

## Systematic review

# Effects of rapid maxillary expansion on the midpalatal suture: a systematic review

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## Summary

**Objective:** To identify and qualify the scientific evidence on the immediate and long-term effects of rapid maxillary expansion on the midpalatal suture in growing teenage or young adults, the related articles were selected.

**Materials and methods:** Literatures were searched in the electronic databases, including Medline, Embase, Web of Science, and Cochrane Library. A methodologic-quality scoring (13-point) scale was used to evaluate the quality of the studies.

**Results:** Twelve relevant articles were identified. Midpalatal suture opening during orthodontic treatment with rapid maxillary expansion (RME) amounted to 12–52.5 percent of the total screw expansion. After the treatment of RME, the midpalatal suture seemed to be recalcified, so the expansion of the midpalatal suture was stable, but there was no consistent evidence on whether the midpalatal sutural opening was parallel or triangular.

**Limitations:** The methodologic quality of the included studies was assessed rigorously and many deficiencies were found.

**Conclusions:** The majority of the articles were judged to be of low quality. Therefore, we could not draw any accurate conclusion on the basis of evidence in this systematic review.

## Introduction

The most effective orthopedic treatment that aims to increase the maxillary transverse width is rapid maxillary expansion (RME) (1). It has also been recognized as a safe and reliable orthopedic procedure.

The first use of RME was described by Angell (2) in 1860. Total expansion from RME has three parts: midpalatal suture expansion, alveolar expansion, and dental tipping.

Previous reports on RME skeletal and dental effects are contradictory because of variable study designs, sample sizes, and research approaches. Two meta-analyses regarding the transverse dental effects of RME have been published (3, 4). One systematic review (5) about the long-term dental effects of RME has been published. Two systematic reviews (6, 7) partly about the immediate skeletal effects of RME have been published but to date there are no systematic reviews specially regarding immediate and long-term skeletal effects on the midpalatal suture.

The objective of this article was to assess the evidence on the amount of midpalatal suture opening and the long-term skeletal effects on the midpalatal suture.

## Materials and methods

### Selection criteria

Two investigators selected articles according to the selection criteria. The inclusion criteria were as follows:

Studies of human clinical trials, published in English.

Studies on healthy children or young adults who had maxillary transverse discrepancy or upper dental arch constriction, such as unilateral or bilateral posterior crossbite, some crowding, and so on, and needed maxillary expansion. Studies that included clear descriptions of the type of appliances applied.

Prospective and retrospective original studies with a minimum of five subjects in the study sample.

During the evaluation period, no surgical or other treatment in progress that would influence the RME therapy.

Studies that concern human subjects with quantitative data on the immediate effect of RME assessed by cone-beam computed tomography (CBCT) or computed tomography (CT) or occlusal radiographs.

The exclusion criteria included studies concerning merely the slow palatal expansion, cleft lip and/or palate or other craniofacial syndrome diagnosis, surgically assisted expansion, functional appliance therapy, and protraction headgear or facemask therapy, and case reports.

### Search methods

Medline (from 1966 to June 2014), Embase (from 1988 to June 2014), Web of Science (from 1945 to June 2014), and Cochrane Library (from 1945 to June 2014) databases were searched, and so were the reference lists of selected articles, which may have been missed in the databases. Two review authors searched the databases independently and disagreements were settled through discussion. The search strategy is shown in [Supplementary Table I](#).

The flow diagram is shown in [Figure 1](#).

### Data extraction and analysis

Articles that seemed to meet the selection criteria on the basis of the title and abstracts were selected. If not enough relevant information was provided in the abstract, the full text would be obtained. The two searchers settled discrepancies through discussion (interexaminer  $\kappa = 0.900$ ).

The final selection was completed by reading the complete articles independently. The selection criterion was used again to make the final decision. We still reach a consensus by discussion in cases of any discrepancies (interexaminer  $\kappa = 0.985$ ). Once specific data were necessary but not stated in the article, we would make efforts to contact the author to obtain the additional information needed.

Finally, 12 articles that met the selection criteria remained. Information on the following items was gathered: study country, design, the size, gender, and age of the participants intervention type, rate of screw activation (mm/day), endpoints, retention time, imaging parameters such as type, measurements, outcome measure, the amount of midpalatal suture opening (mm), midpalatal suture opening parallel or triangular, the post-retention effects of rapid maxillary expansion, and the percent of midpalatal suture opening amounted to the total screw activation.

According to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement, in the design or conduct of a study, the defects may produce bias, so the assessment of methodological quality for this study gives an indication of the strength of evidence. However, no specific approach for evaluating methodological quality can be applied to all systematic reviews (8, 9).

In our study, a 13-point scale was used to assess the quality of the articles, which was developed after the study of Lione *et al.* (6) by analyzing the following characteristics: description of selection process, study design (retrospective, prospective, or randomized),

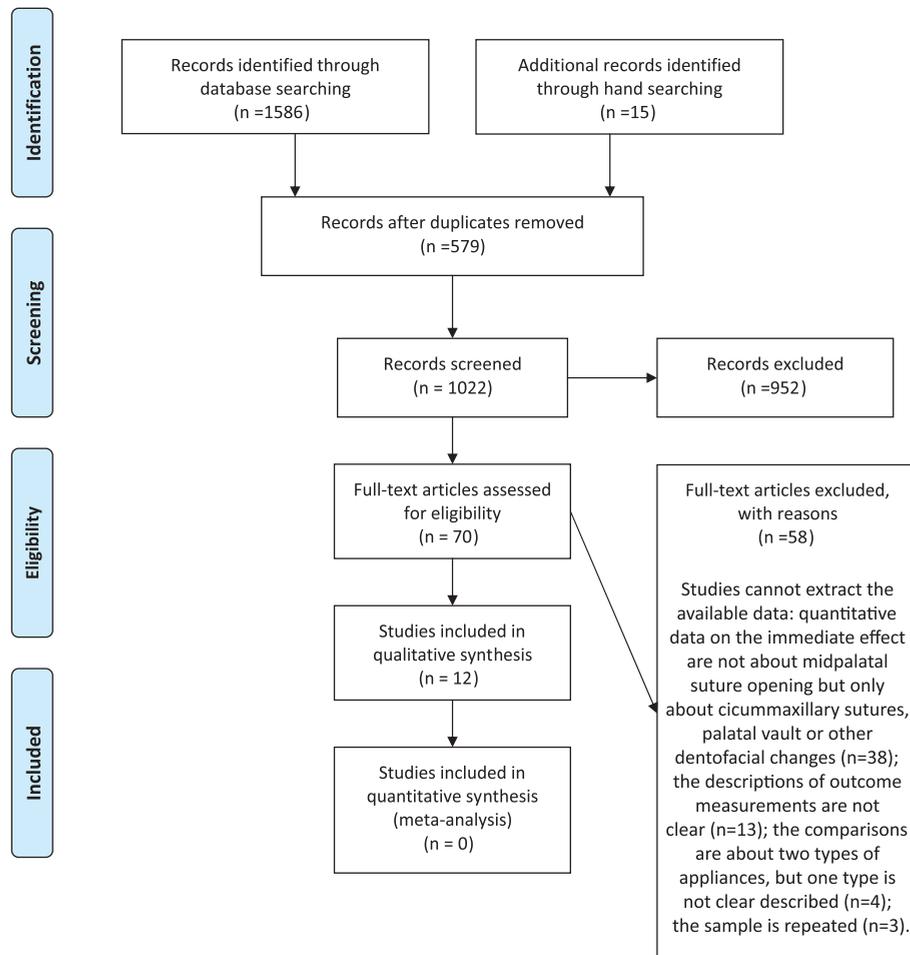


Figure 1. Study flow diagram. From Moher *et al.* (8).

consecutive cases, sample size, choice of outcome measure, adequacy of method error analysis, adequacy of statistical analysis, and power of the study. The quality of the studies was evaluated in [Table 1](#) and [Supplementary Table II](#). The same two researchers scored each study and discrepancies were resolved through discussion and negotiation.

### Statistical analysis

A meta-analysis of the results of the studies was planned, so the assessment of heterogeneity of the studies was made by calculating the  $I^2$  index. However, the heterogeneity is too high ( $I^2 > 75$  percent) to make a meta-analysis, which might lead to misleading results. As a result, a systematic review was considered. By collecting, appraising, and synthesizing the evidence from scientific studies, systematic reviews make a comprehensive summary of the available evidence, so as to provide answers to scientific questions (10).

## Results

Medline yielded 290 publications; Embase, 520 publications; Web of Science, 768 publications; Cochrane Library, 8 publications. In addition, 15 records were identified through hand/manual search. Application of the inclusion and exclusion criteria identified 12 relevant publications finally.

Six studies (12–17) were prospective, and three studies (19, 21, 22) were prospective and randomized. One study (11) was a randomized controlled trial, and the other two (18, 20) studies were unreported.

The average age at the beginning of orthopedic expansion in the samples was ranging from 7 to 15 years. As a whole, in 10 studies (11–16, 18, 20–22), the sample comprised teenagers; in two studies (17, 19), the sample was older than 15 years.

The devices applied were Hass expanders, which were bonded with acrylic coverage on the occlusal surface of posterior upper teeth, or hyrax expanders, which were banded with the two or four anchored tooth.

The methods used to detect the treatment effects were different: two studies (19, 22) used 2D radiographic techniques, and the other 10 studies used 3D radiographic techniques.

The screw was activated 0.5 mm/day in five studies (14–17, 22), 0.8 mm/day initially, then 0.4 mm/day in one study (11).

Four studies (12, 17, 19, 22) used a clinical evaluation. Four investigations (14–16, 21) reported that the required expansion corresponded to a precise amount of screw expansion of 7 mm. Two

investigations (11, 13) reported that the required expansion corresponded to an amount of screw expansion of 8 and 8.19 mm. Two investigations (18, 20) unreported the amount of screw expansion.

### Immediate changes of midpalatal suture

Measurements of changes in midpalatal suture width during RME were presented in all of the included studies.

Six of them presented data for both the anterior and posterior regions. The mean expansion changes in the anterior midpalatal suture in the region ranged from 2.42 to 4 mm, which corresponded to 34.6–50 percent of the total screw expansion. Mean expansion changes in the posterior midpalatal suture ranged from 0.84 to 2.88 mm, corresponding to 12–36 percent of total screw expansion. Five of them presented data for Sut3-3 and Sut6-6 width. The mean expansion changes between the 3-3 midpalatal suture ranged from 1.52 to 4.3 mm, which corresponded to 21.7–52.5 percent of the total screw expansion. Mean expansion changes in the 6-6 midpalatal suture ranged from 1.6 to 4.3 mm, corresponding to 22.9–52.5 percent of total screw expansion.

### Long-term changes of midpalatal suture

Nine studies (11, 14–17, 19, 21, 22) analyzed the long-term effects of RME. After RME therapy, the device was maintained as a passive retainer for a minimum of 3 months and a maximum of 12 months. Long-term changes of midpalatal suture after maxillary expansion were not significant, so the opening of the midpalatal suture was stable.

Four studies (11, 12, 15, 19) concluded that the suture opened in a triangular shape, of which the largest opening was at the anterior region. Two studies (13, 14) reported that the midpalatal suture opening was parallel.

The reviewed articles had different endpoints and different reference points when measuring the midpalatal suture opening, which makes comparisons difficult.

### Quality analysis

A quality analysis of the 12 retrieved studies was accomplished according to the criteria in [Table 1](#). Interexaminer agreement for the quality assessment was 0.95 (kappa statistics). The judged quality and methodologic soundness for the 12 selected studies are presented in [Supplementary Table II](#). Two studies (11, 21) were of medium high quality, four studies (13–15, 19) were of medium quality, and the other six (12, 16–18, 20, 22) were of low quality.

**Table 1.** Quality assessment

Study	Study design	Judged quality standard
Weissheimer <i>et al.</i> (11)	Prospective	Medium high
Ghoneima <i>et al.</i> (12)	Prospective	Low
Christie <i>et al.</i> (13)	Retrospective	Medium
Ballanti <i>et al.</i> (14)	Retrospective	Medium
Lione <i>et al.</i> (15)	Retrospective	Medium
Podesser <i>et al.</i> (16)	Retrospective	Low
Baydas <i>et al.</i> (17)	Prospective	Low
da Silva Filho <i>et al.</i> (18)	Retrospective	Low
Davidovitch <i>et al.</i> (19)	Prospective randomized	Medium
da Silva Filho <i>et al.</i> (20)	Retrospective	Low
Garib <i>et al.</i> (21)	Prospective randomized	Medium high
Lamparski <i>et al.</i> (22)	Prospective randomized	Low

## Discussion

This review is the first systematic review to evaluate the immediate and long-term midpalatal suture response to RME treatment.

### Age

The impact of age on skeletal effects of RME is an interesting issue in the clinical situation. Generally speaking, the expansion through the opening of the palatal suture progressively becomes more difficult as the patients grow old.

The age range in the articles reviewed was 5–20 years. In two studies (17, 19), the sample was older than 18 years, but the midpalate suture was still separated.

In a study by Korbmacher *et al.* (23), human-palate specimens from individuals aged 14–71 using CT were assigned to three age groups (<25, 25 to <30, and ≥30 years). Significant differences between age groups were only found for bone density. The

middle-aged group exhibited the highest bone density (53.2 percent), while it was significantly lower in the youngest and the oldest age groups. Neither the mean obliteration index nor the extent of interdilatation correlated with chronological age. Therefore, sutural bone density seems to be the parameter limiting conservative RME.

### Device

There are a variety of expanding devices applying to rapid maxillary expansion. The type of appliances were expanders that attached primarily to the posterior teeth in all of the included studies and exerted pressure on the hard palate in half of the studies (Haas-type expanders).

Regardless of the type of expanding devices, RME is an effective procedure that is able to produce transverse skeletal effects on the maxilla by opening the midpalatal suture.

### Computed tomography/cone-beam computed tomography

In contrast to the 2D imaging, if the structural overlap is the main issue in the diagnostics, the use of the low-dose CT/CBCT imaging can be justified for gathering the most adequate information for the treatment. Thanks to CT/CBCT technology, it allows clinicians and researchers to make a quantitative evaluation for the bone changes in three dimensions.

However, the radiation dosage and its bearing on growing patients must be kept in mind. Even though CT imaging may be available, regular use of it for orthodontic or dental care may not be justified.

### Rate of screw activation (mm/day) and endpoints

In this study, we found that the midpalatal suture opening was not closely associated with the rate of appliance activation, but with the amount that the appliance is expanded, which means the endpoints and probably the amount of residual load remaining at the termination of appliance activation.

### Retention time

The study by Krebs *et al.* (24) with metallic implants has shown that the expansion of the suture itself is very stable after retention for 3 months but that the unavoidable buccal tipping of premolars and molars was followed by an uprighting for a long time. In the study of Ekström *et al.* (25), after 3 months, the process of mineralization has become fairly well established in the expanded suture.

Not only the formation of the midpalatal suture itself but also the establishment of a stable relationship at the articulations of the maxilla and other bones of the facial skeleton would determine the retention time of RME.

Furthermore, it seems that the length of time needed for the skeletal readjustment during retention depended on the amount of residual load remaining at the termination of appliance activation (26).

### Immediate changes of midpalatal suture

Midpalatal suture opening during orthodontic treatment with RME amounted to 12–52.5 percent of the total screw expansion, which is consistent with the result of previous research (20–50 percent) (7).

### Long-term changes of midpalatal suture

Long-term changes of midpalatal suture after maxillary expansion were not significant, which indicated that the change of the midpalatal suture was stable.

In the study of Davidovitch *et al.* (19), due to 1 year after RPE therapy, the anterior midpalatal suture lost up to 27.5–46.38 percent with the two-band hyrax appliance, while it lost up to 58.87–75 percent with the four-band. The posterior midpalatal suture lost up to 100 percent with the two-band, while it did 73.71 percent with the four-band. Ballanti *et al.* (14) believed that after the 6-month retention period, the midpalatal suture appeared reorganized with a transverse dimension similar to the pre-treatment width. The midpalatal suture lost up to 89.55 and 77.78 percent of its increased area at anterior nasal spine and posterior nasal spine, respectively. However, these results did not exclude the growth factor.

### Limitations

The methodologic quality of the included studies was assessed rigorously and many deficiencies were found. None of the selected studies were of high value of evidence, and only one randomized controlled trial was identified. Most significant deficiency was the lack of characterization of power of the study, consecutive cases, and sample size. Only one study (14) used power of the study.

Therefore, it might be sound to interpret the results from these studies with caution.

### Conclusions

The aim of this systematic review was to find out about the opening of the midpalatal suture and the long-term effects on the midpalatal suture. After assessing the quality of the retrieved articles, it may be concluded that these questions cannot be fully answered.

1. Heterogeneity of the studies was too high ( $I^2 > 75$  percent), so a meta-analysis was not used.
2. RME is an effective procedure that is able to produce transverse skeletal effects on the maxilla by opening the midpalatal suture regardless of the type of palatal expander.
3. Midpalatal suture opening during orthodontic treatment with RME amounted to 12–52.5 percent of the total screw expansion. After RME, the suture seemed to be reorganized, so the expansion of the midpalatal suture was stable, but there was no consistent evidence on whether the midpalatal sutural opening was parallel or triangular.
4. The quality level of the studies was not sufficient enough to draw any accurate conclusion on the basis of evidence. Additional randomized controlled trials with sufficient power are required to add further insight into the 3D effects of RME on midpalate suture.

### Supplementary material

Supplementary material is available at *European Journal of Orthodontics* online.

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