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Evaluation of Skeletal and Dental Expansion in Children and Adults with Mini-Screw Assisted Rapid Palatal Expansion (MARPE): A Systematic Review

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Keywords:

MARPE, transverse maxillary deficiency, dentoalveolar expansion, midpalatal suture, dental tipping.

Abstract

Aim: The aim of this systematic review was to evaluate the maximum skeletal and dental expansion achieved in children (including adolescents) and adults treated with Mini-implant Assisted Rapid Palatal Expansion (MARPE). Material and methods: A search of the keywords "MARPE" and "transverse maxillary deficiency" was conducted on search engines like PubMed, Google Scholar and Cochrane Library from the year 2010-2022. Inclusion criteria for this systematic review included: all Randomized Controlled and Un-Controlled Trials, all non-randomized controlled and un-controlled trials, prospective and retrospective studies, CBCT studies, articles published from the year 2010-2022, articles published in English language, articles with full text available. Statistical analysis: The following characteristics were evaluated: study design, sample size, sample description, error analysis and statistical analysis. The data from the selected articles were divided into 2 broad groups (children and adults) according to age of the subjects: <18 years and ≥18 years. Risk of bias (whether mentioned or not) was checked and quality assessment of studies were performed. Results: Thirteen studies were reviewed in this article. From the included articles, the following data were extracted independently: author names, year of publication, number of miniscrews used & the type of expander, sample size, mean age of subjects, maximum skeletal expansion achieved, maximum dentoalveolar expansion achieved, and dentoalveolar tipping. The maximum skeletal expansion achieved amongst the included studies was 5.3 ± 1.0 mm [Na Li et al; 2020; mean age = 19.4 ± 3.3 [17]], dentoalveolar was 8.32mm [Sung-Hwan Choi et al; 2016; mean age = 20.9 ± 2.9 [19]] and dental tipping was 8°-10° [Manuel O. Lagrave`re et al; 2010; mean age = 14.4 [11]]. More skeletal expansion was found in adolescents and young adults than in children and skeletally mature adults. Conclusions: MARPE is a reliable treatment modality for the correction of maxillary transverse deficiency in children, adolescents and adults. MARPE resulted in both skeletal and dentoalveolar expansion. More dental tipping is seen in skeletally matured individuals rather than skeletal expansion. MARPE should be used carefully in adults where dental tipping is unfavorable.

1. Introduction

Class II and class III malocclusions often have transverse maxillary deficiency with or without an abnormal mandible. Amongst the skeletal problems of the craniofacial region, transverse maxillary deficiency is one of the most pervasive conditions. [1] Approximately 23.3% of the primary dentition

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population is affected, as transverse maxillary deficiency develops during facial growth and development. The chances of spontaneous correction of this type of malocclusion are low, leaving it untreated affects the permanent dentition. Although multifactorial, the commonest culprits are the myofunctional disorders of the stomatognathic system including deleterious habits like thumb/digit sucking etc. [2] This constriction is usually associated with occlusal, functional and aesthetic disharmony, sometimes with other clinical features like narrowing of pharyngeal airway, high nasal resistance, altered tongue posture and mouth breathing. [3] Time is the most important factor as with advancing age, the rigidity of the facial skeleton increases, including the midpalatal suture which consolidates and hardens over time, thereby restricting bony movements. Simply put, the more the suture ossifies, the harder it is to expand. [4] With the advancement in the field of skeletal anchorage with miniscrews in the field of orthodontics, mini-implant assisted rapid palatal expansion (MARPE) became the treatment of choice for skeletally mature patients. When compared with conventional RME, MARPE showed more orthopaedic efficiency and lower dentoalveolar side effects. Literature reports no severe complication with this treatment with the most frequent complication being the inflammation and hyperplasia of the oral mucosa around the mini-implant, usually due to inadequate oral hygiene. [2]

Overall, MARPE is a clinically viable and stable treatment modality for children (with open midpalatal sutures) and adults with transverse maxillary deficiency, with a success rate of 86.9% for ages 18 to 28 years. [5] The aim of this systematic review was to evaluate the skeletal and dental expansion achieved in children and adults with Mini-implant Assisted Rapid Palatal Expansion (MARPE).

2. Material And Methods

TABLE 1- Eligibility criteria for study selection

1. Types of studies	• Retrospective or prospective controlled/un-controlled trials • Randomized clinical trials • CBCT studies of mini-implant assisted rapid palatal expansion (MARPE) done on children or adults for correction of transverse maxillary deficiency associated with/without OSA (obstructive sleep apnea).
2. **Participants**	• Children & adolescents (13 years – 18 years) • Adults (≥ 18 years) With class II or class III malocclusion with/without posterior crossbite or OSA, undergoing MARPE treatment for the correction of transverse maxillary deficiency/constricted maxillary arches.
3. **Intervention**	• Mini-implant assisted rapid palatal expansion with any expander design (bone anchored or tooth-bone anchored)
4. **Outcome measure**	Transverse dentoalveolar and skeletal expansion measured • Radiographically (including CBCTs)

This systematic review was based on the PRISMA guidelines and the main objective was defined with PICO format [6,7]

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TABLE 2	
PICO FORMAT	
Population	Children (<18 years) and adult (≥18 years) subjects requiring correction of transverse maxillary deficiency
Intervention	Treatment with mini-implant assisted rapid palatal expansion (MARPE) and any type of expansion appliance (tooth-bone anchored or bone anchored)
Comparison	Comparison between children (including adolescents; <18 years), and adults (≥18 years)
Outcome	Skeletal and dentoalveolar expansion measured radiographically (including CBCTs) in millimeters (mm).

A search of the keywords "MARPE" and "transverse maxillary deficiency" was conducted on search engines like PubMed, Google Scholar and Cochrane Library from the year 2010-2022. Initially the articles were selected on the basis of title and abstracts, then the selected articles were thoroughly analyzed and inclusion & exclusion criteria were applied for the final selection of articles. Inclusion criteria for this systematic review included: all Randomized Controlled and Un-Controlled Trials, all non-randomized controlled and un-controlled trials, prospective and retrospective studies, CBCT studies, articles published from the year 2010-2022, articles published in English language, articles with full text available. Case reports, case series, systematic reviews, in-vitro studies, books and documents, expert opinions and reviews, transverse maxillary deficiency treated with Alt-RAMEC therapy, cases of syndromic patients were excluded from this review. The selection process was independently conducted by 2 researchers, and the results were compared to identify discrepancies and reduce inter-personnel errors. The articles with unsatisfactory abstracts, were completely read and analyzed. Inter-examiner conflicts were resolved by discussion of each article to reach a consensus regarding all selection criteria.

The quality of each included article was scored by using an adapted version of 3 methods previously used by Fudalej and Antoszewska[8], Cozza et al[9] and Chen et al[10]. The following characteristics were evaluated: study design, sample size, sample description, error analysis and statistical analysis. The data from the selected articles were divided into 2 broad groups (children and adults) according to age of the subjects: <18 years and ≥18 years.

3. Results

After a thorough search of electronic databases, 66 studies were retrieved from PubMed, 108 from Cochrane Library, and 6649 from Google Scholar. After application of the initial inclusion and exclusion criteria and elimination of studies indexed in more than 1 database, 6823 were retrieved. The full texts were accessed, studies irrelevant to this systematic review were excluded. Ultimately, 13 articles that fulfilled all inclusion and exclusion criteria were included in this systematic review (Fig.1).

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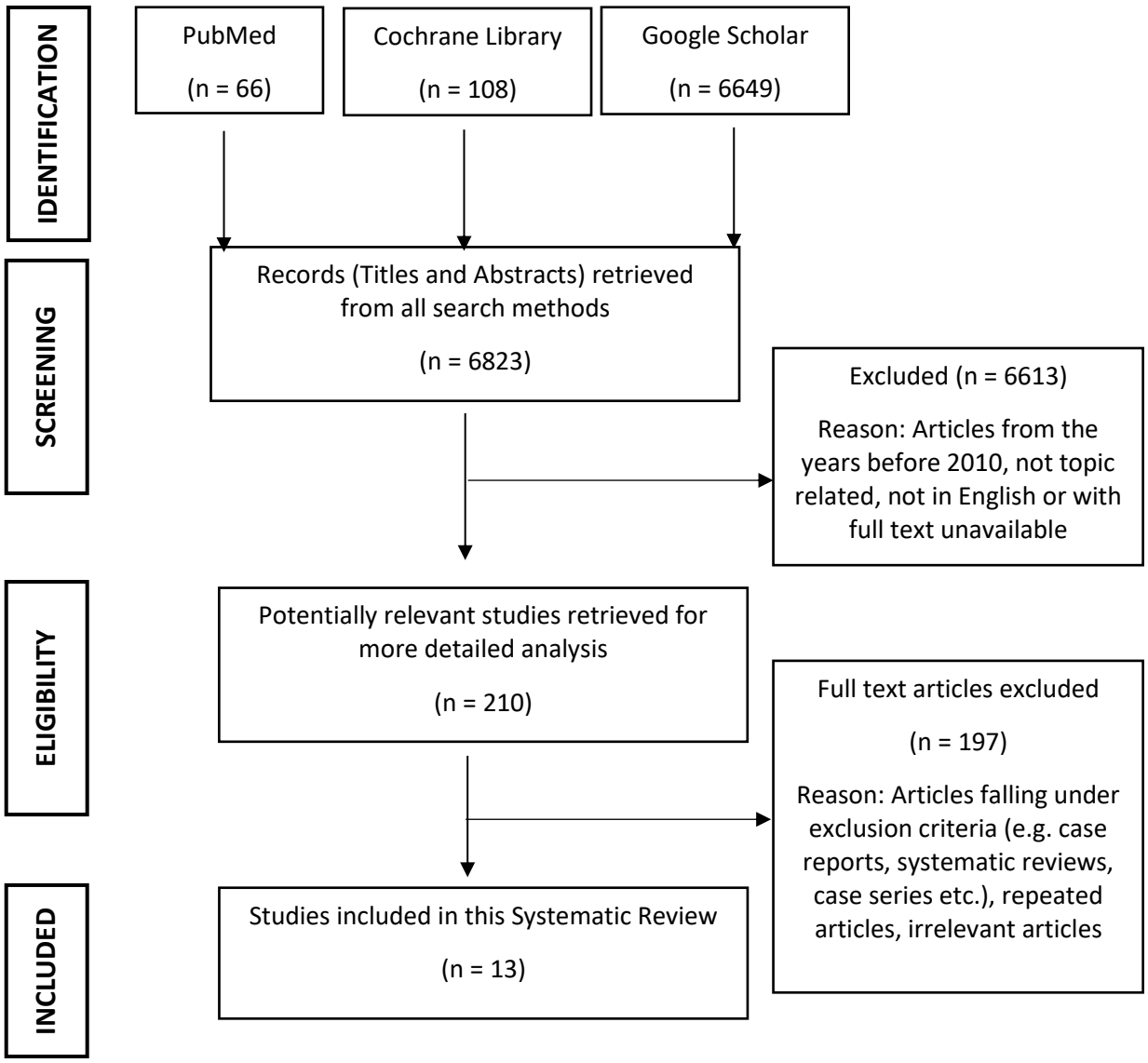
Fig. 1: PRISMA flow diagram



From the included articles, the following data were extracted independently: author names, year of publication, number of miniscrews used & the type of expander, sample size, mean age of subjects, maximum skeletal expansion achieved, maximum dentoalveolar expansion achieved, and dentoalveolar tipping (Table 3)

TABLE 3: Characteristics of included studies

S.no.	Study & Year of publication	No. of miniscrews and type of expander used	Sample size	Mean age (years)	Maximum Skeletal Expansion at molars (mm)	Maximum Dento-alveolar Expansion at molars (mm)	Dento-alveolar tipping

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1	Manuel O. Lagrave`re et al; (2010) [11]	2 onplants, 2 mini-screws; Palex II Extra-Mini Expander (6 months)	21	14.4	2.22 ± 1.84 mm	5.75 ± 1.98 mm	8° - 10°
2	Haichao Jia et al; (2021) [12]	4 mini-screws; MARPE appliance with jackscrew	30	15.1 ± 1.6	3.99 ± 1.04 mm	6.36 ± 1.30 mm	6° - 7°
3	Chen Zong et al; (2019) [13]	4 mini-screws; MSE appliance	22	14.97 ± 6.16	3.15 ± 1.64	2.27 ± 1.25	2.56° ± 2.65°
4	Daniele Cantarella et al; (2017) [14]	4 mini-screws; MSE appliance	15	17.2 ± 4.2	4.75 ± 2.59 mm	N/A	N/A
5	Lu Lin et al; (2015) [15]	4 mini-screws; C-expander	15	18.1 ± 4.4	2.79 ± 1.55 mm	3.46 ± 1.06 mm	1.16° ± 1.2°
6	Kyeong Tae Song; (2019) [16]	4 mini-screws; MSE appliance	15	18.8	1.68 ± 0.85 mm	2.53 ± 0.67 mm	N/A
7	Na Li et al; (2020) [17]	4 mini-screws; MSE type II appliance	48	19.4 ± 3.3	5.3 ± 1.0 mm	7.2 ± 1.4 mm	2.3°
8	Kyung A Kim; (2019) [18]	4 mini-screws; MSE appliance	66	19.3 ± 5.7	3.90 ± 1.07 mm	4.27 ± 1.24 mm	N/A
9	Sung-Hwan Choi et al; (2016) [19]	4 mini-screws; Hyrax expander	20	20.9 ± 2.9	2.11 mm	8.32 mm	N/A
10	Jung Ji Park et al; (2017) [20]	4 mini-screws; modified Hyrax expander	14	20.1	2.0 ± 1.4 mm	5.4 ± 1.7 mm	1.1° – 2.9°
11	Hyung-Mook Lim et al; (2017) [21]	4 mini-screws; MARPE appliance (1 year)	24	21.6 ± 3.1	2.60 ± 0.85 mm	5.63 ± 1.90 mm	2.07°

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12	Roberta Caetano Calil et al; (2021) [22]	4 mini-screws; MARPE with PecLab expansion appliance	16	24.92 ± 7.60	2.82 ± 1.54 mm	6.37 ±1.72 mm	4.14° ± 3.43°
13	Cibele Braga de Oliveira et al; (2021) [23]	4 mini-screws; MARPE appliance with jackscrew	17	26 ± 11	2.27 ± 1.10 mm	5.25 ± 2.34 mm	2.87° ± 1.94°

Quality assessment was done to classify the included studies into High, Medium or Low-quality studies (Table 4).

TABLE 4: Assessment of Quality of the studies

S.no.	**Study**	**Study design**	**Sample size**	**Sample description**	**Method error analysis**	**Adequacy of statistical analysis**	**Quality score**	**Study quality**
		0-3	**0-1**	**0-2**	**0-1**	**0-2**	**0-9**	
1	Manuel O. Lagrave`re et al; (2010) [11]	3	1	2	0	1	7	High
2	Haichao Jia et al; (2021) [12]	3	1	2	1	2	9	High
3	Chen Zong et al; (2019) [13]	1	1	2	0	1	5	Medium
4	Daniele Cantarella et al; (2017) [14]	1	1	2	1	1	6	Medium
5	Lu Lin et al; (2015) [15]	2	1	1	1	2	7	High
6	Kyeong Tae Song; (2019) [16]	0	1	2	1	2	6	Medium

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7	Na Li et al; (2020) [17]	0	1	2	1	2	6	Medium
8	Kyung A Kim; (2019) [18]	0	1	2	0	2	5	Medium
9	Sung-Hwan Choi et al; (2016) [19]	0	1	2	1	2	6	High
10	Jung Ji Park et al; (2017) [20]	0	0	2	1	2	5	Medium
11	Hyung-Mook Lim et al; (2017) [21]	0	1	2	0	2	5	Medium
12	Roberta Caetano Calil et al; (2021) [22]	0	1	2	0	2	5	Medium
13	Cibele Braga de Oliveira et al; (2021) [23]	3	1	2	1	2	9	High

TABLE 5: Assessment of bias of studies

S.no.	**Study**	**Randomization / allocation concealment**	**Blinding levels**			
			Level of participant	**Level of operator**	**Level of data collector**	**Level of data analyst**
1	Manuel O. Lagrave`re et al; (2010) [11]	Yes	N/A	N/A	N/A	yes
2	Haichao Jia et al; (2021) [12]	Yes	N/A	N/A	N/A	Not mentioned

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3	Chen Zong et al; (2019) [13]	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned
4	Daniele Cantarella et al; (2017) [14]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective
5	Lu Lin et al; (2015) [15]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective
6	Kyeong Tae Song; (2019) [16]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective
7	Na Li et al; (2020) [17]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A Retrospective
8	Kyung A Kim; (2019) [18]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A Retrospective
9	Sung-Hwan Choi et al; (2016) [19]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A Retrospective
10	Jung Jin Park et al; (2017) [20]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective
11	Hyung-Mook Lim et al; (2017) [21]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective
12	Roberta Caetano Calil et al; (2021) [22]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective
13	Cibele Braga de Oliveira et al; (2021) [23]	N/A retrospective	N/A retrospective	N/A retrospective	N/A retrospective	yes

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After quality assessment, 5 studies were classified as high quality and 8 studies as medium quality (Table 4). It was observed that, most of the studies performed were retrospective and uncontrolled clinical trials. Randomization of the sample during original treatment was not mentioned in most of the included retrospective studies. Blinding at the level of participant, operator and data collector was impossible with the selected intervention; only 2 studies mentioned blinding at the level of data analyst (Table 5). Additionally, the skeletal expansion parameters taken in the performed studies were variable. The type of appliance and mono/bicortical penetration of the mini-screw was observed to not have significant correlation with the amount of skeletal expansion achieved. Consistently, in all age groups, the maximum transverse expansion was achieved at the level of 1st molar crowns, showing buccal dental tipping. Tooth-bone-anchored expanders created more tipping than bone-anchored expanders. Congruent with previous studies, majority of the included studies concluded that the amount and success rate of skeletal expansion was inversely proportional to the age of the subject and the mid-palatal suture maturation.

4. Discussion

Rapid palatal expansion is a necessary treatment procedure for patients exhibiting transverse maxillary deficiency.[4] Existing literature reports that the midpalatal suture maturation is highly variable when correlated with chronological and skeletal age.[24] Thus, rendering mini-implant assisted rapid palatal expansion a viable, dependable and stable treatment modality for the correction of maxillary transverse deficit.[2][14] Previous studies [5] have reported that MARPE shows a success rate of 100% in individuals with the midpalatal suture maturation stages: A,B and C; and a success rate of 71.4% - 86.9% for individuals aged between 18-28 years (midpalatal suture maturation stages D and E). [7][5][25][26]

After a detailed search of the databases, a total of 6823 articles were reviewed for this systematic review. Thorough filtering through application of inclusion and exclusion criteria was done, and 13 suitable articles were selected in the end. The parameters selected for evaluating skeletal expansion were mainly transverse measurements between the lateral—most points on the maxillary bases, nasal bases or the zygomaticomaxillary buttress area, between the innermost points of the anterior or posterior nasal spine, and in some studies, transverse distance between maxillary fist molar root apices due to lack of data. For evaluating dental expansion, the parameter selected was the transverse distance between the buccal cusp tips or central groove of the maxillary 1st molar crowns, and for evaluation of dental tipping the angulation changes in the long axis of the 1st molar tooth was selected.

The findings of the present systematic review corroborate with that of the previously reported data regarding achieving satisfactory to successful skeletal expansion in adults. Due to the lesser consolidation of the palatal suture in children and adolescents, the skeletal transverse correction achieved was greater than that found in adults.

In the present study, it was found that skeletal expansion was more that the dental expansion and dental tipping in children and adolescents (<18 years). In case of adults, due to a more rigid midpalatal suture, the dental expansion and dental tipping was found to be more than the skeletal expansion (Table 3). The skeletal parameters evaluated in the included studies were variable making the quantification of average skeletal expansion achieved difficult. On the other hand, the dental expansion and tipping measurements had common parameters making the results generalizable for all the studies.

As suggested in the previous studies, the present review also found that the amount of transverse correction (skeletal) and the success rate of mini-implant assisted rapid palatal expansion decreases with the increase in chronological and skeletal age of the individual. Simply put, growing patients (<18 years) showed more skeletal than dental expansion than non-growing patients (>18 years) with MARPE.

5. Conclusion

It can be stated from this systematic review that MARPE is a reliable treatment modality for the correction of maxillary transverse deficiency in children, adolescents and adults. MARPE resulted in both skeletal and dentoalveolar expansion. The maximum skeletal expansion achieved amongst the included studies was 5.3 ± 1.0 mm [Na Li et al; 2020; mean age = 19.4 ± 3.3 [17]], dentoalveolar was 8.32mm [Sung-Hwan Choi et al; 2016; mean age = 20.9 ± 2.9

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[19]] and dental tipping was 8°-10° [Manuel O. Lagrave`re et al; 2010; mean age = 14.4 [11]]. More skeletal expansion was found in adolescents and young adults than in children and skeletally mature adults. Due to common reference points of measurement, data related to dentoalveolar tipping and expansion can be generalized, on the contrary, for evaluating skeletal expansion, more prospective CBCT studies with common reference points are required to generalize the maximum achievable expansion in children as well as adults.

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