

Does rapid maxillary expansion change natural head position in children with maxillary constriction? A systematic review and meta-analysis

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ABSTRACT

Objective: a systematic review was performed to evaluate the natural head position (NHP) in children with maxillary constriction before and after rapid maxillary expansion (RME). **Material and Methods:** a comprehensive search was carried out in the MEDLINE via PubMed, Scopus, Web of Science, LILACS, BBO and Cochrane Library and SIGLE without restrictions. The annual conference of the IADR abstracts (1990–2017) and unpublished and ongoing trials registry were also searched. Dissertations and theses were searched using the ProQuest Dissertations and "Periódicos CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) Theses Databases". The studies compared the natural head position in patients submitted rapid maxillary expansion (RME) and untreated patients both with maxillary constriction.

Results: a total of 3023 studies were identified, three remained in qualitative study and all these studies were considered at "unclear" risk of bias in the key domains. Only two studies presented similar data to be included in the meta-analysis. Both studies evaluated the natural head position, through the angle between nasion-sella line and true vertical (SN-Ver). The meta-analyses demonstrated that after 12 months follow-up, the SN-Ver angle decreased by 3.39 degrees (95% confidence interval [CI]= 0.57 to 6.21; p=0.02). **Conclusion:** the RME promoted increase in SN-VER angle in child after 12 months for intervention; however, there are few studies in the literature about this topic, and there is a need of further well-designed trials to investigate this alteration.

Keywords: Palatal expansion technique; Posture; Cephalometry; Respiratory physiologic phenomena; Child.

Introduction

Transverse maxillary deficiency is commonly found in patients with sleep apnea and also related to abnormal breathing patterns.^{1,2} Anatomic and functional alterations often affected physiological breathing. Thus the respiratory cycle becomes also initiated through the mouth not only through the nose, on the other hand, the respiratory function also influences on craniofacial development and head posture.^{3,4}

Head posture had been associated with respiratory function by Ricketts 1968,⁵ who suggested that the craniocervical angulation increase is a functional response to facilitate oral breathing to compensate nasal obstruction, Cole *et al.* 1988⁶ defined the natural head position (NHP) as "the relation of the head to the true vertical" and also "the relation of the head to the cervical spine".

In this context, it has been demonstrated previously that oral breathing children exhibit commonly the typical adenoid faces like a facial retrognathism, upper lip shorter, nose and nostrils smaller.³ Also, an open mouth posture may be the source for mandible rotation to back and down, which causes an increase in vertical development of the lower anterior face and a narrower anteroposterior upper airway dimension.⁷ These anatomic recondition cause muscle imbalance that may lead to craniocervical

hyper-extension and kyphotic posture.³

The rapid maxillary expansion (RME) is a technique used when there is disharmony between the dental arches, caused mainly by skeletal maxillary transverse deficiency, resulting in posterior crossbite, and other alterations like moderate crowding, and sleep-disordered breathing.⁸

This approach promotes the mechanical separation of the midpalatal suture by rupture of the sutural connective tissue using orthopedic forces in a short period time. Normally, palatal growth is completed between 6 to 9 years old. In patients after puberty, with the interdigitation increase of the suture occur a difficulty the palatine suture. Because this, in patients who have finished the growth spurt, the RME is contra indicated.⁹

Due to the influence of maxillary artesian on head positioning, some studies have investigated whether RME treatment has any influence on head position.^{4,6,10,11,12}

In the present study, we systematically reviewed the studies investigating NHP before and after the RME therapy in young patients.

Material and Methods

Protocol and registration

The protocol of this study was registered at the PROSPERO (CRD42017077759) according to PRISMA

statement recommendations, for reporting this systematic review.¹³

Information sources and search strategy

The PICOS question was the base to defined the controlled vocabulary (mesh terms) and free keyword in the search strategy:

1. Population (P): patients with maxillary constriction.
2. Intervention (I): rapid maxillary expansion.
3. Comparison (C): no treatment.
4. The outcome (O): head posture alteration.
5. Study design (S): randomized controlled trial.

The search strategy meticulously an expert librarian guided. In this review the trials included were searched on the electronic databases MEDLINE via PubMeb, Scopus, Web of Science, Latin American and Caribbean Health Sciences Literature database (LILACS), Brazilian Library in Dentistry (BBO) and Cochrane Library. The first study were selected in the PubMed database, the reference lists of these studies, and the related articles link, were hand-searched without restrictions. To identify more articles, other sources were also used. To access Grey literature was used the database System for Information on Grey Literature in Europe (SIGLE), and to access dissertations and theses was accessed the ProQuest Dissertations and Theses Full text database and the CAPES Periodic Theses database.

To access unpublished trials related to the review subject and ongoing trials was performed a search in the following clinical trials registry: Current Controlled Trials (www.controlled-trials.com), International Clinical trials registry plataform (<http://apps.who.int/trial-search/>), the ClinicalTrials.gov (www.clinicaltrials.gov), Rebec (www.rebec.gov.br), and Clinical Trials Register (<https://www.clinicaltrialsregister.eu>).

Eligibility criteria

The randomized clinical trials (RCTs) which evaluated head posture alterations in individuals with maxillary constriction submitted to RME compared to individuals with maxillary constriction untreated were included.

Study selection and processing data

Primarily, the articles were selected by title and abstracts as the search strategy description. When was found the same articles in more than one database, was considered only one study. When the title and abstract did not have information, full-text articles were accessed to make more clear the decision. Then, articles that accomplished the inclusion criteria were classified for three reviewers (AMS, KVO, NDM). Customized extraction forms were used to extract the data. For each included study, were recorded all the details of the study including year of publication, author(s), the study

design and setting and details of participants.

When there was more than one report of the same study, with different follow-ups for example, to avoid overlapping data, were extracted data from all reports directly into a single data collection form.

Risk of bias in individual studies

The same three independent reviewers were performed quality assessments of the selected trials. To assess the risk of bias in randomized trials, it was used the Cochrane Collaboration's tool. Six items composed the assessment criteria: incomplete outcome data, selective outcome reporting and other possible sources of bias, sequence generation, allocation concealment and blinding of the outcome assessors. When there were any disagreements between the reviewers during data selection and quality assessment, these were solved through discussion between them, and when was necessary, a fourth reviewer was consulted.

The risk of bias, for each aspect of the quality assessment, was scored following recommendations describing in Cochrane Handbook for Systematic Reviews of Interventions 5.1.0 (<http://handbook.cochrane.org>). For each aspect, was recorded 'yes' to indicate low risk of bias, 'no' to indicate high risk of bias, and 'unclear' to indicate either lack of information or uncertainty over the potential for bias. Adequate sequence generation and allocation concealment was the main key domains considered in this study.

Summary measures and synthesis of the results

The Revman 5.3 (Review Manager ver. 5.3, The Cochrane Collaboration, Copenhagen, Denmark) was used to analyzed data. The data from eligible studies were continuous (NHP alteration by cephalometric measurement and inclinometer).

To summarize the NHP was measured for each study in intervention (ERM) and control groups. The standardized mean difference for the continuous data were calculated (NHP alteration by cephalometric measurement and inclinometer) with a 95% confidence interval.

Assessment of the quality of evidence using GRADE

The quality of the evidence was graded for each outcome across studies (body of evidence) using the Grading of Recommendations: Assessment, Development and Evaluation (GRADE) (<http://www.gradeworkinggroup.org/>) to determine the overall strength of evidence for each meta-analysis. The GRADE approach is used to contextualize or justify intervention recommendations with four levels of evidence quality, ranging from high to very low.

The GRADE approach begins with the study design (RCTs or observational studies) and then addresses five reasons (risk of bias, imprecision, inconsistency, indirectness of

evidence, and publication bias) to possibly rate down the quality of the evidence (1 or 2 levels) and three to possibly rate up the quality (large effect; management of confounding factors; dose-response gradient). Each one of these topics was assessed as “no limitation”; “serious limitations” and “very serious limitations” to allow categorization of the quality of the evidence for each outcome into high, moderate, low, and very low. The “high quality” suggests that we are very confident that the true effect lies close to the estimate of the effect. On the other extreme “very low quality” suggests that we have very little confidence in the effect estimate and the estimate reported can be substantially different from what it was measured.

Results

Literature search

The first stage a literature search of the studies published from 1965 to 2017 resulted in 3506 articles identified through an electronic search in 6 databases and grey literature. In second stage studies that presented potential relevant titles and abstracts were selected, resulting in a number of 341. Abstracts were assessed and 32 articles were included skilled for full-text review in the third stage. After manual selection 3 more relevant studies McGuinness and McDonald 2005; Tecco and Festa 2006, Yagci *et al* 2011 were chosen in this systematic review.^{11, 12, 14}

For the meta-analysis two study McGuinness and McDonald 2005; Tecco and Festa 2006, completing the fourth step (Figure 1).^{11, 12}

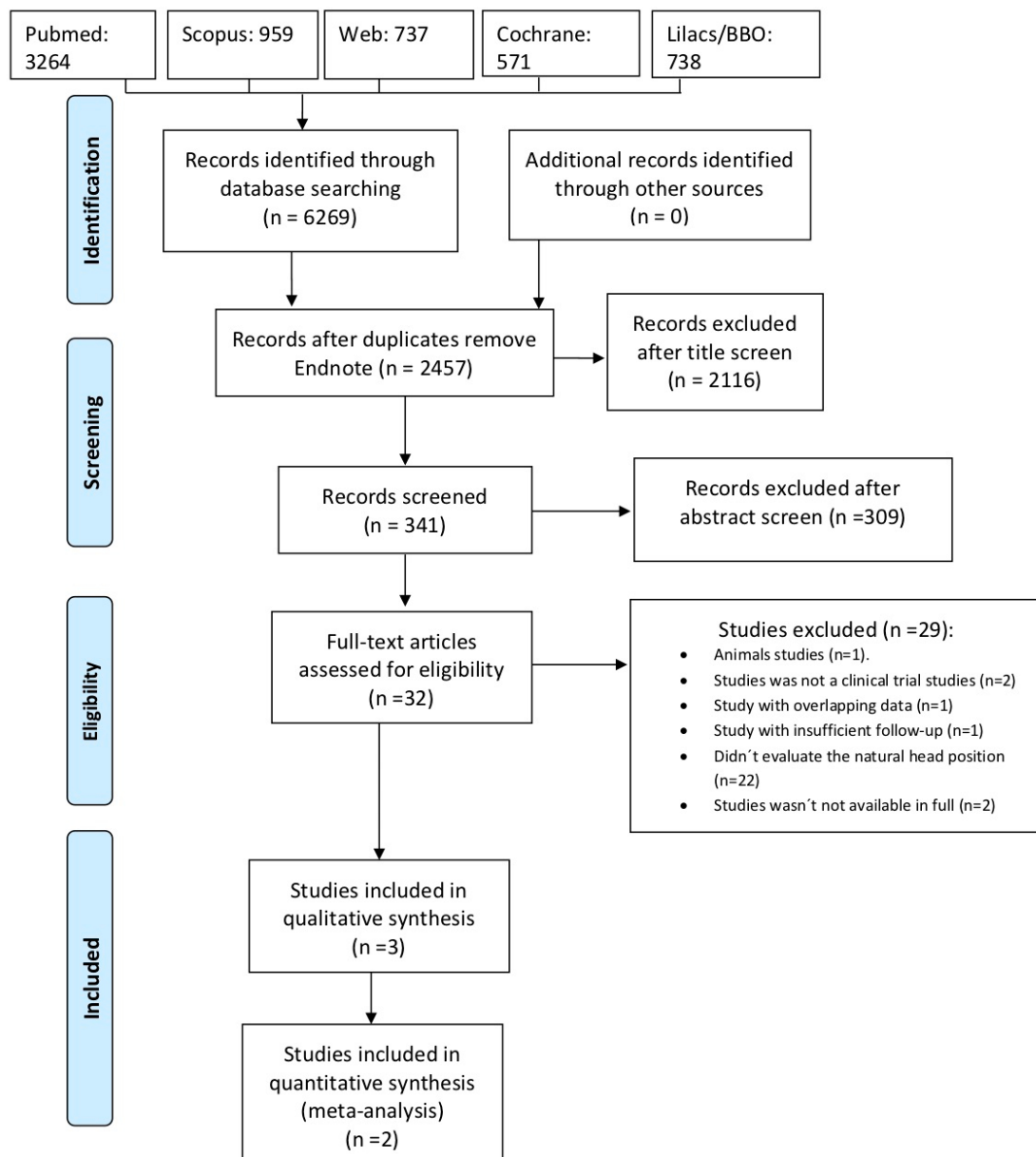


Figure 1. Flow diagram of study

Included studies

At the end the fourth stage, three studies were full reviewed and considered adequate for this systematic review, their characteristics and results are presented in Table 1. All selected studies presented are clinical trials. The sample size of studies was between 36 and 79 individuals divided in control and case groups. The study included just girls, in the study McGuinness and McDonald 2005 and Yagci *et al* 2011 the gender female corresponding a few more than 50% in both control and case groups. About the age, study McGuinness and McDonald 2005, varied between 10-16 years old, in study Tecco and Festa 2006 between 8-15 years and study Yagci *et al* 2011 just described the mean 10.1 (± 1.1) years. About evaluation times, all studies evaluated the head position in pre-treatment.^{11, 12, 14}

In the post-treatment period, study McGuinness and McDonald 2005 evaluated the patients immediately after treatment and one year after, study Tecco and Festa 2006 performed the evaluation six months and one year

after, and study Yagci *et al* 2011 evaluated after 6-8 months. The expander apparatus used in study McGuinness and McDonald 2005 was described as splinted with full cast metal coverage of the buccal teeth (654/456) occasionally covering 3/3 or 7/7. Study Tecco and Festa 2006 did not described the apparatus, and the study Yagci *et al* 2011 used a splint-type tooth and tissue-born. To access the head position studies McGuinness and McDonald 2005; Tecco and Festa 2006 performed cephalometric analyses, but there was just one common measure between the studies, the angle between nasion-sella a line and true vertical (NSL/VER). Study Yagci *et al* 2011 used an inclinometer to access the dynamic mean of head position.

About the results changes in head posture after RME were observed in McGuinness and McDonald 2005; Tecco and Festa 2006 but not in the other the Yagci *et al* 2011. The authors mentioned there was no conflict of interest in any article.

Table 1. Studies characteristics and results included in systematic review

STUDY	CHARACTERISTICS				RESULTS			
	Inclusion criteria	Sample size	Evaluated times	Kind of expansior	Kind of analyses	Evaluate Measures	Adequate samples allocation	Changes in head posture
1/Mc Guinness/ European Journal of Othodontics/ 2006 ⁸	10-16 years old Good general and dental health Bilateral crossbite in the buccal segments, or unilateral crossbite with displacement on closure. Full permanent dentition in the maxillary arch, consisting of 654321/123456. No history of surgery to the nasal, paranasal, or oral cavities . No allergies, nasal decongestant medication, or history of nasal obstruction.	Experimental: 43 Control: 36	Pre-treatment Immediately after Post-treatment 1 year	Splint with full cast metal coverage of the buccal teeth (654/456), occasionally covering 3/3 or 7/7	Lateral cephalometric	OPT/NSL ^o CVT/NSL ^o OPT/CVT ^o NSL/VER ^o OPT/HOR ^o CVT/HOR ^o	No. Without randomization	Yes
2/Simona Tecco/ European Journal of Othodontics/ 2007 ⁹	Children Girls Mouth breathing Need maxilla expansion No nasal allergic conditions No airway obstruction due to enlarged adenoids No history of previous orthodontic treatment.	Experimental: 23 Control: 22	Pre-treatment Post-treatment 6 months Post=treatment 1 year	Not described	Lateral cephalometric	CVT/EVT ^o OPT/Ver ^o CVT/Ver ^o EVT/Ver ^o SN/Ver ^{o*} PP/Ver ^o MP/Ver ^o SN/OPT ^o SN/CVT ^o PP/OPT ^o PP/CVT ^o MP/OPT ^o MP/CVT ^o	+- (unclear)	Yes
3/Ahmet Yagci/ Angle Othodontist/ 2011 ¹⁰	Children Maxillary cross deficiency Class I Normal vertical growth pattern Posterior crossbite No dental absences from extraction or abnormality congenitas Absence of deformities in the neomaxilar complex	Experimental: 23 Control: 15	Pre-treatment Post-treatment 6-8 months.	Splint-type tooth and tissue-born.	Inclinometer	Dynamic mean of head posture	+- (unclear)	No

Risk of bias

Other important aspects related the quality of included studies are reported in Figure 2. The key domains were considered unclear in all studies.^{11, 12, 14}

Meta-analysis

Were conducted the meta-analyses just on studies classified as been at “unclear” risk of bias in the key domains. It was possible to performed a meta-analysis just for one common measure (OPT/NSL= SN/OPT) between two studies. This measure is considered a continuous variable.

SN-Ver angulation

This analysis was based on McGuinness and McDonald 2005; Tecco and Festa 2006. The risk ratio was 3.39 (95%) in confidence interval [CI] of 0.57 to 6.21 (*p*=0.02). The data were homogeneous (chi² test *p*=0.63; I²=0%; Figure 3).

Assessment of the quality of evidence

In the summary-of-findings table (Table 2), the meta-analysis was graded as moderate in the quality of evidence. The reasons for downgrading the evidence were that both RCTs are at “unclear” risk of bias and presence imprecision with a high 95% confidence interval, which does not exclude important harm or benefit (Table 2).

Discussion

In the health area has a lot of scientific publications, making our formation of opinion about treatments increasingly challenging. In the midst of such vast and controversial literature, we must pay attention to the quality of studies. In the scientific evidence pyramid, the systematic review and meta-analyze are at the top, seeking to solve the controversy between studies and improve the power of the findings. Also, promote a critical evaluation of evidence,

	Adequate sequence generation?	Allocation concealment?	Blinding?	Incomplete outcome data addressed?	Free of selective reporting?
Mc Guinness <i>et al.</i> , 2006	?	?	?	+	+
Tecco <i>et al.</i> , 2007	?	?	?	+	+
Yagci <i>et al.</i> , 2011	?	?	?	+	+

Figure 2. Summary of the risk of bias assessment according to the Cochrane Collaboration tool

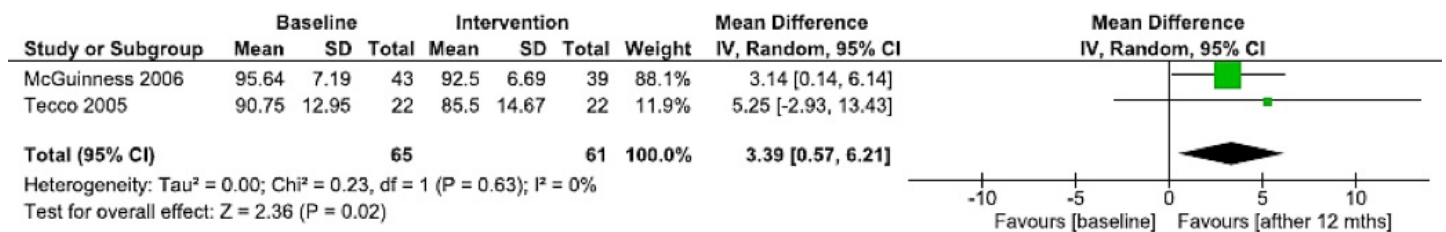


Figure 3. Meta-analyses of McGuinness and Tecco studies about SN-VER angle changes from preoperative to postoperative period

Table 2. Summary of findings table

Patient or population: children					
Intervention: baseline					
Comparison: after 12 months					
Outcomes	Anticipated absolute effects † (95% CI)		Relative effect (95% CI)	Nº of participants (studies)	Quality of the evidence (GRADE)
	Baseline	After 12 months			
Natural head position	SMD3.39 SD lower (0.57 to 6.21)	-	-	65 (2 RCTs)	⊕⊕○○ MODERATE‡



summarizing information with true evidence for developing recommendations for clinical implementation.¹⁵⁻¹⁶

Our systematic review began with a large number of articles about RME because to unite all the information available on the subject of our research. The extensive search strategy was performed including all necessary and relevant studies. However, the methodology of systematic review seeks high sensitivity search strategy, promoting a large reduction in the number of the studies because select just the relevant reports.¹⁷

Unfortunately, when the sensitivity is increased, the accuracy of the search is reduced. Thus, we end up with just a few studies on the subject, mainly because the outcome we analyzed in this article has not been evaluated in most RME studies. Also, to minimize bias, the methodology needs patronizations to show the data.¹⁶

When analyzing clinical trials, it is important to emphasize the importance of randomization and allocation. The most of the studies did not explain how the randomization and allocation secrecy were performed, so most studies were unclear for these key domains. There is a need for clinical studies to follow the recommendations of CONSORT to minimize study bias risks.¹⁸

Despite there are a lot of studies about RME including metanalyses about the maxillary dentoalveolar transversal dimensions in Boluyt *et al* 2008 and about the airway after the treatment, few studies evaluated the NHP, which is an important data.¹⁹⁻²¹

It was suggested that the improvement in the breathing mode from oral to nasal as a result of RME cause alterations in head posture, thereby contributing to a change in craniofacial development, supporting and adding to the soft tissue

stretching hypothesis.¹¹

The three selected studies used different methods to determine the position of the head. Two of them evaluated through cephalometry and one through an inclinometer apparatus. The two studies used cephalometry considered different angles and measurements to determine NHP, just one angle was the same and made possible the meta-analyses, the SN-Ver angle. The meta-analysis shows that the SN-Ver angle decreased by average 3.39 degrees one year after the procedure compared with to pre-procedure period, which could be associated with a change in the NPH. The study uses de inclinometer obtained results with no significant changes. Probably this apparatus is not effective for this evaluation. We did not find others studies that use this methodology.

We also did not found recently studies evaluating this topic after RME in child. Nowadays, most studies use tomographic exams to evaluate airway volume, dimensional bone and tooth changes, but none considered the postural changes. It is necessary future studies about RME a more complete evaluation, in a long follow-up, to observe these changes about respiratory and postural habits in the long term after RME treatment, comparing to a control group, and also to verify differences in the craniofacial development.

Conclusion

The RME promoted crease in SN-VER angle in child after 12 months of intervention; however, there are few studies in the literature about this topic, and there is a need for further well-designed trials to investigate this alteration.

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