Treatment Stability and Intermolar Width Changes in Patients Undergoing Surgically Aided Rapid Palatal Expansion: A Systematic Review

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KEYWORDS

Surgically Assisted Rapid Palatal Expansion, bone, PRISMA, Intermolar, RCTs

ABSTRACT

Introduction: The primary objectives of this systematic review were to critically evaluate clinical research assessing the stability of treatment outcomes following surgically aided rapid palatal expansion (SARPE) and to review published studies on intermolar width measurements taken before and after the treatment.
Materials and Methods: A complete search across the electronic databases of the Cochrane Library, Google Scholar, PUBMED, Europe PMC and Science Direct, and a complimentary manual search of all orthodontic journals until 2024 were carried out. Selection criteria were used in the evaluation of the articles.
Selection Criteria: Based on the PICOS (population, intervention, comparison, outcome, study design), the inclusion criteria were established. Adult patients with constricted maxillary arches and resulting transverse discrepancies were included in the study, and SARPE was carried out to address this clinical problem. Although many studies have been conducted on this topic, only randomized clinical trials were covered in this review. Excluded from this review were case reports, conference papers, animal experiments, in vitro research, case series, and FEM studies.
Data Collection and Analysis: The primary outcome of the systematic review was the assessment of treatment stability and intermolar width changes in patients who underwent surgically aided rapid palatal expansion (SARPE). The selection of studies and data collection were conducted using standard methodological techniques. The assessment of the risk of bias was conducted, and the results were synthesized. Cochrane Risk of Bias was used for evaluating the outcomes obtained in the various studies. They were assessed by the GRADE protocol for Outcome Assessment for listing the parameters studied.
Results: No significant difference in stability was noted between the two groups.
Conclusion: With adequate literature review and outcome assessment, it can be concluded from this review that weak evidence exists to conclusively prove the stability of SARPE in the inter-molar and inter-first premolar regions. Immediate post-surgical stability is dependent on a variety of factors that have not been standardized in the various RCTs. Further well-designed trials that establish the extent of transverse discrepancies along with defining the obtained results with clarity are required before we obtain sufficiently conclusive outcomes.

1. Introduction

Surgically Assisted Rapid Palatal Expansion (SARPE) is a combined surgical and orthodontic technique designed to increase the maxillary arch in patients with transverse maxillary deficiency, particularly when the lateral maxillary and mid-palatal sutures are fused [1,2]. The procedure involves a lefort I and midpalatine osteotomy and the placement of a rapid palatal expander, which gradually separates the maxillary bones through daily activation of a screw, allowing for expansion of the palate [3,4]. SARPE is indicated in cases of bilateral posterior crossbite and dental crowding, while contraindications may involve certain medical conditions or insufficient bone quality [5,6]. Advantages of SARPE include the ability to correct significant maxillary constriction without tooth extractions, cortical fenestration, buccal root resorption, periodontal membrane compression, maxillary segmental tipping, anchoring tooth tipping can be prevented, and improved facial aesthetics; however, disadvantages include a prolonged recovery period and the need for patient compliance during the expansion phase [1].

Stability following treatment with SARPE pertains to the preservation of the attained maxillary width and skeletal alterations over time after the expansion procedure has been completed [7]. It is crucial because it determines the long-term effectiveness of the treatment, influencing both functional outcomes and patient satisfaction [8,9]. The relevance of understanding the stability of SARPE outcomes is particularly important when formulating post-treatment retention protocols, which are critical to maintaining the expanded width and

preventing relapse [10]. As a result, assessing the long-term retention of intermolar width changes is a key component of evaluating SARPE's overall success.

Previous systematic reviews on surgically aided rapid palatal expansion (SARPE) have significantly contributed to our understanding of treatment outcomes and stability. For instance, Kilic et al. (2021) compared bone-borne and tooth-borne expanders, highlighting that bone-borne appliances tend to produce more skeletal effects with less dental tipping, which is crucial for selecting the appropriate device based on desired treatment results. Vilani et al. (2022) assessed the effects of SARPE on facial soft tissues, noting variability in outcomes that underscores the need for standardized measurement techniques. Nada et al. (2013) conducted a meta-analysis on volumetric changes in the nasal airway after RPE, demonstrating significant increases in airway volume and highlighting the functional implications of treatment. This systematic review aims to assess the existing evidence on the stability of SARPE, with a specific focus on the maintenance of inter-premolar and intermolar width changes over time.

2. Materials and Methods

Search methods for identification of studies

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis standards were adhered to during the systematic review process. (PRISMA). To screen all the relevant studies, two separate authors first went through titles and abstracts. If the abstracts were not sufficiently comprehensible, the full text of the articles was retrieved to assess their suitability for our review. All differences of opinion were discussed and resolved between the two authors. If necessary, the third author was consulted.

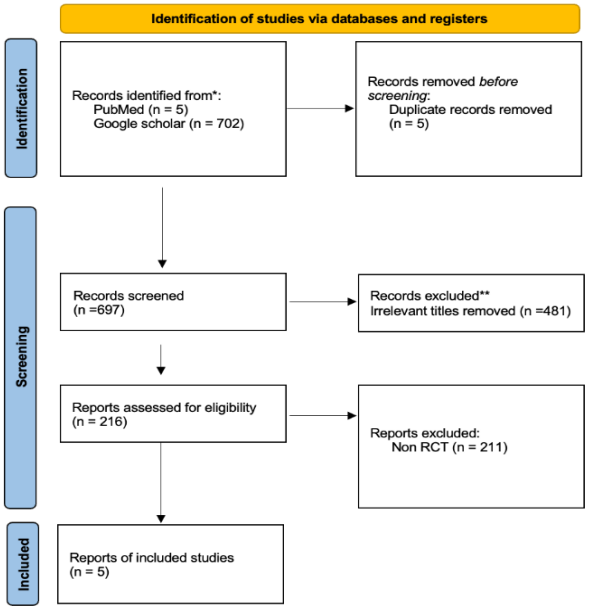

Figure 1. Prisma flow chart

Electronic searches

A search was conducted electronically through Cochrane Library, PubMed, Science Direct, European PMC, Google Scholar, and Lilacs till September 2024. No language restrictions were applied and any publication year was included. Complete search terms for PubMed: (((((((((((((maxillary arch) OR constricted maxillary arch) OR constructed palate) OR maxillary crossbite) OR palatal crossbite) OR narrow palate) OR narrow maxillary arch) OR maxillary dental crossbite) OR maxillary skeletal crossbite)) AND (((((surgical assisted rapid palatal expansion) OR sarpe) OR surgically assisted rapid maxillary expansion) OR sarpe) OR surgically assisted rapid palatal expansion)) AND ((((intermolar width measurement) OR arch width measurements) OR stability) OR retention)) AND ((Clinical Trial[ptyp] OR Randomized Controlled Trial[ptyp])). All electronic search strategies had similar MeSH terms and texts. A manual search of the full-text articles' references was also conducted.

Searching other resources

To choose which studies to include in this review, the titles and abstracts were screened. To find any clinical

trials that were overlooked in the first search, the references utilized in these studies were manually searched. The most recent search was conducted on June 2024.

Data collection and analysis

Data was collected from the included studies according to the following criteria: author name, year of publication, study type, subjects, interventions, age group, treatment duration, measurement technique, and outcomes examined.

Inclusion criteria	Exclusion criteria
1. Studies done on patients who underwent SARPE. 2. Studies that used intermolar width measurements. 3. Studies that assessed the post-operative stability of SARPE	1. Research that used FEM analysis or was conducted in vitro. 2. Studies that were done on animals 3. Research using transverse malocclusion correction techniques apart from SARPE.

Selection of studies

Studies evaluating the post-operative stability of SARPE in patients undergoing transverse expansion due to maxillary constriction were taken into account. The pertinent data was summarized and explained where the parameters of the two trials were comparable. The third author was consulted after two independent writers evaluated the studies that were included in the analysis.

Data extraction and management

After using a search method to find potential publications, two authors assessed the abstracts and titles of those articles and extracted the information from the papers that satisfied the inclusion criteria. If the abstract and title screening failed to adequately clarify the article, the entire content was evaluated. If any disagreements were raised, it was discussed and solved by consulting the third authors. The studies that did not comply with the inclusion criteria were excluded. The data that were being assessed in this review were extracted from tables and figures included in this study. A Preferred Reporting Item for Systematic Reviews was used to document the screening process

Assessment of bias in included studies

For each of the included studies, the risk of bias was evaluated by two separate authors. If there were any disputes among the writers that couldn't be resolved through conversation, after consulting with a third author, the ultimate choice was decided. Data from randomized controlled trials were taken and analyzed for this investigation. Since study bias is independent of our review goal, the risk of bias for the randomized controlled trials was evaluated using a randomized trials risk of bias method.

Qualitative assessment

Randomized trials were assessed using the Cochrane Risk of Bias (RoB 2.0) method. It involves making decisions based on seven headings that were developed by the Cochrane Group. The overall risk of bias as well as the risk of bias for each domain were determined using the RoB 2.0 tool's recommendations. The studies were classified as having a low risk of bias overall, some concerns about bias, or a high risk of bias based on the results of the RoB 2.0 tool. The overall risk of bias as well as the risk of bias for each of the headers were determined using the ROBINS-I tool's recommendations. All trials were categorised as lacking information, low, moderate, serious, or critically biased risk.

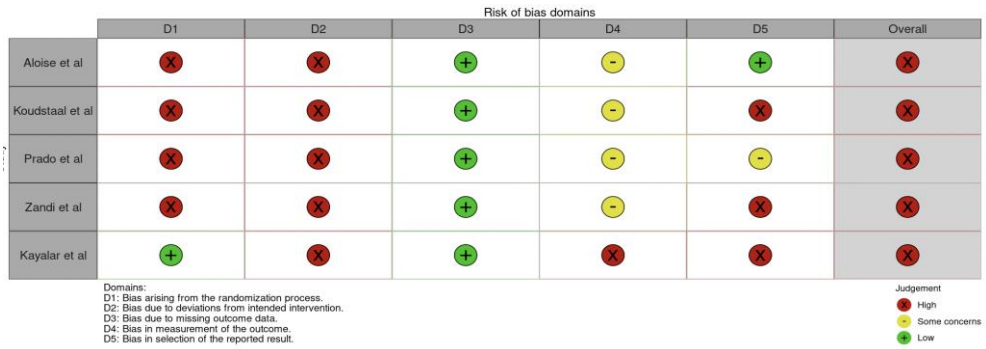

Table 3. Risk of bias table

Assessment of heterogeneity

Clinical heterogeneity was expected to be minimized given the provided inclusion criteria for studies (diagnosis/condition, intervention, and outcome measure), even if it was addressed in the results section. Statistical measures of heterogeneity such as the Chi-square test, Cochran's Q, or I2 statistic could not be applied with any degree of confidence in a longitudinal meta-analysis because the exact impact size of the intervention was unknown.

Assessment of reporting bias

The GRADE level of evidence took into account the potential impact of publishing and small research biases on review findings. The "study size" risk of bias criterion addressed the impact of small study biases. Using Oxford's CEBM table, the body of evidence's quality is evaluated.

Data synthesis

The findings of the trial were unable to converge and take into consideration study variability both within and across studies. The data evaluated and the methods employed precluded the application of comparative analysis.

3. Results

Inter premolar and intermolar width

Two studies, Aloise et al and Zandi et al reported no difference in inter premolar and intermolar width in SARPE with retention using TPA, while a significant difference was noted in SARPE without retention. Prado et al reported a significant difference post SARPE in both the groups. Koudstaal et al noted a significant different in both tooth borne and bone borne groups while Kalayar et al did not find a significant difference. Table 2 shows the characteristic table of the included studies.

In accordance with the inclusion criteria, a total of 5 studies were included in this systematic review.

Table 1. Characteristics table

Study	Design and Subjects	Intervention	Outcome	Results	Inference
Aloise *et al* (2017)	RCT SS: 30; mean age: 27.3; M: 16; F: 14	Group A: retention using TPA; Group B: no retention	Stability At T1- removal of appliance and T2- after 6 months	Group A: IPW: 1.1mm IMW: 0.32mm MMD: 1.54mm Group B: IPW: -1.54mm IMW: -0.76mm MMD: 0.84mm	Group A (IPW and IMW): p>0.05 Group B (IPW and IMW): p< 0.05 Group A and B (MMD): p>0.05
Koudstaal *et al* (2009)	RCT SS: 46; mean age: 30; M: 23; F: 23	Group A: bone borne; Group B: tooth-borne	Stability and relapse	Group A: IPW: 12.2 +/- 4.0mm IMW: 16.6+/- 4.7mm Group B: IPW: 12.6 +/- 3.9mm IMW: 15.8+/- 3.8mm	Group A (IPW and IMW): p< 0.05 Group B (IPW and IMW): p< 0.05
Prado *et al* (2014)	RCT SS: 30; mean age: 25.8; M: 18; F: 12	Group A: retention using TPA; Group B: no retention	Relapse At T1: Pre Op At T2: 4 months At 3: 10 months	Group A: IPW T1: 27.1 +/- 3.15mm IPW T2: 35.6 +/- 2.9mm IPW T3: 35.68 +/- 3.2mm IMW T1: 36.03 +/- 3.82mm IMW T2: 44.91 +/- 3.94mm IMW T3: 44.34 +/- 3.44mm Group B: IPW T1: 25.68 +/- 3.58mm IPW T2: 34.10 +/- 3.55mm IPW T3: 32.26 +/- 3.05mm IMW T1: 34.88 +/- 4.47mm IMW T2: 43.22 +/- 4.72mm IMW T3: 41.73 +/-	Group A (IPW and IMW): p< 0.05 Group B (IPW and IMW): p< 0.05

				4.32mm	
Zandi *et al* (2018)	RCT SS: 40; mean age: 28.8; M: 25; F: 15	Group A: retention using TPA); Group B: no retention	Stability and relapse	Retention: 1.5 (2.8) No retention: 1.8 (4.9)	Group A (IPW and IMW): p>0.05 Group B (IPW and IMW): p>0.05
Kayalar *et al* (2019)	RCT SS: 40; mean age: 28.8; M: 25; F: 15	Group A: tooth borne Group B: no retention	Stability and relapse	Retention: 1.5 (2.8) No retention: 1.8 (4.9)	Group A (IPW and IMW): p>0.05 Group B (IPW and IMW): p>0.05

SS: Sample size, M: male, F: female IPW: inter premolar width, IMW: intermolar width, MMD: Maxillomandibular differential

4. Discussion

SARPE has proven to be a dependable and efficient treatment for transverse maxillary insufficiency in skeletally mature patients. Nevertheless, there is no clarity as to what kind of distractor would offer the optimum skeletal and dental stability [11]. Tooth-borne devices transfer the expansion force to the anchor teeth, which can lead to a variety of complications such as periodontal disease, root resorption, tooth extrusion, cortical bone resorption and fenestration, speech problems, and relapse. The expansion force can also cause buccal tipping of the anchor teeth and maxillary dentoalveolar tipping [12,13]. However, by applying the expansion force directly to the palatal bone through bone-borne devices, the palatal halves expand in tandem, minimising the difficulties related to segmental and tooth tipping [14]. Following bone-borne and tooth-borne SARPE, the study demonstrates comparable modifications to the skeleton and dental structure. The total rate of complications for the combination of both treatment modalities was quite low.

In a cohort of skeletally formed non-syndromic patients with transverse maxillary hypoplasia undergoing SARPE, Koudstaal et al. examined the stability, segmental maxillary tipping, and relapse in tooth-borne versus bone-borne distraction [15]. Between the two groups, there were no appreciable differences. For skeletally mature, non-syndromic patients with transverse maxillary hypoplasia, their working hypothesis—that a bone-borne device results in less tipping of maxillary segments and improved stability in transverse dimensions at tooth and bone levels—is therefore disproved. In contrast, a tooth-borne expander is used in SARPE. Dental research cast results demonstrate a substantial rise in maxillary breadth and arch perimeter as a result of the therapy, which has persisted for a full year [16,17]. Little (0.5–0.6 mm) relapse in width at the dental level is consistent with previous research employing tooth-borne expansion following SARPE. Using PA cephalograms, the rotational mobility and skeletal expansion of the maxillary segments were examined [18–20]. Because of the therapy, both groups exhibited rotational movement of the maxillary segments, which increased over the retention period. In comparison to the caudal level, there was more relapse at the higher level. The locations of the bone-borne and tooth-borne distractions on the palate did not significantly differ from one another [21,22]. Since segmental maxillary tipping was observed in both groups and increased during the retention period, it may be inferred that it has no effect on relapse in SARPE using either tooth-borne or bone-borne distraction. This finding is further supported by the modest amount of relapse. For skeletally developed, non-syndromal patients with transverse maxillary hypoplasia, tooth-borne SARPE results in a stable clinical outcome and a less invasive and expensive surgery [19]. The Rotterdam palatal distractor is a bone-borne device that may be beneficial for patients with a congenital deformity and very small maxillae [21]. Notable variations exist between the two groups. Regardless of whether a tooth-borne or bone-borne distractor is used, the growth in SARPE at the dental level is consistent over the course of the 12-month observation period. It doesn't seem like excessive adjustment is necessary [22].

The transverse dimension of the maxilla was assessed by Antonio C. Aloise et al. both with and without the use of transpalatal arch fixed retention following surgically performed rapid palatal expansion [23]. Prior to the maxillary surgery, the expansion appliance was placed, and subtotal Lefort I osteotomy with pterygoid process separation was used in the study. Compared to the rapid enlargement of the maxilla, SARPE showed more stability. The front region had a larger expansion than the posterior region. A duration of four to twelve months is advised for the retention appliance. A brief relapse condition may result from the vestibular inclination of the supporting teeth, the degree of expansion, the type of osteotomy extension, the mobility of the teeth, and other individual characteristics. During the first six months, relapse is expected in many cases, necessitating the use of a retention appliance. The results demonstrated that the stability of the maxilla's transverse dimension was maintained when retention was used in the assessments of the cast models and PA radiographs, and that stability was lost in both of these situations when retention was not used. It did not matter whether fixed retention was

applied following SARPE, as evidenced by the comparable behaviour observed in the cross-valuations of the groups with and without retention [20].

After dividing 30 people having SARPE into two groups—no retention (n = 15) and retention (n = 15) Dentoskeletal stability was assessed by Gabriella Pereira Ribeiro Prado et al. in relation to orthodontic retainers. Because there was no transpalatal arch anterior prolongation at the 10-month mark, there was a notable relapse (1.8 mm, 5.4%), at the premolar intercusp distance, in the no-retention group only [17]. Between 4 and 10 months, there was a 1.04mm (2.35%) relapse in the molar intercusp distance. The transpalatal arch as a retention device does not appear to enhance dento-osseous stability, according to the examination of relapse in both groups.

The short- and long-term stability of SARPE was assessed by Sylvain Chamberland et al. 7.60 + 1.57 mm was the mean maximal growth from SARPE at the first molar. Relapse rates were 1.83 + 1.83 mm on average (24%). After the distraction stopped, the retention device was placed for six months [18]. There was a noteworthy correlation ($P<0.0001$) seen between the degree of recurrence following SARPE and the post-treatment observation. A steady skeletal expansion of 3.58 + 1.63 mm was achieved at maximum. SARPE caused slight but stable skeletal alterations. The posterior teeth's lingual migration was identified as the cause of the dental expansion relapse. Dental recurrence was unaffected by phase 2 surgery. The effectiveness of bonded expanders was equal to that of banded expanders.

Using two osteotomy incisions on either side of the mid-palatal suture, K. Al-OUF et al. devised a novel method for carrying out a symmetric or asymmetric maxillary expansion that is governed by the stability of the mid-palatal area. A hyrax-style expansion device is employed post-operatively [17]. There was a 9.9 mm and a 7.1 mm mean enlargement at the canine and molar regions, respectively. Between the time of appliance removal and the 6-month follow-up, there was very little relapse (0.35 mm at canine, 0.8 mm at molar regions).

The quantity of skeletal and dental growth and stability following SARPE was assessed by Chamberland et al. In post-surgical orthodontics, the mean relapse was 2.22 + 1.39 mm (30%), and the mean expansion at the first molar was 7.48 + 1.39 mm. The largest skeletal expansion measured was 3.49 + 1.37 mm, and this growth was shown to be consistent, resulting in an average net expansion of 67% skeletal. [17]. After the expansion ceased, the expander was remained in situ for a period of six months. The degree of postoperative relapse with SARPE seems to be comparable to the dimensions of the dental arch following non-surgical fast palatal expansion and to the alterations in the dental arch following segmental maxillary osteotomy for expansion. At the highest growth point, skeletal expansion with SARPE involves almost half of the total intermolar expansion. After that, there is a dental relapse, but the skeletal expansion continues steadily, resulting in roughly two-thirds of the net expansion being skeletal by the end of treatment. Segmental Le Fort I osteotomy and SARPE's transverse stability are not appreciably different from one another. [24].

The transverse movement of teeth, its change in inclination, and the ensuing modifications to the arch's length, width, and sagittal form were researched by Karl-Friedrich Krey et al. According to the results, the second molars moved 28% less after the active treatment than they had during the entire expansion. The anchored teeth were likewise more buccally pointed at 9.6 degrees (first bicuspid) and 11.6 degrees (first molar) than the second molars (7.4 degrees). In contrast to traditional maxillary growth, the quantity of anchorage teeth extension was correlated with the measured increase in arch length. In the teeth that are in front of and behind the anchorage teeth, the sagittal arch considerably shrank during the retention period. The canines and second molars had absorbed 68% of the initial growth. [25]. The inclination of the teeth reduced marginally yet noticeably. Following appliance activation, there was a brief increase in the sagittal dimension. At the conclusion of the retention phase, an average loss of 0.83 mm was observed. There is a fifty percent increase in space above the initial expansion of the front dental arch length. Canines and second molars should be incorporated into the appliance in situations of severe crowding in order to reduce the likelihood of relapse. The recommended approach was a bone-borne appliance.

5. Conclusion

From the review, we have inconclusive evidence to definitively prove the stability of the inter-molar and inter-premolar widths post-SARPE. It is essential to select good control groups and establish standardized reference planes for assessing transverse maxillary discrepancies. The diagnostic assessment of transverse problems includes PA cephs and CBCTs in which the reference planes are not judged to be accurate with any third-party measurement. Hence, it is essential to obtain more well-designed trials before we can justify SARPE as a

treatment modality for transverse discrepancies correction in adults.

Research Implications

To improve the predictability of the post-treatment with SARPE, more studies on the quantity and variables influencing stability and relapse should be conducted with a larger sample size.

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