.

The most optimal treatment timing for facemask therapy is in the deciduous or early mixed dentition. However, patients who are likely to have unfavourable mandibular growth or who present with a severe skeletal discrepancy are not candidates for growth modification

treatment. At present, we require long-term randomized controlled clinical trials to answer the many questions around the stability of Class III growth modification.

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Cochrane Synopses

INITIAL ARCH WIRES FOR ALIGNMENT OF CROOKED TEETH WITH FIXED ORTHODONTIC BRACES

Wang Y, Jian F, Lai W, Zhao Z, Yang Z, Liao Z, Shi Z, Wu T, Millett DT, McIntyre GT, Hickman J. Initial arch wires for alignment of crooked teeth with fixed orthodontic braces. Cochrane Database of Systematic Reviews 2010, Issue 4. Art No: CD007859. DOI: 10.1002/14651858 CD007859 pub2.

'Fixed orthodontic appliance treatment may use arch wires to exert force upon teeth. The success of a 'fixed appliance' orthodontic treatment may depend on the selection of arch wires. The initial arch wire is the first arch wire to be inserted into the fixed appliance at the beginning of the orthodontic treatment and is used mainly for correcting crowding and rotations of teeth i.e. 'crooked teeth'. There is some evidence to suggest there is no difference between the speed of tooth alignment or pain experienced by patients when using one initial aligning arch wire over another. However, in view of the general poor quality of the including trials, these results should be viewed with caution. Further research to study initial arch wires is required.'

ORTHODONTICS FOR TREATING TEMPOROMANDIBULAR JOINT (TMJ) DISORDERS

Luther F, Layton S, McDonald F. Orthodontics for treating temporomandibular joint (TMJ) disorders. Cochrane Database of Systematic Reviews 2010, Issue 7. Art No: CD006541 DOI: 10.1002/14651858. CD006541 pub2.

'There is no evidence about the effects of different types of orthodontic braces for problems associated with the joint between the lower jaw and skull. When the joint between the lower jaw and the base of the skull is not working well (temporomandibular disorders (TMD)), it can lead to abnormal jaw movement or locking, noises (clicking or grating), muscle spasms, tenderness or pain.

TMD is very common, and it is believed by some that it may be caused by the occlusion (the way the teeth bite), trauma or psychological stress. There is also a belief that the pain associated with TMD is similar, in that respect, to low back pain and may be related to variations of a person's individual pain perception.

Changes in the way the teeth meet can be produced by the use of active orthodontic appliances. This review found that there is no evidence from trials to show that active orthodontic treatment can prevent or relieve temporomandibular disorders adding support to teeth not being part of its cause. It is suspected that we do not know the real cause of TMD at present.'