

Stability of protraction Facemask/Rapid Maxillary Expansion in skeletal class III malocclusion with maxillary deficiency: Rapid Review

Citra Elitasari Rigel PUTRI*, Avi LAVIANA, Gita GAYATRI

Departement of Orthodontics, Faculty of Dentistry, Universitas Padjadjaran, Bandung, Jawa Barat, Indonesia

*Corresponding Author: Email: citra17001@mail.unpad.ac.id

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ABSTRACT. this study aimed to evaluate the stability of PFM/RME outcomes in class III skeletal malocclusion with maxillary deficiency performed during childhood. Electronic database search conducted from 2011-2020 with criteria RCT, clinical trials, and cohort studies with a treatment group of class III skeletal malocclusion with maxillary deficiency patients, using PFM/RME and a minimum of 2 years follow-up. The PFM/RME device has been commonly used for maxillary protraction in cases of maxillary growth deficiency and is used during childhood. The stability of the PFM/RME protocol results aims to maintain the best possible treatment results. There were 439 articles from the preliminary search. Six articles were included in this study, two articles were RCT types, and the other four were CCT types. Clinical evaluation and cephalometric are used to evaluate skeletal and dentoalveolar changes. 68%-90% of participants maintained overjet until the follow-up period ended. PFM/RME protocol reduced the need for orthognathic surgery by 3,5 times compared with a control group with no treatment. PFM/RME treatment can effectively show in the short term from skeletal dan dentoalveolar changes. There were relapses during the long-term follow-up period. Further evaluation and research are needed regarding the long-term stability of PFM/RME outcomes.

KEYWORDS: Class III malocclusion, Growth modification, Maxillary deficiency Protraction facemask (PFM), Rapid maxillary expansion (RME)

INTRODUCTION

The Indonesian dental and oral health prevalence problems are around 80%, and malocclusion disorders are still found in the community¹. Class III malocclusion is quite a complex and challenging case for dentists. Class III skeletal malocclusion is a mismatch between the maxilla and the mandible to the cranial base, which can be a prognathic mandible, retrognathic maxilla, or a combination of both. Maxillary deficiency can be measured using Steiner cephalometric analysis, which measures the angles formed by points S (sella), N (nasion), point B ($80^{\circ} \pm 2^{\circ}$), and points A ($82^{\circ} \pm 2^{\circ}$). The recessive maxilla anteroposterior shows an SNA angle of less than 82° . The etiology of skeletal class III malocclusions ranges from maxillary deficiency, mandibular overgrowth, or a combination of both^{2,3}.

The studies' skeletal class III malocclusion prevalence ranges from 0-26.6% with a mean of

7.04% and is relatively higher in East Asian populations⁴. Most skeletal class III malocclusion due to maxillary deficiency ranges from 42-63%⁵. The patient's age becomes essential for class III skeletal malocclusion treatment success. Class III malocclusion treatment was performed early, generally using orthodontic measures such as chin cap devices, facemasks, and Frankel regulators^{4,6}. Studies explain that early treatment is best done at under ten years^{6,7}. To optimize skeletal changes in the primary or mixed dentition period. Skeletal changes in the early treatment of class III malocclusion, resulting in a similar gonial angle to class I⁸. Early orthodontic treatment of class III malocclusion results in good facial balance, modification of maxillofacial growth, and development to prevent orthognathic surgical intervention and reduce surgical morbidity in the future^{7,9}.

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Protraction Face Mask and Rapid Maxillary Expansion (PFM/RME) treatment are one of the most common orthodontic treatments. Several kinds of literature^{4,5,8,10} state the effectiveness of short-term PFM/RME treatment or a combination of skeletal and dentoalveolar. Class III malocclusions associated with craniofacial disharmony during childhood have a relapse tendency in adulthood^{11,12}. The study stated that 88.9% of patients with class III malocclusion maintained long-term stability of correction, and the remaining 11.1% experienced posttreatment relapse¹³. Relapse associated with unfavorable craniofacial modification occurred after the posttreatment period between a sample of

treated and untreated subjects with the same type of malocclusion, characterized by an overjet of less than or equal to 0 mm at the end of treatment¹⁴. The main goals of PFM/RME treatment are to eliminate the occlusal attachment of the anterior reverse bite, provide a maxillary growth site and reduce the need for follow-up orthognathic surgery⁸.

There has been no rapid review on the stability of long-term PFM/RME maxillary protraction treatment in skeletal class III malocclusion patients with maxillary growth deficiency. This study aimed to evaluate the strength of PFM/RME treatments to further determine the potential for relapse.

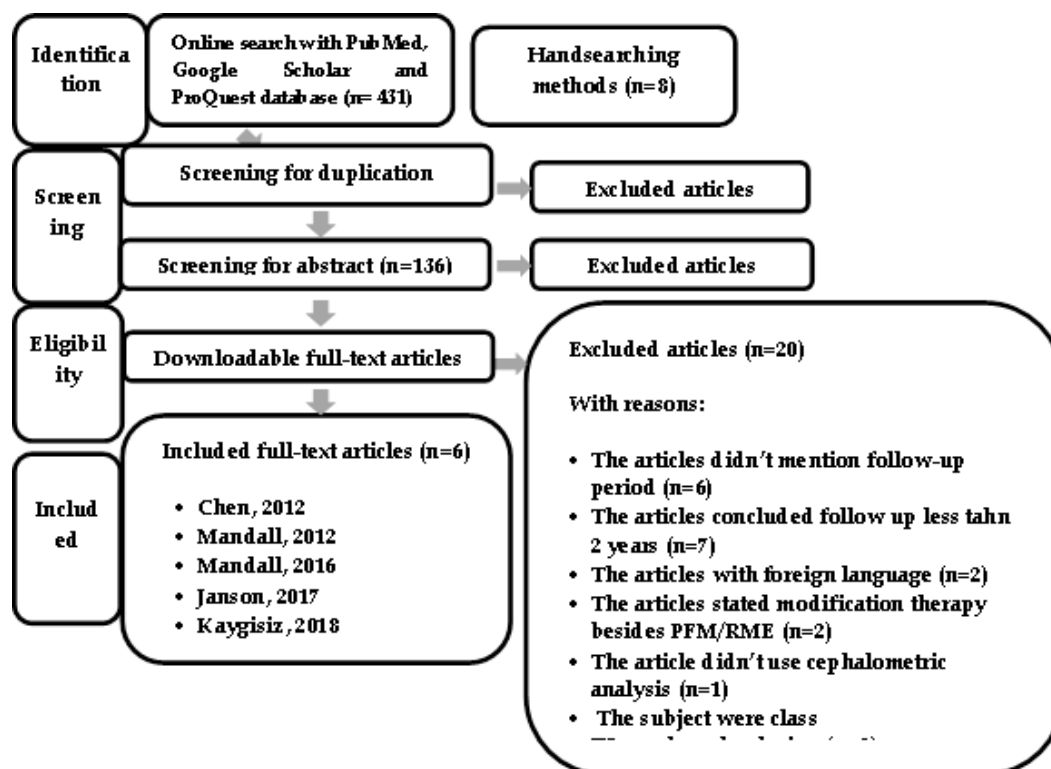
RESULTS

Selection of Article

The screening and selection of studies were carried out by one author, filtering the title, abstract, and whole article. The qualified articles will be processed for data extraction and analysis. Subjectivity risk for the RCT study used the Cochrane Collaboration's Risk of Bias tools. The seven criteria analyzed in the RCT study were: randomized sequencing, closure of intervention

allocations, masking of participants and personnel, masking of interventions derived from outcome measures, incompleteness of outcome data, reporting subjectivity, and risks of other subjectivity. Measurement of subjectivity risk for non-RCT studies using Methodological Items of Non-RCTs Studies (MINORS).

Figure 1 PRISMA flow chart



Based on a search of the three electronic databases PubMed, Google Scholar, and ProQuest, 431 journal articles and eight articles were found

using the hand searching method. After selecting from the title and abstract, 26 articles were obtained for full-text screening. A total of 20 articles were

issued for various reasons, and six articles were selected according to the selection criteria.

RCT studies are rarely carried out in the orthodontic field, so articles with prospective and retrospective methods are widely used in this study. There are two articles with a RCT study plan^{16,17}, one with a prospective cohort design and a retrospective control group¹⁸, two with a retrospective plan^{13,19}, and one with a prospective plan²⁰.

The research sites are spread across UK^{16,17}, Brazil¹³, Italy¹⁸, China²⁰, and Turkey¹⁹. The total participants were 207 patients with 10 patients²⁰, 13 patients¹⁹, 18 patients¹³, 63 patients¹⁷, 65 patients¹⁶, and 101 patients¹⁸. The average age is below 10 -11 years starting the treatment.

After the end of the PFM/RME treatment period, all studies indicated a minimum follow-up of 2 years with a mean age at the follow-up period of 12-24 years. All articles report sex comparisons. One article used a double plate appliance/facemask (DPA/FM)¹⁹, two reported a protraction facemask/rapid maxillary expansion (PFM/RME) intervention^{16,18}, and one reported the use of

banded PFM/RME²⁰, one article used bonded PFM/RME¹⁷. The other describes the intervention of the chin cap and Frankel regulator III²¹.

Duration of active use in the PFM/RME treatment period ranged from 8.6 months¹⁷ to 3.4 years¹³. After the end of active treatment for maxillary protractors, one article reported the use of a Hawley plate retainer and a mandibular canine retainer for one year¹³, one piece described the use of a chin cap while sleeping, a mandibular retractor, and a class III bionator for one year¹⁸ and five articles told the use of fixed orthodontic appliances.^{13,17-20}.

The stability of PFM/RME treatment was reported to be successful in non-extracted patients of 88.9%. Chen et al. ²⁰ reported a success rate of 60%. Mandell et al. ^{16,17} said a finding that approximately 70% of participants maintained a positive overjet at a 3-year follow-up period, and a follow-up longitudinal study 3 years later showed almost similar results in that 68% of participants supported a positive overjet with an average overjet of around 0.8mm. One article reported successful stability over the 5-year follow-up period of 73.2%²⁰.

Table 1. Description of study characteristics

Author	Method		Participants					Intervention				
	Study	Location	Age	F/M	Part	F-up part	D (M)	Appl.	Force	F-up period (years)	Fixed ortho dontic	Retention appliances
Janson 2017	Retrospective cohort	Brazil	T1: 11,8 years old	12/ 6	18	18	40,8	FM, chin cap, frankel regulator III	200 gr/edge	8,3	Edgewise appliance	Hawley plate and canine retainer
Chen 2012	Prospective cohort	China	TG :11,38 years old, CG:1 1,54 years old	20 /29	TG: 22, CG: 17	10	18	Banded RME/F M	250-300 gr/edge 15-30°	3	Yes	NM
Mandal 2012	RCT	UK	< 10 years old	33/ 30	TG: 35, CG: 58	86% .	< 15	RME/F M	400 gr/edge 30°	3	N	N
Mandal 2016	RCT	UK	<10 years old	33/ 30	TG: 35, CG: 58	TG: 33, CG: 32, 89%	8,6	Banded RME/F M	400 gr /edge , 30°	6	Ya	N
Kaygisi z 2018	Retrospective cohort	Turki	11,1 years old	5/ 8	13	NM	10,8	Double plate appliance/ FM	350-400 gr/edge	5	Ya	N

Author	Method		Age	Participants			D (M)	Appl.	Intervention			
	Study	Location		F/M	Part	F-up part			Force	F-up period (years)	Fixed ortho dentic	Retention appliances
Souki 2020	Retrospective cohort (BG: prospective, IG: retrospective)	Italy	BG : 7,1 years old IG: 9 years old..	55/46	BG: 73 and IG:28	NM	12	RME/FM	400-500 gr/edge	5	Ya	Chincap,M andibular retractor/ class III bionator

Note: Part (Participation); Appl (Appliance) F-up part (Follow-up participation); D M (Duration Month)

Table 2 Outcomes result

Author (year)	Result						
	Skeletal changes	Dentoalveolar changes	Outcomes prediction	TMJ	Psychosocial	Orthognatic needed	Clinical stability
Chen 2012	A point +3,93 mm, SNA +2,25°, PP-SN -1,04°. B point -0,52 mm, pogonion -0,36mm, SNB -1,18°, Y-axis +1,63°, SN-MP +2,46°	Maxillary insisive protrusion+7,09mm Mandibular insisive protrusion +0,37 mm	NM	NM	NM	NM	SNA maintain stable during follow-up period. SNB changes related to sagittally growth of mandible.
Manda ll 2012	ANB +1,5°, A point +2,3°, B point -0,8°	70% patients maintained a positive OJ at follow-up period.	NM	PFM/RME unlikely attributed to TMD	Self esteem increases seems insignificant	NM	Maxillary protraction has its own skeletal benefit at 10 years old patients or younger.
Manda ll 2016	CG: SNB +1,6°, ANB -0,7°, TG: SNB +0,6°.	CG: OJ +1,7mm, TG: OJ +3,0mm	NM	NM	Self esteem increases seems insignificant	CG: 66% need orthognatic surgery, TG:36% need orthognatic surgery	68% patients maintained OJ during 6 years follow up period
Janson 2017	SNA +1,1°, SNB +0,3°, ANB +0,8°	Mx1.PP +5°, OJ +1,6 mm,	NM	NM	NM	NM	88,9% maintained OJ during 8,3 years follow-up period
Kaygis iz 2018	SN +6mm, SNA +2,9°, SNB -0,3°, COA +11mm, CoGn 13,7mm	OJ +5 mm, molar relationr +7,1 mm	NM	NM	NM	NM	DPA/FM appliances vertically stable during 5 years follow-up period.

Author (year)	Result						
	Skeletal changes	Dentoalveolar changes	Outcomes prediction	TMJ	Psychoso cial	Orthognathic needed	Clinical stability
Souki 2020	SN +2,8mm, SNA +3,5°, ANB+2,2°, SNB -3,5°	NM	CondAX- MP	NM	NM	NM	Success rate 70% with 14,7 years follow-up period.

DISCUSSION

Skeletal effect on long-term facemask treatment does not have a significant impact, according to Mandall et al.¹⁷. A maxillary protraction device with jawbone anchorage is better than facemask treatment. It was also stated by Masucci et al.²², that craniofacial changes in long-term PFM/RME treatment did not show significant results and were only effective in short-term treatment.

Chen et al.²⁰ explained that the skeletal effect of PFM/RME treatment could be achieved before peak growth ends. This effect can be maintained for long-time use. Effects such as maxillary protrusion, dentition, and mandibular growth inhibition were the effects seen in PFM/RME treatment performed before the peak of growth. After the growth peak ends, the tendency for relapse after active it will decrease²³.

Changes in the molar relationship in the posttreatment period are close to normal development, so they have not been considered a contributing factor to posttreatment relapse¹³. Dentoalveolar changes were reflected in increased overjet and overbite during the active treatment period. However, these only represented the dentoalveolar relationship and did not explain the skeletal correction.

Positive overjet was successfully maintained until the follow-up ranged from 68% to 90%. One of the reasons why the positive overjet could not be retained until the follow-up period was due to the varying mandibular growth pattern in each person and the presence of labial tipping of the mandibular incisors during the posttreatment period. These inconsistent results were due to the post-PFM/RME retainer device and the different duration of use of fixed orthodontic appliances in each research article.

The long-term success prediction of PFM/RME treatment becomes a goal to determine the prognosis of successful maxillary protraction treatment. Souki et al.¹⁸ explained that the inclination of the condylar axis to the mandibular plane is an excellent variable to predict the treatment outcome of skeletal class III malocclusion with PFM/RME. This finding is also supported by a systematic review from Fudalej²⁴, which states that

the gonial angle can be a variable to predict the treatment outcome for skeletal class III malocclusion.

Cond-Ax-MP cephalometric measurements show low results before PFM/RME treatment was started, combined with lower anterior facial height can predict poor or unsuccessful treatment outcomes. These results are also supported by Masucci²², who explained that the long-term success of PFM/RME treatment was influenced by patient adherence to the protocol and the patient's facial characteristics before treatment started.

The need for orthognathic surgery increased 3.5 times in the control group without maxillary protraction treatment¹⁷. Assessing the need for active posttreatment orthognathic surgery is considered subjective. The assessment tends to be abstract by using panelists for decision-making. This limitation is considered personal compared to using a measured index such as IOTN.

A 6-year follow-up study showed that 1/3 of the control group did not require orthognathic surgery¹⁷. It can be an opportunity for further discussion regarding the need for orthognathic surgery in skeletal class III malocclusion cases of all ages.

The psychosocial impact of PFM/RME treatment shows that results of PFM/RME treatment with a 3-year follow-up in pediatric patients did not have a clinically significant psychosocial impact¹⁶. It happens because children do not yet have an awareness of a substantial change in increasing self-confidence that affects psychosocial aspects. The patient's psychosocial improvement may be significant in the early adolescent age group.

The author suggests that there is a need for education to the public regarding the prevention of the worsening of class III skeletal malocclusion in childhood with protraction facemask/rapid maxillary expansion treatment. The limitation of the results of this review is that it is difficult to obtain research articles using the RCT method, so the authors use more prospective or retrospective clinical studies. Blinding patient care is also difficult

for ethical reasons, as no studies have described a significant effect of long-term PFM/RME with a follow-up period until the end of peak growth.

Some studies are still centered on facemask protocols, follow-up time does not explain the

significant impact of treatment at the end of peak growth or post-pubertal period, and soft tissue changes after PFM/RME treatment are also not explained in detail.

CONCLUSION

PFM/RME treatment is effective in early treatment before the peak growth period and produces skeletal and dentoalveolar effects. PFM/RME treatment can correct class III skeletal discrepancies by creating a clockwise rotation of the mandible.

The results can decrease gradually with age, so the overproduction of treatment results, retention devices, and fixed orthodontic appliances are recommended to maintain active treatment results

if possible. The clinical stability of PFM/RME treatments ranges from 68%-90%. It is influenced by the patient's adherence to the treatment protocol and facial characteristics before treatment.

The long-term success of maxillary protraction treatment can be determined by measuring CondAx-MP cephalometry. Maxillary protraction PFM/RME treatment could reduce the need for orthognathic surgery by 3.5 times compared to the control group that was not treated.

MATERIAL AND METHODS

The PRISMA rapid review strategy (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines¹⁵ from January 2021 - March 2021 using the PubMed, Google Scholar, and ProQuest databases.

Search Strategy

The strategy was searched by entering keywords like malocclusion lean angle class III, maxillary protraction therapy, stability, relapse, and long-term effect. The search is adjusted for each database using advanced search and the

Boolean operators "AND" and "OR" as well as the limit function of each database.

Eligibility Criteria

The inclusion criteria include full-text articles in English and Indonesian, articles published from 2011-2020, RCT studies, clinical trials or cohort studies, and studies conducted on humans. Exclusion criteria included patients with craniofacial abnormalities, congenital abnormalities of cleft lip and palate, patients with TMJ disorders, adult patients, and studies that did not include cephalometric analysis. Further inclusion and exclusion criteria are in **Table 3**.

Table 3 Inclusion and Exclusion Criteria

	Inclusion	Exclusion
Types of research	Randomized controlled trial Clinical trial Cohort and case-control	Case report Systematic review or Meta-analyses Reviews
Participant	Pediatric patients with class III skeletal malocclusion	Patients with a craniofacial disorder Patients with cleft lip Patients with myofascial disorders Patients with TMJ disorders
Comparison	Maxillary protraction therapy with an extra-oral face mask and rapid maxillary expansion	Orthognathic treatment
Follow-up	Studies with long-term care followed by at least 2 years of follow-up	The study does not state follow-up or less than two years
Result	Skeletal changes, dentoalveolar, soft tissue	Studies that do not include cephalometric analysis

Table 4 Search Strategy on Data Base

Basis Data	Search Strategy	The number of articles
PubMed	((Maxillary protraction OR facemask OR face mask OR facial mask OR reverse headgear) AND ((Class III OR Class 3) OR (Malocclusion, angle class III [Mesh]))) AND (((Long-term OR long-term OR long term OR follow-up OR follow-up OR longitudinal) OR (Relapse OR recurrent OR posttreatment OR posttreatment)) OR (Stable OR stability OR instability OR retention OR retainer))	22
ProQuest	malocclusion class III AND ((follow-up treatment) OR (Long term effect) OR (Longitudinal) OR (Posttreatment)) AND ((maxillary protraction) OR (facial mask) OR (reverse head gear)).	267
Google Scholar	Malocclusion class III AND follow-up treatment AND maxillary protraction therapy face OR mask	112

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Conflict of Interest

The authors report no conflict of interest

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