COMPARISON OF PAIN PERCEIVED DURING RAPID MAXILLARY EXPANSION WITH TOOTH-BORNE RME AND TOOTH-BONE-BORNE RME- A SYSTEMATIC REVIEW

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ABSTRACT
BACKGROUND: Maxillary transverse deficiency is characterized by unilateral or bilateral crossbites, crowded teeth and a constricted maxillary arch. Transverse maxillary alterations are more prevalent in children and growing adolescent, conventional orthodontic rapid maxillary expansion successfully be used to treat maxillary constriction. Rapid maxillary expansion (RME) is a common procedure in young children with a constricted maxilla and transverse discrepancies between the maxilla and the mandible. Pain and discomfort are well-known side effects of orthodontic treatment with maxillary expansion devices but few studies have explored pain and discomfort during RME treatment.

OBJECTIVE: The aim of this review is to systematically analyze and critically review the available literature about the pain experienced during rapid maxillary expansion with tooth-borne rapid maxillary expander and tooth-bone-borne rapid maxillary expander.

SEARCH STRATEGY: Electronic databases PubMed, Cochrane Library, Google Scholar, Science direct, Europe PMC and LILACS were searched for articles till January 2021 for articles published on pain experienced by patients undergoing maxillary expansion using tooth borne and tooth-bone borne RME devices. Articles were selected based on the selection criteria.

SELECTION CRITERIA: Only randomized control trials (RCTs) comparing the pain experienced by the patient undergoing rapid maxillary expansion with tooth-borne rapid maxillary expander and tooth-bone-borne rapid maxillary expander were included in the systematic review. Non-randomized studies, prospective studies, case control studies and animal studies were excluded.

DATA COLLECTION AND ANALYSIS: Eligible studies were reviewed and data was extracted. Cochrane review manager software (Revman version 5.4) and Cochrane Rob 2 tool were used for bias assessment. Data extraction was done from the included articles by the two authors independently and then combined together. Data collected were put in a study characteristic table.

RESULTS: Two RCTs were included in the review and a total of 90 participants were treated with tooth borne RME and tooth-bone borne RME. One of the two selected studies showed a low risk of bias and the other unclear risk of bias.

CONCLUSION: Based on present evidence, tooth borne rapid palatal expander appears to cause more pain when compared with bone-borne rapid palatal expanders. There needs to be more clinical trials to arrive at a proper conclusion. Based on the available evidence we can conclude that the pain perceived by patients undergoing bone borne RME is lower compared to tooth borne RME.

KEYWORDS: Pain Measurement, Maxillary expansion, palatal expansion techniques, MARPE.

INTRODUCTION
Maxillary transverse deficiency is characterized by unilateral or bilateral crossbites, crowded teeth and a constricted maxillary arch. Transverse maxillary deficiency is more prevalent in children and growing adolescent, conventional orthodontic rapid maxillary expansion successfully be used to treat maxillary constriction. Rapid maxillary expansion (RME) is a common procedure in young children with a constricted maxilla and transverse discrepancies between the maxilla and the mandible. The primary goal of RME is to maximize dentofacial orthopaedics and
minimize orthodontic movement, but the skeletal effects (i.e., the opening of the midpalatal suture) account for only approximately 20%–50% of the total screw expansion, meaning that the dentoalveolar effects in terms of molar tipping and alveolar bending account for over 50% of the total effect. To minimize these dental side effects, which likely increase the risk of relapse, skeletally anchored RME appliances have been introduced.[5][5, 6]. This procedure is widely used in primary, mixed, or permanent dentition[7]. The hyrax appliance is the most common type of RME device. Once maxillary skeletal/dental transverse deficiency or posterior crossbite appears to exist, maxillary expansion is an effective orthodontic treatment for malocclusion correction[8][9]. Other implications for maxillary expansion are: space regaining and arch perimeter increase for facilitation of orthodontic treatment without the need for tooth extraction (in absence of posterior crossbite), improvement of nasal breathing, and improvement of class II interarch relationships by spontaneous repositioning or growth of mandible in nongrowing patients[10–12].

Transverse maxillary expansion was introduced in 1860 by Emerson C. Angell, but was not placed in routine orthodontic treatments until 1961. The first bone borne appliance was introduced in 1999, which transferred expansive forces directly to alveolar bone in order to reduce destructive orthodontic and periodontal side effects on anchor teeth[13].

In contemporary orthodontics, expansion appliances are generally divided into three groups: tooth-borne, bone-borne, and hybrid appliances. In tooth-borne appliances, stress is transferred to roots and periodontal ligaments; therefore, less force is directly transferred to maxillary bone, and the side effects of these movements occur in anchor teeth, and also osseous movements are not preserved in the consolidation phase[14][15][16]. Skeletal expansion in bone-borne appliance is accomplished by separating the maxillary halves at the mid-palatal suture, which is done non-surgically for young adolescents and surgically for mature adults[17]. The hybrid appliances have been designed to reduce the side effects and improve skeletal to dental changes[18].

Earlier studies showed that young patients have a good tolerance of the insertion of miniscrews, since the introduction of skeletally-anchored RME appliances, few studies have explored the pain intensity and discomfort with tooth-borne as compared with bone-borne RME appliances[19]. Children frequently report pain during the RME expansion phase. Pain is dependent upon such factors as age, sex, individual pain threshold, and the magnitude of force applied. Pain and discomfort are well-known side effects of orthodontic treatment with maxillary expansion devices but few studies have explored pain and discomfort during RME treatment[1–4]. The primary aim of this study was to compare the perceived pain intensity during the activation phase of RME, with tooth-borne (hyrax appliance) and bone-borne RME appliance.

OBJECTIVE
The aim of this review is to systematically analyze and critically review the available literature about the pain experienced during rapid maxillary expansion with tooth-borne rapid maxillary expander and tooth-bone-borne rapid maxillary expander.

PICO ANALYSIS

POPULATION
Patients requiring maxillary expansion for the correction of transverse maxillary deficiencies.

INTERVENTION
Patients who received tooth-bone borne rapid maxillary expanders for the correction of transverse malocclusion.

COMPARISON
Patients who received tooth borne rapid maxillary expanders for the correction of transverse malocclusion.

OUTCOME
Primary outcome: The primary outcome we have assessed in this review is the pain experienced by the patient undergoing rapid maxillary expansion with tooth-bone borne rapid maxillary expander and tooth borne rapid maxillary expanders.

MATERIALS AND METHODS

PROTOCOL AND REGISTRATION
The systematic review followed the preferred reporting items for systematic reviews and Meta-Analysis [PRISMA] statement. The review protocol was registered with PROSPERO(CRD42021234512). PRISMA statement was followed for developing the protocol as well as during conduct and reporting.

ELIGIBILITY CRITERIA

Inclusion criteria
● Randomized controlled trials
● Studies done on human subjects with tooth-bone borne rapid maxillary expander and tooth borne rapid maxillary expanders.
● Studies done on pain and oral health related quality of life of patients undergoing rapid maxillary expansion.
● Studies with appropriate statistical analysis

Exclusion criteria
● Case control studies, retrospective studies, case reports, animal studies, narrative reviews
● Studies that used other modes of transverse malocclusion correction, cleft and craniofacial syndromes etc.

SEARCH STRATEGY
A systematic search in the medical databases produced between January 2001 to January 2021 was performed to gather relevant articles related to the review topic. Detailed search strategies were followed for each database, considering the differences in the controlled vocabulary and syntax rules. The following electronic databases were searched: PubMed Central, Cochrane Library, LILAC’s, European PMC ScienceDirect and Google Scholar. Unpublished literature was searched on ClinicalTrials.gov, Dissertation abstracts and Thesis database. The search attempted to identify all the related studies irrespective of the language.

Figure 1: PRISMA flowchart
STUDY SELECTION AND DATA EXTRACTION
All studies meeting the selection criteria were included in the review. The selection process of included studies was reported in the PRISMA flow chart. A table for describing the ‘Study characteristics’ of the included articles was made that included the following information: first author, year of publication, study design, sample size, age, comparison group, participant, treatment duration, outcome, activation schedule, recorded days, assessment, inference in the studies.

QUALITY ASSESSMENT
The quality assessment and risk of bias was performed using the Cochrane risk of bias (ROB 2) tool [Table 2].

RESULTS
The electronic search identified a total of 1,288 studies. After removal of duplicates there were a total of 802 articles; which were then subjected to further screening. After screening through titles and abstracts a total of 197 articles were assessed for eligibility. From this based on the inclusion criteria 195 articles were excluded. Only 2 relevant studies were identified and were included for the qualitative analysis. The results of the search are illustrated in the PRISMA flow chart (Figure 1). Two RCTs were included in the review and a total of 90 participants were treated with tooth borne RME and tooth-bone borne RME. One of the two selected studies showed a low risk of bias and the other unclear risk of bias.

CHARACTERISTICS OF THE INTERVENTION
All studies assessed the pain experienced by patients who underwent maxillary expansion using tooth borne and tooth bone borne RME [Table 1]. Feldmann et al assessed pain perception, discomfort, jaw function impairment on the first day and fourth day of device activation using VAS scale[19]. The overall pain experienced by patients on day 1 was similar in both the groups. The patients who underwent expansion with tooth bone borne RME reported to experience pain on day 1 around the molars and the group with tooth borne RME experienced pain around the incisors. However, the overall pain experienced by the patients on the fourth day was higher in the tooth borne RME group. The pain experienced around the molars and incisors on the day 4 was higher in the group with tooth borne hyrax. Both of the groups reported to have experienced overall pain on day 1 than on day 4. Altieri et al (2020) evaluated the pain intensity using GRS and FPS scales and oral health quality of life using OHIP-14 questionnaire [20]. The pain was assessed from day 1 till day 12. The patients who underwent expansion with the bone borne RME experienced higher intensity of pain on day 1 and day 4. The group which underwent expansion with tooth borne RME experienced higher intensity of pain on day 4 and the group which underwent expansion with bone borne RME experienced higher intensity of pain on day 1 according to the graphic rating scale (GRS). According to the Wong-Baker faces pain scale (FPS) pain experienced by the tooth borne RME group is higher on day 1 and day 4 than bone borne RME. The pain experienced by tooth borne RME on day 1 is higher than that of day 4 and pain experienced by bone borne RME is higher on day 4 when compared with day 1.

RISK OF BIAS OF THE INCLUDED STUDIES
The overall risk of bias for Feldmann et al (2017) is low and Altieri et al (2020) is unclear risk of bias [Figure 2]. The risk of bias in the individual studies assessed by the seven criteria of Cochrane RoB tool 2. The green sign stands for low risk and the blank space stands for unclear risk. The Cochrane Risk of Bias (RoB) was used to determine the quality of the studies in the two included RCTs. The quality of the studies is assessed based on the seven criteria decided by Cochrane RoB. The green sign stands for low risk, the red sign stands for high risk and the blank space stands for unclear. Out of the six criterions, even if one criterion is unclear or high, then the overall risk of bias becomes unclear or high respectively. Hence the overall risk of bias for Feldmann et al (2017) is low risk and Altieri et al (2020) is unclear risk.
DISCUSSION
This systematic review included 2 RCTs which assessed the intensity of pain experienced by subjects undergoing rapid maxillary expansion with a tooth-borne RME and tooth-bone-borne RME device. The studies included in the systematic review were RCTs and the pain scales which measured the intensity of pain perceived by subjects varied among the studies. The level of evidence in this systematic review is high as only RCTs have been included. Since one of the two included studies has reported an unclear risk of bias, we can summarize that even though all the studies unanimously report a higher perceived pain intensity following treatment with tooth borne rapid maxillary expansion, the results should be taken with caution.
Out of the 2 studies, one had a low risk of bias and the other had an unclear risk of bias. F. Altieri et al had not mentioned how they had blinded their participants and personnel in addition to the detection bias which was observed in the study[20].

Both the included studies involved assessment of pain perception in subjects belonging to the late mixed detention age group with unilateral/bilateral crossbites undergoing maxillary expansion treatment with tooth-borne RME and tooth-bone borne RME. However, the assessment of pain intensity differs in each of the studies. Feldmann et al in his study measured the intensity of pain using visual analogue scale (VAS)[19]. Altieri et al used Graphic Rating Scale for Pain (GRS) and Wong-Baker Faces Pain Scale (FPS) to assess the pain perception[20]. Despite the different scales used in these studies to assess pain, all the studies reported a higher intensity of pain perceived in the tooth-borne RME group. Both studies included in the review have reported collecting data of pain perception on the first day and fourth day.

Pain is a complex emotion that alters from one individual to another; hence its objective evaluation is difficult. Multiple tools have been used for the measurement of pain intensity or severity. It is reported that most patients undergoing RME perceive pain, especially during the early phase of expansion. Earlier studies of pain during conventional RME treatment have stated that pain and discomfort levels peaked on days 3 and 4 and thereafter remained relatively constant[2, 3]. Hence in this systematic review, pain intensity scores of day 1 and day 4 were assessed from both the included RCTs.

Feldmann et al assessed pain perception, discomfort, jaw function impairment on the first day and fourth day of device activation using VAS scale[19]. The overall pain experienced by patients on day 1 was similar in both the groups. The patients who underwent expansion with tooth bone borne RME reported to experience pain on day 1 around the molars and the group with tooth borne RME experienced pain around the incisors. However, the overall pain experienced by the patients on the fourth day was higher in the tooth borne RME group. The pain experienced around the molars and incisors on the day 4 was higher in the group with tooth borne hyrax. Both of the groups reported to have experienced overall pain on day 1 than on day 4.

Altieri et al (2020) evaluated the pain intensity using GRS and FPS scales and oral health quality of life using OHIP-14 questionnaire[20]. The pain was assessed from day 1 till day 12. The patients who underwent expansion with the bone borne RME experienced higher intensity of pain on day 1 and day 4. The group which underwent expansion with tooth borne RME experienced higher intensity of pain on day 4 and the group which underwent expansion with bone borne RME experienced higher intensity of pain on day 1 according to the Graphic Rating Scale for Pain (GRS). According to the Wong-Baker Faces Pain Scale (FPS) pain experienced by the tooth borne RME group is higher on day 1 and day 4 than bone borne RME. The pain experienced by tooth borne RME on day 1 is higher than that of day 4 and pain experienced by bone borne RME is higher on day 4 when compared with day 1.

Pain intensity levels reported here were low overall compared with those reported in studies examining pain during conventional RME treatment and pain in the first week with a fixed appliance[2–4, 21], indicating that RME treatment, both conventional and skeletal, is well accepted by patients in this young age group.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Author and Year</th>
<th>Study design</th>
<th>Sample size and Age group</th>
<th>RME used</th>
<th>Outcome assessment</th>
<th>Criteria used</th>
<th>Variables evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Feldmann et al 2017</td>
<td>Randomized controlled trial</td>
<td>54 children in the age group 8-13 years, late mixed dentition.</td>
<td>Hybrid hyrax expander (bone-borne RME)</td>
<td>Conventional banded hyrax (tooth borne RME)</td>
<td>i) Visual analogue scale (VAS) ii) Self report questions with pain intensity, discomfort, jaw function impairment.</td>
<td>i) pain</td>
</tr>
<tr>
<td>2.</td>
<td>Altieri et al 2020</td>
<td>Randomized controlled trial</td>
<td>36 children in the late mixed dentition with mean age 12.3 ±0.82</td>
<td>computer guided skeletal RME</td>
<td>Tooth borne hyrax</td>
<td>i) GRS ii) FPS iii) OHIP-14</td>
<td>i) pain</td>
</tr>
</tbody>
</table>

Table 1: Characteristics of Included Studies
Table 2: General information on the results of included studies

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Author and Year</th>
<th>Parameter</th>
<th>Results</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Feldmann et al 2017</td>
<td>Pain Intensity using VAS</td>
<td>Overall pain: day 1; similar in both groups Molar pain: day 1; group B&gt;A Incisor pain: day 1; group A&gt;B Group A: overall pain day1&gt;day4 Group B: overall pain day1&gt;day4</td>
<td>Overall pain on 4th day; group A&gt;B Molar pain: 4th day; group A&gt;B Incisor pain: 4th day; group A&gt;B</td>
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<td></td>
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<td>p-value</td>
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<tr>
<td>2.</td>
<td>Altieri et al 2020</td>
<td>Pain intensity using: GRS; FPS</td>
<td>GRS Day 1 pain: Group B&gt;A (6.7&gt;2.1) Group B: Day1 pain&gt;day 4 pain (6.7&gt;4) FPS scale: Day 1 pain; group A&gt;B (3.6&gt;1) Group A: Day 1 pain&gt;day 4 pain (3.6&gt;2.2)</td>
<td>GRS Day 4 pain: Group B&gt;A (4.0&gt;2.4) Group A: Day1 pain&lt; Day4 pain (21.1&lt;2.4) FPS scale: Day 4 pain; group A&gt;B (2.2&gt;1.4) Group B: Day 1pain&lt;day4 pain (1.0&lt;1.4)</td>
</tr>
</tbody>
</table>

Pain scale ● Pain on day 1 is observed more in tooth-bone borne RME. ● Pain is more on the day 1 with Bone borne RME than on day 4. ● Pain on day4 is observed more in tooth-bone borne RME. ● Pain is more on the day 4 with tooth- borne RME. 

FPS scale ● Pain is more on the day 1 and day 4 with tooth- borne RME. ● Pain is more on the day 1 with tooth borne RME than on day 4. ● Pain on day4 is observed more in bone borne RME than on day 1.

Table 2: General information on the results of included studies

STRENGTH AND LIMITATIONS OF THE STUDY
The studies included in this review were all randomized controlled trials. Hence this review can be scientifically validated leading to the conclusion that clinically randomization should be considered as a critical factor in decision making. This systematic review followed the PRISMA guidelines. Various databases were searched following a detailed search strategy for each database, considering the differences in the controlled vocabulary and syntax rules. Article screening, data collection, evaluation of the study characteristics, risk of bias, level of evidence was performed individually by two authors and were combined together. Quality assessment of the included RCTs were done using Cochrane risk of bias tool (RoB).

The main limitation of this review is the heterogeneity in the included studies. The studies in the systematic review included RCTs which assessed the intensity of pain using various pain intensity scales. Feldmann et al (2017) gave the measurements of intensity of pain using VAS Scale. Altieri et al (2020) evaluated the pain intensity using GRS and FPS scales. In addition to the measurement of pain intensity, Altieri et al also assessed the oral health quality of life using OHIP questionnaire in patients undergoing rapid maxillary expansion with tooth-borne and tooth-bone borne rapid maxillary expanders. The limitations of this review include the measurement of pain intensity using different pain scales reported in the selected studies. This has an impact on the interpretation and results of systematic review. Meta-analysis was not performed for the systematic review as the above studies lacked homogeneity.

The number of randomized clinical trials available are very few and amongst them, studies which evaluated pain, discomfort and quality of life were limited. Another factor which is limiting the validity of the included studies is the limited sample size. This could influence the generalizability of the outcome measured.

CONCLUSION
Based on present evidence, the tooth-borne rapid palatal expander appears to cause more pain when compared with the bone-borne rapid palatal expander. A higher perceived pain intensity in the patients treated using a bone-borne skeletal RME appliance was limited to the first day of screw activation. There needs to be more clinical trials to arrive at a proper conclusion. Based on the available evidence we can conclude that the pain perceived by patients undergoing bone borne RME is lower compared to tooth borne RME.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE
Not applicable

AVAILABILITY OF DATA AND MATERIALS
The data extraction and articles collected were done in a meticulous and systematic way through various information databases such as PubMed, Science Direct, Europe PMC, LILACS, Google Scholar and Cochrane Systematic Reviews.

COMPETING INTERESTS
No competing interests were applicable in this manuscript

FUNDING
Not applicable

AUTHORS CONTRIBUTIONS
The data extraction, articles gathered, review of literature and manuscript writing was carried out by the first author. Manuscript proofing, review of gathered articles, supervision of obtained results and overall guidance was carried out by the second author.

REFERENCES


