Research, Society and Development, v. 9, n. 11, e259119055, 2020
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i11.9055

# Bone-borne distractor versus tooth-borne distractor for maxillary expansion: a Systematic Review

# Distrator ósseo versus distrator dentário para expansão maxilar: uma revisão sistemática

# Distractor óseo versus distractor dental para la expansión maxilar: una revisión sistemática

Received: 10/05/2020 | Reviewed: 10/06/2020 | Accept: 10/29/2020 | Published: 02/11/2020

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**Abstract**

The etiology of transverse maxillary deficiency is considered multifactorial, and has a deleterious effect on the bone development of the maxilla and nasal cavities, causing maxillary atresia and posterior crossbite. The objective of this systematic review was to compare in the scientific literature the effectiveness of the maxillary disjunction treated using dental distractor versus bone distractor. A systematic literature review was performed using the Science Direct, Embase, Cochrane Collaboration Library, and PubMed / MEDLINE databases. The search strategy provided a total of 119 studies. After screening by reading the titles and abstracts, seven articles met all the criteria and were included in this systematic review. Studies have shown that the choice of type of orthodontic-orthopedic appliance is directly related to the prior individualized planning of each patient. With regard to patients who are in the development phase, the recommendation is the use of dental maxillary expanders, such as the Hyrax appliance. In addition, it is not recommended to perform rapid

maxillary expansion in adult patients, due to the expansion resistance that occurs in the palatine sutures. The treatment of patients with closed median palatine suture must be done by surgically assisted maxillary expansion.

**Keywords:** Maxilla; Malocclusion; Palatal expansion technique; Surgery oral; Orthodontic appliances functional.

**Resumo**

A etiologia da deficiência maxilar transversal é considerada multifatorial, e repercute de forma deletéria no desenvolvimento ósseo da maxila e das cavidades nasais, ocasionando atresia maxilar e mordida cruzada posterior. O objetivo desta revisão sistemática foi comparar na literatura científica a eficácia da disjunção maxilar tratada através da utilização distrator dentário versus o distrator ósseo. Uma revisão sistemática da literatura foi realizada utilizando as bases de dados Science Direct, Embase, Cochrane Collaboration Library, and PubMed/MEDLINE. A estratégia de busca forneceu um total de 119 estudos. Após a triagem através da leitura dos títulos e resumos, sete artigos atenderam a todos os critérios e foram incluídos na presente revisão sistemática. Os estudos demonstraram que a escolha do tipo de aparelho ortodôntico-ortopédico está diretamente relacionada ao prévio planejamento individualizado de cada paciente. No que se refere aos pacientes que encontram-se em fase de desenvolvimento, a recomendação é a utilização de expansores maxilares dentários, como o aparelho Hyrax. Além disso, não é recomendado realização da expansão rápida da maxila em pacientes adultos, devido a resistência de expansão que ocorre nas suturas palatinas. O tratamento de pacientes que apresentam a sutura palatina mediana fechada deve ser feito através da expansão da maxila cirurgicamente assistida.

**Palavras-chave:** Maxila; Má oclusão; Técnica de expansão palatina; Cirurgia bucal; Aparelhos ortodônticos funcionais.

**Resumen**

La etiología de la deficiencia maxilar transversal se considera multifactorial y tiene un efecto deletéreo sobre el desarrollo óseo del maxilar y las cavidades nasales, provocando atresia maxilar y mordida cruzada posterior. El objetivo de esta revisión sistemática fue comparar en la literatura científica la efectividad de la disyunción maxilar tratada con distractor dental versus distractor óseo. Se realizó una revisión sistemática de la literatura utilizando las bases de datos Science Direct, Embase, Cochrane Collaboration Library y PubMed / MEDLINE. La estrategia de búsqueda proporcionó un total de 119 estudios. Después de la selección

mediante la lectura de títulos y resúmenes, siete artículos cumplieron con todos los criterios y se incluyeron en esta revisión sistemática. Los estudios han demostrado que la elección del tipo de aparato ortodóncico-ortopédico está directamente relacionada con la planificación previa individualizada de cada paciente. Con respecto a los pacientes que se encuentran en fase de desarrollo, la recomendación es el uso de expansores maxilares dentales, como el aparato Hyrax. Además, no se recomienda realizar una expansión maxilar rápida en pacientes adultos, debido a la resistencia a la expansión que se produce en las suturas palatinas. El tratamiento de pacientes con sutura palatina media cerrada debe realizarse mediante expansión maxilar asistida quirúrgicamente.

**Palabras clave:** Maxilar; Maloclusión; Técnica de expansión palatina; Cirugía bucal; Aparatos ortodóncicos funcionales.

## 1. Introduction

In order to establish an ideal occlusion, the upper dental arch needs to be proportionally larger than the lower dental arch, causing the palatal cusps of the premolars and maxillary molars to adequately adapt to the occlusal fossae of the premolars and mandibular molars. Treatments involving dental malocclusions are often associated with corrections of transverse maxillary deficiencies (Cappellette-Júnior et al., 2017; Souza et al., 2018).

The etiology of transverse maxillary deficiency is considered multifactorial, and has a deleterious effect on the bone development of the maxilla and nasal cavities, causing maxillary atresia and posterior crossbite (Park et al., 2017; Cappellette-Júnior et al., 2017). Rapid maxillary expansion (RME) is indicated to treat conditions that are related to transverse maxillary deficiency, through the use of an orthodontic-orthopedic appliance in young patients, in which the process of ossification of the medial palatal suture has not been completed (Zhang et al., 2017; Sánchez et al., 2020).

The mechanism of action of RME is based on the use of forces that are applied to the teeth and the alveolar process, thus causing the disjunction of the maxillary bones, expanding the median palatal suture (Canan, Şenişik., 2017). The maxillary expanders are a type of orthodontic-orthopedic device used to promote RME, through the rupture of the medial palatal suture. The principle of action of these devices is based on the use of an expander screw that is positioned transversely to the center of the palate, resting on the upper posterior teeth, with or without mucous support (Hassan et al., 2014; Alghamdi et al., 2017).

However, in adult patients, the median palatal suture is closed, making it impossible to correct transverse maxillary discrepancies through the use of intraoral orthodontic appliances. The osteogenic activity of the median palatal suture corresponding to the transverse growth of the palate continues until 16 years of age for females and 18 years of age for males. To obtain a better result in the bone expansion process, other procedures such as surgically assisted rapid maxillary expansion (SARME) have been used (Krüsi et al., 2019). The therapeutic protocol for this type of approach is based on the combination of orthodontic procedures and different surgical techniques that promote an increase in the space of the dental arch (Fonseca et al., 2019). Therefore, the objective of this systematic review was to compare in the scientific literature the efficacy of the maxillary disjunction treated using dental distractor versus bone distractor.

## 2. Material and Methods

This study followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Statement (Moher, Liberati., 2009; Honório, HM, Santiago., 2018). The following review question was developed according to population, intervention, comparison, and outcome (PICO): “Bone-borne distractor versus tooth-borne: What is the most appropriate treatment method for rapid maxillary expansion?” and a keyword search was performed. A literature search was performed in September of 2020 in the following electronic databases: Science Direct, Embase, Cochrane Collaboration Library, and PubMed/MEDLINE.

The search was carried out without time and language restrictions. Hand searches were also conducted by cross-checking the reference lists of the included articles. Duplicates were removed upon identification. Manuscripts that were not published in English were translated for further evaluation. The search strategy was based on combinations of the following keywords: ("Maxillary expansion", "Orthognathic surgery", "Skeletal stability", "Surgically assisted rapid maxillary expansion", "bone-borne distraction", "Tooth-borne distraction"[tw]).

The reviewer independently screened and assessed potential articles. Studies that did not fulfil the inclusion criteria were excluded. In the first stage, the titles and abstracts of all retrieved reports were screened for potentially eligible studies. The full text articles of the previously identified studies were then examined in detail according to predefined eligibility criteria for inclusion in the qualitative review. Disagreements were solved by discussion between the authors. Eligibility criteria: The review included randomized controlled trials,

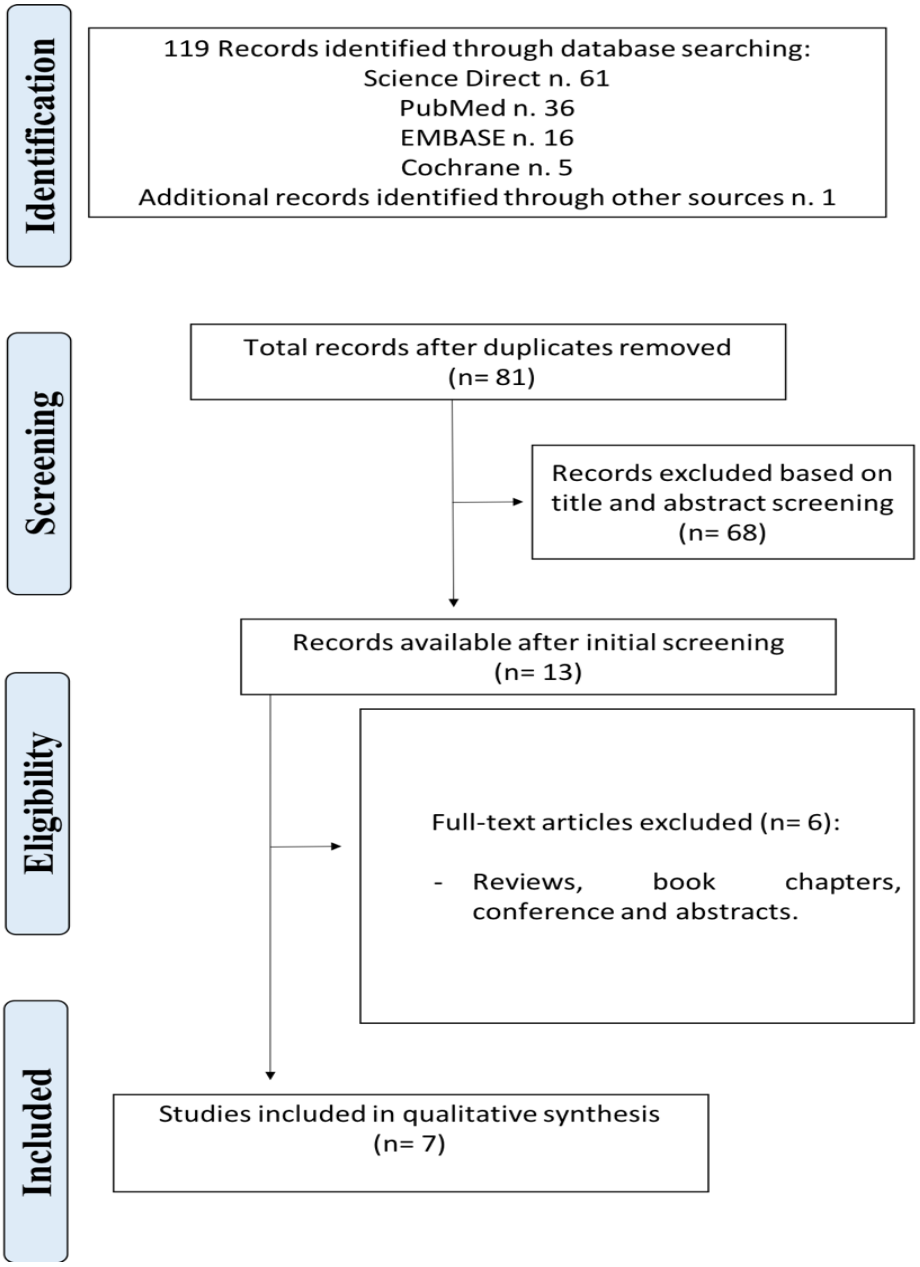
comparing the bone distraction device with the dental distraction device for maxillary expansion. Exclusion criteria: Animal studies, opinion articles, letters to the editor, review articles, interviews, updates, abstracts, and unpublished studies were excluded. The review authors independently screened the articles for data extraction. Any disagreements were resolved by discussion.

## 3. Results

### *Study selection and characteristics*

The search strategy developed in this systematic review identified a total of 119 studies located in the evaluated databases. After screening by reading the titles and abstracts and excluding duplicate articles, 13 studies were considered potentially eligible and read in full by the evaluators. At the end of the analysis, seven articles published between 2009 and 2016 met all inclusion criteria and were selected for systematic review. The flowchart applied for the article selection and selection process is illustrated in Figure 1.

**Figure 1.** PRISMA flow diagram of screened studies.




Source: Authors.

All the studies included performed a comparative analysis between the maxillary disjunction treated by a dental versus bone distractor. In total, 264 patients were evaluated in the ten selected studies, with the sample ranging from 28 patients (Kunz et al., 2016) to 50 patients (Landes et al., 2009). The follow-up time ranged from 3 months (Seeberger et al., 2015) to 22 months (Nada et al., 2012). The main methodological aspects and observed results can be seen in Table 1.

**Table 1.** Summary of the descriptive characteristics and results of the included studies (n=7).

| Author (year) | Number of patients | Groups | Methods | Followup (months) | Summary of the results |
|---|---|---|---|---|---|
| Koudstaal et al. (2009) | 46 | Group I - Bone-borne distractor (n= 25).<br><br>Group II - Tooth-borne distraction (Hyrax) (n= 21). | The study is a randomized, open-label, clinical trial. Patients were randomized to bone-borne and tooth-borne groups. The surgical technique for corticotomy was the same in both groups. | 12 | In conclusion, the results of this prospective randomized patient trial show that there is no significant difference between the two groups. In surgically assisted rapid maxillary expansion, when using either a bone-borne or tooth-borne distractor, the widening achieved at dental level is stable at the 12-month follow up. Over-correction does not seem to be necessary. |
| Landes et al. (2009) | 50 | Group I - Bone-borne distractor (n= 24).<br><br>Group II - Tooth-borne distraction (Hyrax) (n=26). | Bone-borne devices were preferred in patients who required major transverse expansion and had periodontal attachment loss or reduced tooth number; Tooth-borne devices were preferred in patients who had proper tooth condition, extremely narrow palates, and sufficient teeth number. | 12 | Tooth-borne versus bone-borne surgically assisted rapid maxillary expansion should be based on individual patient requirements: tooth-borne whenever tooth arch symmetry is required under good periodontal status; bone-borne in cases of major space limitations, reduced tooth number, and compromised parodontia at the price of more asymmetric expansion. |

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|---|---|---|---|---|---|
| Nada et al. (2012) | 45 | Group I - Bone-borne distractor (n= 17).<br><br>Group II - Tooth-borne distraction (Hyrax) (n=28). | This prospective cohort study comprised 45 consecutive skeletally mature nonsyndromic patients with transverse maxillary hypoplasia. Cone beam computed tomography scans were performed before treatment (T0) and 22 months later, after fixed appliance treatment (T1). | 22 | Bone-borne and tooth-borne surgically assisted rapid maxillary expansion were found to produce comparable results at the end of fixed appliance treatment regarding skeletal changes. |
| Zandi et al. (2014) | 30 | Group I - Bone-borne distractor (n= 15).<br><br>Group II - Tooth-borne distraction (Hyrax) (n= 15). | Before treatment and immediately after the consolidation period, cone beam computed tomography was obtained and the nasal floor width, interdental root distance, palatal bone width and interdental cusp distance were measured at first premolar and first molar regions of maxilla. | 4 | Selection of an expansion device should be based on each individual patient's requirements. Future long-term clinical trial studies to evaluate the stability and relapse of these two techniques are recommended. |
| Seeberger et al. (2015) | 33 | Group I - Bone-borne distractor (n= 19).<br><br>Group II - Tooth-borne distraction (Hyrax) (n= 14). | A sample of 33 skeletally mature patients with transverse maxillary deficiencies was examined with cone beam computed tomography before and 3 months after surgery. Fourteen patients were treated with tooth-borne devices and | 3 | Both tooth-borne and bone-borne devices are effective treatment modalities to correct maxillary transverse deficiencies. Bone-borne devices produced greater widening of the skeletal nasal floor and fewer dental side effects in the |

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|---|---|---|---|---|---|
| | | | 19 patients with bone-borne devices. | | first molars. |
| Garreau et al. (2016) | 32 | Group I - Bone-borne distractor (n= 10).<br><br>Group II - Tooth-borne distraction (Hyrax) (n= 22). | This retrospective study compared orthodontic distraction using a bone-borne or a tooth-borne distractor from the point of view of tolerance, ease of use and overall patient satisfaction, by means of a questionnaire completed by patients undergoing maxillary expansion surgery. | 3 | The use of a bone-borne distractor for orthodontic distraction after maxillary expansion surgery appears to be an effective, simple and well-tolerated alternative to the use of a tooth-borne distractor. According to patients, this distractor also appears easier to use than the traditional Hyrax-type distractor. This ease of use is correlated with overall satisfaction. |
| Kunz et al. (2016) | 28 | Group I - Bone-borne distractor (n= 16).<br><br>Group II - Tooth-borne distraction (Hyrax) (n= 12). | Before and after palatal expansion, an impression of each maxilla was taken. Casts fabricated on this basis were digitized with a 3D scanner. Based on the resultant virtual models, both the amounts of expansion and the angles of crown tipping from the canines through the second molars were determined and the results of the two groups were compared. | 5.5 | Either a transpalatal distractor or a hyrax appliance can be successfully used to expand a narrow maxilla by surgically assisted rapid maxillary expansion. The two appliances, however, cause different amounts of dental arch expansion and buccal crown tipping. A hyrax appliance should be expected to result in a parallel expansion pattern with the largest increase in the premolar area. A transpalatal distractor is likely to cause more of a V-shaped pattern of |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | expansion. Thus, in clinical practice, specific patterns of distraction can be selectively achieved by taking advantage of specific appliances and various options of positioning. |

Source: Authors.

***Main results***

The selected studies point out the importance of an individualized treatment, making a plan according to the individual characteristics of each patient. Koudstaal et al. (2009) point out that patients diagnosed with skeletal maturation and transverse maxillary hypoplasia, the performance of SARME associated with the use of dental distractors provided a stable clinical result, less invasive and with a lower financial cost. The author also points out that there is an indication for a bone distractor (Rotterdam palatal distractor) in patients with congenital deformity and extremely narrow jaws.

In the study developed by Landes et al. (2009), the authors concluded that dental distractors should be chosen whenever the symmetry of the dental arch is in good periodontal condition, whereas bone distraction in cases of great space limitations, reduced number of teeth and compromised parodontics at the price of a more asymmetric expansion. Nada et al. (2012) described that the amount of tooth expansion increased significantly from canines to molars through bone distraction, while it tended to be more parallel along the arch with tooth expansion.

The study by Zandi et al. (2014) obtained strong points for the present analysis: a randomized clinical study design; operation of all patients by the same surgeon using uniform surgical technique, expansion protocol and distraction device (in each group); and using an advanced imaging technique to evaluate the results. The dental and bone devices produced a V-shaped expansion of the dentoskeletal structures with greater widening at the level of the dental arch than in the nasal floor area (segmental inclination). Subsequently, parallel expansion of the dental arch, palatal bone and nasal floor was observed. The amount and pattern of expansion were not significantly different between maxillary expansion through the dental and bone distractor. The overall rate of complications was negligible in both

techniques. The selection of the distraction device should be based on the needs of each individual patient.

In the study by Seeberger et al. (2015), both SARME with dental or bone distractor are effective treatment modalities to correct transversal maxillary deficiencies. Bone devices have been found to cause greater widening of the skeletal nasal floor compared to dental devices. The nasal floor had a V-opening from anterior to posterior, regardless of the device used. In the first molar, the dental device group showed significantly greater buccal inclination than the bone device group. For Kunz et al. (2016), both a Hyrax device and a transpalatal distractor can be used to obtain transverse expansion of a narrow maxilla with the help of surgery. The Hyrax appliance should result in a parallel expansion pattern with the transverse increase in its largest axis between the premolars. The transpalatal distractor should be selected whenever a more V-shaped pattern of transverse expansion with a more anterior maximum increase is necessary.

## 4. Discussion

The maxilla shows a different behavior during human development, showing an antero-posterior growth through the remodeling process, where bone deposition and reabsorption occurs. The horizontal growth of the maxillary arch is accomplished by remodeling the maxillary tuberosity. These bones are connected by a cartilaginous tissue that is later replaced by mineralized tissue. The medial palatal suture is located in the anteroposterior direction, associating the base of the skull with the facial skeleton, being responsible for the growth of the maxilla in the transversal direction (Enlow, Hans., 2012).

Cappellette-Júnior et al. (2017) and Park et al. (2017), mentioned that transverse maxillary deficiencies can cause maxillary atresia, asymmetric facial growth, positioning and functional deviation of the mandible, periodontal problems and dentofacial involvement. However, when these skeletal deformities are correctly diagnosed, they adapt better to orthopedic treatment, when compared to other deformities present in the regions of the craniofacial complex. These findings corroborate the present study, in which it was observed that the performance of SARME associated with the use of dental distractors provided good results in the treatment of atrophic jaws.

According to Hartono et al. (2018), in order to establish the method to be used for the correction of transverse maxillary deficiency, one must take into account the quantity and quality of orthodontic anchorage of the expanders. Most clinical failures associated with RME

when using only the orthodontic appliance occur due to resistance to expansion, as well as the presence of pain during bone expansion. In adult patients, due to the closure of the palatal suture, it is not feasible to perform the treatment using only orthodontic appliances, in which case a SARME is indicated, in which a combination of procedures is performed to obtain better results. These findings are in agreement with the results observed in the present systematic review, in which it was possible to observe that the selection of the distraction device must be based on the needs of each individual patient.

According to Algharbi et al. (2018) and Maspero et al. (2020) the Hyrax orthodontic-orthopedic appliance is the most commonly used in young people, due to its easy adaptation, being activated by the patient or guardian with professional guidance through an intraoral device. Activation is painless, and occurs between 2 to 4 weeks, and should be used for a minimum of 3 months. It has advantages related to hygiene, not causing ulcerative and erythematous lesions in the palatal mucosa. However, there are other types of expanders, which vary according to teeth conformity (Machado et al., 2012; Gómez et al., 2019). In the present systematic review, it was observed, as shown by the study by Kunz et al. (2016), that the use of the Hyrax appliance promotes a parallel pattern of expansion with the transverse increase in the largest axis between maxillary premolars. However, when transverse expansion is indicated with a maximum increase earlier, one should choose to use a transpalatal distractor.

## 5. Conclusion

In view of the diagnosis and indication of maxillary expansion, it is up to the professional to choose the type of expander device as well as the expansion protocol to be used, however the choice of the type of orthodontic-orthopedic device is directly related to the prior individualized planning of each patient. With regard to patients who are in the stage of pubertal development, the recommendation is the use of dental maxillary expanders, such as the Hyrax appliance.

RME is a procedure that has several advantages in the treatment of transverse defects of the upper arch. However, this procedure is limited in adult patients, due to an expansion resistance that occurs in the maxillozygomatic and maxillofrontal sutures. The treatment of patients with closed median palatal suture should be done through SARME, using a combination of procedures, orthodontic and surgical, thus providing better results in the treatment of patients with transverse maxillary deficiencies.

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