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Evidences From Systematic Reviews Regarding Miniscrew-Assisted Rapid Palatal Expansion (MARPE) Approach In Orthodontics

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Abstract

Background. Miniscrew-assisted rapid palatal expansion (MARPE) has been considered as relatively novel and effective method of orthodontic treatment, but the discussion is still ongoing regarding effectiveness of MARPE for different age population groups, while also in comparison with surgically assisted rapid palatal expansion or conventional rapid maxillary expansions, since evidences available for MARPE is mostly of insufficient quality.

Objective. To collect and represent evidences of MARPE treatment outcomes in orthodontics based on the data available within systematic reviews.

Materials and Methods. Search was provided via PubMed Central, Web of Science and Scopus databases, while also within Cochrane Library. Only systematic reviews written in English were considered for analysis. Primary outcomes such as success rate (percentage of cases, where required maxillary width was achieved) and maxillary expansion rate in means of midpalatal split, dental intermolar width, skeletal and dentoalveolar expansion, palatal suture opening, palatal width measured in millimeters or percentage were tabulated and analyzed. Secondary outcomes were presented in descriptive manner

Results. Overall 12 systematic reviews were enrolled into study group of targeted publications. Among these 12 systematic reviews primary outcomes were extracted from 8 of them, while rest 4 systematic reviews were used for analysis of secondary outcomes. Succes rate of MARPE varied in the range of 82.8-100%, while intermolar width increase after MARPE treatment – in the range of 4.79-6.55 mm.

Conclusion. Considering data available within systematic reviews MARPE approach seems to be reliable orthodontic treatment option, which help to gain significant increase for skeletal and dental intermolar width among patients with maxillary transverse deficiency. Such treatment strategy provides better results than conventional rapid maxillary expansion and lesser periodontal negative consequences compare to surgical-assisted rapid palatal expansion, even though quality of data supporting these statements are insufficient and debatable.

Introduction

Maxillary transverse deficiency characterized with 8-23% prevalence among growing patients and will less than 10% prevalence among adult population [1]. Recent systematic review revealed that surgically assisted rapid palatal expansion and rapid maxillary

expansion with the use of both tooth-borne and bone-borne devices result in the same outcome for maxillary expansion, even though such are related with few clinical disadvantages and drawbacks [2]. On the other hand miniscrew-assisted rapid palatal expansion (MARPE) has been considered as relatively novel and effective method of orthodontic treatment, which could be used for the patients with transverse maxillary deficiency and allows to avoid surgical interventions [3, 4, 5]. But the discussion is still ongoing regarding effectiveness of MARPE for different age population groups, while also in comparison with surgically assisted rapid palatal expansion (SARPE) or conventional rapid maxillary expansions (RME), since evidences available for MARPE is mostly of insufficient quality [5, 6, 7, 8, 9].

Recent umbrella review dedicated to MARPE complex assessment provided analysis of some clinical parameters included within previous systematic reviews, but presented such only in brief manner with no clinically-oriented discussion between publications [3].

Also it was recommended that in future systematic review and clinical trials dedicated to assessment of MARPE should be provided following some standardized guidelines to strengthen the quality of received evidences and optimize reporting homogeneity of data [3].

But even considering some limitations of already provided systematic reviews it is important to highlight that such represents the sort of data that has been already processed due to the number of quality criteria, which make it the most reliable among all accessible evidences. Nevertheless, interpretation of results obtained in systematic reviews and meta-analyses should be provided with the caution taking into account focused objective of such including both primary and secondary outcomes, specifics of realized literature search and analysis methodology, while also quality of evidences available within pool of literature sources.

Objective

To collect and represent evidences of MARPE treatment outcomes in orthodontics based on the data available within systematic reviews.

Materials and Methods

Eligibility criteria

Population represented by adults and late adolescents, but no strict limitation on age, with diagnosed transverse maxillary deficiency, treated with MARPE approach regardless of used design of device or treatment protocol were considered as one of the eligibility criteria during the systematic reviews selections for further analysis. Primary outcome included: the success rate of the transverse maxillary deficiency treatment and skeletal and dentoalveolar expansion rates in millimeters, while secondary outcomes consists of registered changes within root resorption frequency, tooth tipping, bone crest level, buccal bone thickness, airways volume. Only systematic reviews with or without supplemental meta-analyses were considered as eligible for the analysis and evidences collection. No exclusion criteria were applied, since such were already implemented within analyzed systematic reviews, collected into formulated study sample of publications.

Search strategy, Study Selection and Data Collection

PICOS criteria were formulated to aid searching procedure (Table 1).

Table 1. PICOS inclusion criteria applied during targeted systematic reviews search

PICOS	Inclusion criteria
Population	Patients with Maxillary transverse deficiency who undergone MRAPE treatment
Intervention	Treatment with mini-implant assisted rapid palatal expansion
Comparison	Pre-treatment vs. post treatment or MARPE vs. SARPE or MARPE vs. RME
Outcome	Primary: success rate, skeletal and dentoalveolar expansion rates in millimeters Secondary: changes within root resorption frequency, tooth tipping, bone crest level, buccal bone thickness, airways volume
Study Design	Systematic review with or without supplemental meta-analyses

Search was provided via PubMed Central (https://www.ncbi.nlm.nih.gov/pmc/), Web of Science (https://clarivate.com/cis/solutions/web-of-science/) and Scopus (https://www.scopus.com/home.uri) databases, while also within Cochrane Library (https://www.cochranelibrary.com/). Only systematic reviews written in English and available till 20th of September 2023 were considered for analysis. Manual search through Google Scholar (https://scholar.google.com/) was performed to depict any grey literature that may be potentially associated with study objective. All available systematic reviews' full texts were carefully assessed.

Data extraction was provided regarding following parameters: studies' bibliographic data, type of studies included within systematic reviews, studies' objectives, involved population's parameters and outcomes. The extracted data was grouped within Microsoft Excel 2019 spreadsheet software (Microsoft Office, Microsoft, United States).

Primary outcomes such as success rate (percentage of cases, where required maxillary width was achieved) and maxillary expansion rate in means of midpalatal split, dental intermolar width, skeletal and dentoalveolar expansion, palatal suture opening, palatal width measured in millimeters or percentage were tabulated and analyzed. Secondary outcomes were presented in descriptive manner. No tabulation or quantitative analysis was provided for secondary outcomes.

Results

Overall 12 systematic reviews were enrolled into study group of targeted publication. Among these 12 systematic reviews primary outcomes were extracted from 8 of them, while rest 4 systematic reviews were used for analysis of secondary outcomes. Systematic reviews included analysis of prospective and retrospective studies, while also of randomized controlled trials (RCT). The minimum amount of studies included into systematic reviews used for primary outcomes extraction was 6, the maximum – 16. The minimum age of patients involved in studies was 13.5 years old. Succes rate of MARPE varied in the range of 82.8-100%, while intermolar width increase after MARPE treatment – in the range of 4.79-6.55 mm. Grouped and tabulated primary outcomes (quantitative measurements) extracted from systematic reviews available in Table 2.

Table 2. Primary outcomes extracted from systematic reviews

Systematic review	Number of included articles	Type of included articles	Study group	Outcomes
Kapetanovic A. et al. (2021) [9]	8	2 prospective, 6 retrospective observational studies	> 16 years (late adolescents and adults)	Success rate: mean – 92.5%; skeletal width increase: mean difference – 2.33 mm; dental intermolar width increase: mean difference – 6.55 mm
Silva Sazo J., Perez-Flores A. (2022) [10]	9	Not mentioned	18-25 years	Success rate for opening of the palatal suture: 84.2% and greater
Huang X. et al. (2022) [11]	12	3 RCT, 9 NRCT	12.1 ±2.1 - 21.9 ±1.5	Success rate: 86.96%
Siddhisaributr et al. (2022) [12]	14	10 retrospective one-group, 3 retrospective cohort, 1 prospective	> 15 years	Success rate: midpalatal split – 84% (50% of studies did not report this outcome); skeletal expansion zygomatic width – 2.39 mm; alveolar molar width expansion – 4.80 mm; inter-molar width expansion – 5.99 mm
Basu S., Goje S. (2023) [13]	13	10 retrospective, 2 studies include allocation concealment	14.4-26± 11 years	Maximum skeletal expansion – 5.3 ± 1.0 mm; maximum dentoalveolar expansion – 8.32 mm
Bi W.K., Li K. (2022) [14]	6	6 RCT	Full text not available for analysis	Increased palatal width at the first molars MD – 0.75 mm (compare to RME); increased palatal suture opening at the first molars MD – 1.18 mm (compare to RME)
Zeng et al. (2023) [15]	12	1 prospective, 11, retrospective observational	> 13.5 years	Mean success rate: 93.87% (82.8-100%.); intermolar width increase – 4.79 mm; maxillary alveolar bone increase – 2.70 mm; mean basal bone expansion – 1.67-4.04 mm
Inchingolo et al. [16]	16	8 RCT, 7 retrospective, 1 observational	10-16 years	No systematized data available

Discussion

Usage of MARPE approach among late adolescents and adults, as a group of patients with already densified interdigitation of palatal suture, demonstrated significant positive results regarding skeletal width and dental intermolar width increase, thus conforming high success rate of up to 92,5% considering primary outcomes [9]. Available histological findings supports such results and argument it by the fact that palatal suture is not undergoing through complete ossification, due to the mechanical stress constantly present at the maxillary region [9]. On the other hand Silva Sazo J. and Perez-Flores A. resumed that the age even not being the only regressor for MARPE efficiency prognosis, still showing negative correlation with MARPE success outcomes [10].

Huang X. et al. reported mean intermolar width increase of 6.48 mm and mean alveolar width increase of 3.23 mm after MARPE treatment based on the used fixed effect model considering homogeneity of targeted outcomes [11].

Systematic review of CBCT studies revealed that expansion effect of MARPE quantified of being 55.76% for skeletal expansion, 24.37% for alveolar molar width expansion and 19.87% for dental expansion [12]. In Zeng et al. systematic review distribution of expansion was established as following: 48.85% – basal bone expansion, 7.52% – mean alveolar bone expansion, 43.63% – mean dental expansion [15].

Systematic review of Silva Sazo J. and Perez-Flores A. reported transverse width of the nasal cavity increase to 1.07 mm right after MARPE treatment and up to 2.2 mm at 10 month post-treatment period [10]. Zeng et al. systematic review reported mean 2.18 mm nasal floor width increase, while also mean 1.96 nasal lateral width increase [15].

Kapetanovic et al. concluded that clinical results obtained with MARPE approach is clinically analogical to those obtained with SARPE method of treatment, even though Bortolotti et al. reported greater mean skeletal expansion (3.3 vs. 2.33 mm), while SAPRE also supported mean 7.0 mm intermolar width increase [9]. In the systematic review of Siddhisaributr et al. authors highlighted that in means of percentage skeletal expansion with SARPE and MARPE could be interpreted as analogical, even though provided comparison was indirect [12]. Huang X. et al. concluded that MARPE provides better skeletal expansion than RME [11]. Another systematic review concluded that MARPE method is suitable for less than 7 mm maxillary transverse discrepancy among skeletally mature patients with intact periodontal status, while intermaxillary width relapse was minimized to 0.07 mm during post-treatment period [10].

Data obtained in systematic review of Bi et al. revealed that MARPE may be preferred over conventional rapid maxillary expansion approach due to the obtainment of greater palatal suture opening both at the area of anterior nasal spine and posterior nasals spine, while also due to the decreased level of tooth tipping (first premolar and first molars) [14].

Several systematic reviews pointed out that skeletal and dental expansion pattern during MARPE approach realized in pyramidal configuration [9, 10, 11, 12, 13].

MARPE method was not free of side-effects: analyzed studies demonstrated buccal dental tipping occurrence (within the range of – 5.5° to 8.01°), decrease in buccal wall thickness (0.36-0.6 mm) and bone crest level (0.74-1.7 mm), while also perio-oral soft tissue changes (nasal widening) were observed [9]. In other systematic review registered changes of bone thickness either at the buccal or palatal sides were not statistically significant, while clinically ranging within 0,13-0,33 mm; while bone level reduction rate counted to 0.11-0.8 mm at the molar area [15].

Data of all other systematic reviews regarding tooth tipping ranges, while also regarding bone level and thickness reduction falls into ranges highlighted in the systematic review of Kapetanovic et al. [9]. In analogical by the design systematic review of Zeng et al. authors reported smaller degree of tooth tipping within the range of 0.6-4.9°, and differences of such with values mentioned in Kapetanovic et al.

systematic review authors explained with dental width relapse effect [9, 15]. Molar tipping during MARPE could be associated with the fact that dental expansion in the molar region is greater compared to inter-canine region, and such outcome could be interpreted as a pattern after corresponding argumentation within future studies, but it was already approved during finite element analysis which revealed that the most prominent skeletal expansion was noted at the area of MARPE device itself [12].

Systematic review of Vidalon J.A. was targeted strictly on assessment of periodontal effects after different maxillary expansion techniques and resulted in limited but available evidences that bicortical MARPE (either bone-borne or tooth-bone-borne) provokes lesser periodontal complication compared to SARPE [17]. Difference between MARPE and SARPE during literature data comparison was the following: for alveolar bending 0.5-2.05° vs. 6.4°; for dental inclination – 0.7-4.8° vs. 0.63-3.11°; for alveolar crest level reduction – 0.6-1.33 mm. vs. 0.31 mm to –1.42 mm; for buccal alveolar bone thickness reduction – 0.58 mm vs. 0.2-0.64 mm [17]. MARPE results were also different for bone-borne and tooth-bone-borne devices: for dehiscence incidence – 4.2% vs. 31.3%, for fenestration incidence – 2.08% vs. 12.5% [17].

In systematic review and case report of Inchingolo et al. it was found that vestibular tipping of molar associated with MARPE it twice smaller compared to such related with the use of Hyrax device [16]. Only limited available evidences support the fact that MARPE could minimize the loss of buccal alveolar bone compared to the conventional rapid palatal expansion approach in means of SMD equal to 0.55 mm [18]. Without providing any generalization over population it was found out that based on three randomized clinical trial and one retrospective study MARPE associated with less bone thickness loss compared to conventional rapid palatal expansion (SMD = 0.55), which was statistically significant for premolar region bilaterally, but was not statistically proven for molar region [18]. Also risk of gingival recession development in remote period after MARPE treatment should be considered for the future studies [10].

Systematic review of Arqub S.A. and colleagues revealed limited evidences regarding reduced volumetric root resorption found during MARPE treatment compared to conventional rapid palatal extension, while resorption process during palatal extension with different borne devices usually taking place on the buccal surface of posterior tooth [19].

Due to the systematic review of Arqub S.A. et al. MARPE do not impact airway volumetric changes in short-termed perspective, even though such approach reduces airway resistance by increasing nasal cavity width [20]. While another systematic review provided by Liu et al. revealed that MARPE supports increase of nasal cavity volume, nasopharyngeal volume, oropharyngeal volume and total volume of the upper airway (WMD: 1.67 cm3, 95% CI: 0.68, 2.66) among non-growing patients with palatopharyngeal volume, glossopharyngeal volume and hypopharyngeal volume representing no changes [21]. In the systematic review of Li and co-authors it was found that MARPE is related with increase in nasal volume and nasopharynx volume after retention period, however no changes were registered within oropharynx volume, palatopharynx volume, glossopharynx volume and hypopharynx volume after retention period [22]. Preve S. and Alcazar B.G. suggested that MRAPE impact on nasal airflow was significant and related with reduced nasal resistance at the nearest period after maxillary expansion was held, while long-monitoring studies also should take place to verify long termed associations [23].

In the systematic review of Zeng et al. it was mentioned that most of the studied parameters used for the MRAPE approach efficiency evaluation demonstrated mostly minimal level of relapse during 1 year monitoring [15]. However, such parameters as interdental width at the area of first and second premolar did not shown any relapsing trend, which may be caused by the deficiency of reporting this data within analyzed studies [15]. On the other hand Huang X. et al. found out 1.56 mm intermolar width reduction and 0.55 mm alveolar width decrease 1 year after MARPE treatment was finished [11]. 6-7 months after expansion mid-palatal suture density still not returned to its initial levels neither in cases of using MRAPE approach, nor in cases of using SARPE approach in anterior, middle and posterior regions [24].

General limitation reported in the majority of analyzed systematic reviews was the significant risk of biases found within selected studies. Also, significant differences in methodology of provided measurements for primary outcomes and in data collection protocols were found in most of the studies.

Potential also may be revealed if the results of MARPE approach would be categorized not based on the age classification but based on palatal suture condition.

Future studies of MARPE efficiency evaluation should also take into consideration the need to objectify skeletal expansion results based on CBCT scans for its further generalization, while dentoalveolar tipping and dentoalveolar expansion characterized with the possibility of greater objectification and further population generalization taking into account well adapted measurement approaches [13].

Conclusion

Considering data available within systematic reviews MARPE approach seems to be reliable orthodontic treatment option, which helps to gain significant increase for skeletal and dental intermolar widths among patients with maxillary transverse deficiency. Effectiveness of such approach depends on variety of determinants, among which age parameter is also considered, but no well-established quantitative inter-relations may be drawn between efficiency level of MARPE and age of the patients without taking into account impact of other significant factors. Such treatment strategy provides better results than conventional rapid maxillary expansion and lesser periodontal negative consequences compare to surgical-assisted rapid palatal expansion, even though quality of data supporting these statements are insufficient and debatable. MARPE potential regarding positive improvements within upper airways volumes remains under research for consolidated results obtainment.

Conflict of Interest

Authors do not have any potential conflict of interests that may influence the decision to publish this article.

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Докази систематичних оглядів щодо використання підходу до швидкого розширення піднебіння із застосуванням міні-імплантатів у якості опор (MARPE) в ортодонтичній практиці

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A – розробка концепції та дизайну дослідження, B - збір та або систематизація даних дослідження, C - аналіз та тлумачення даних дослідження, D - написання публікації, E - критичне доопрацювання тексту публікації, F- остаточне затвердження.

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техніка розширення піднебіння, систематичний огляд, доказова стоматологія

Анотація

Вступ. Підхід до швидкого розширення піднебіння із застосуванням міні-імплантатів у якості опор (MARPE) вважається відносно новим і ефективним методом ортодонтичного лікування, проте успішність MARPE для різних вікових груп населення залишається питанням дискусії, крім того потребує уточнення ефективність MARPE в порівнянні зі швидким розширенням піднебіння з додатковим проведенням хірургічного втручання або ж за алгоритмом класичного швидкого розширення верхньої щелепи, оскільки доступні докази щодо успішності техніки MARPE характеризуються здебільшого недостатньою якістю.

Мета. Систематизувати та представити докази щодо ефективності застосування MARPE в ортодонтичній практиці на основі даних, доступних у систематичних оглядах.

Матеріали та методи. Пошук проводився у таких базах даних, як PubMed Central, Web of Science та Scopus, а також у Cochrane Library. Для аналізу відбиралися лише систематичні огляди, написані англійською мовою. Первинні результати аналізу, такі як рівень успішності (відсоток випадків, в яких була досягнута необхідна ширина верхньої щелепи) і величина розширення верхньої щелепи, виражена у таких показниках як розщеплення піднебінного шва, зміни міжмолярної відстані, скелетного та зубоальвеолярного розширення, розкриття піднебінного шва, ширина піднебіння, виміряні у міліметрах або у відсотках, були зведені у таблицю і кількісно проаналізовані. Вторинні результати були представлені лише в описовій формі

Результати. Всього до групи дослідження було включено 12 систематичних оглядів. Серед цих 12 систематичних оглядів первинні результати, які підлягали аналізу, були екстраговані із 8 публікацій, тоді як вторинні результати були екстраговані із 4 систематичних оглядів. Успішність MARPE варіювала в діапазоні 82,8-100%, а збільшення міжмолярної ширини після лікування технікою MARPE сягала діапазону 4,79-6,55 мм.

Висновки. Враховуючи дані, доступні в систематичних оглядах, підхід MARPE можна інтерпретувати як надійний варіант ортодонтичного лікування, який дозволяє досягти значного скелетного розширення та збільшення міжмолярної ширини у пацієнтів із дефіцитом трансверзальних розмірів верхньої щелепи. Дана стратегія лікування забезпечує

кращі результати, ніж класичне швидке розширення верхньої щелепи, і характеризується меншою вираженістю пародонтологічних ускладнень в порівнянні зі швидким розширенням піднебіння з додатковим проведенням хірургічного втручання, хоча якість даних, які можуть підтвердити ці висновки, залишається недостатньою та дискусійною.

Заява про конфлікт інтересів

Цим автори підтверджують відсутність зв'язку з будь-якою організацією чи компанією, яка може мати будь-який фінансовий або нефінансовий інтерес до матеріалів дослідження, розглянутих в цій статті.

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Заява про фінансування

Не було отримано жодного фінансування для допомоги в підготовці та проведенні цього дослідження, а також для написання цієї статті.