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Briana Yarely Medina Lizarraga
Master's in Sciences Student, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Mariela Rocha Gómez
Professor, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Julio Benitez Pascual
Professor, Universidad Autonoma de Sinaloa, Facultad de Odontologia, Culiacan, Sinaloa, Mexico

Daniel Lizarraga Rodriguez
Professor, Universidad Autonoma de Sinaloa, Facultad de Odontologia, Culiacan, Sinaloa, 80013 ZIP, Mexico

Francisco Guadalupe Arreguin Ceniceros
Professor, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Sergio Eduardo Nakagoshi Cepeda
Professor, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Luz Eli Martinez Rodriguez
Dentistry Student, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Juan Manuel Solis Soto
Professor, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Corresponding Author:
Juan Manuel Solis Soto
Professor, Universidad Autonoma de Nuevo Leon, Facultad de Odontologia, Monterrey, Nuevo Leon, Mexico

Rapid maxillary expansion in children, an update

Briana Yarely Medina Lizarraga, Mariela Rocha Gómez, Julio Benitez Pascual, Daniel Lizarraga Rodriguez, Francisco Guadalupe Arreguin Ceniceros, Sergio Eduardo Nakagoshi Cepeda, Luz Eli Martinez Rodriguez and Juan Manuel Solis Soto

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Abstract
Introduction: Rapid maxillary expansion (RME) increases oxygen saturation in children with Obstructive Sleep Apnea (OSA) in the short and long term.
Objective: To analyze the current literature about rapid maxillary expansion, its effects on anatomical structures, midpalatal suture opening (MPS) and obstructive sleep apnea.
Methodology: Articles published at MEDLINE/PubMed and Science Direct were analyzed, with an emphasis on the last 5 years. Articles were evaluated with the PRISMA and AMSTAR guidelines. The search was carried out using the words "rapid maxillary expansion", "therapy" and "children".
Results: RME increases the transverse dimension of the maxillary bone, the nasal cavity, and the distance between zygomatic bones and mandibular condyles. It promotes the opening of the MPS, whose ossification is variable, that's why in children older than 10 years a CBCT study is recommended. It corrects malocclusions and widens the nasopharyngeal area by increasing the volume of the upper airways. Children with OSA show improvements in their apnea-hypopnea index, oxygen saturation, and decreased snoring when undergoing RME.
Conclusion: RME works by opening the MPS, resulting in an increase in the transverse dimension of the maxilla. In addition to correcting malocclusions, it increases the volume of the upper airway and is an effective treatment option in patients with OSA who present craniofacial discrepancies.

Keywords: Maxillary expansion, obstructive sleep apnea, children, mid-palatal suture

1. Introduction
Rapid Maxillary Expansion (RME) increases oxygen saturation in children with Obstructive Sleep Apnea (OSA) in the short and long term [1]. The RME generates an increase in the transverse dimension of the maxilla at the skeletal and dental level, in addition to promoting forward movement of this bone [2], these treatments are effective and have longitudinal stability with a minimal degree of recurrence over time [3]. RME does not resorb or suspend root or permanent first molar formation in young patients [4], when used in young children the transverse width of the maxilla increases in size as well as the nasopharyngeal and nasal cavity volumes [5]. This increase in dimensions promotes the correct positioning of the tongue and improves the respiratory pattern in children [6], optimizing their oxygen levels and serving as a coadjuvant treatment in patients with maxillary constriction [7]. For this reason, dentists and otolaryngologists work together in the treatment of pediatric patients with upper airway obstruction [8]. There are a large number of children who present maxillary constriction, which triggers conditions that can be treated or prevented through RME. Evaluating the literature, there is no recent review on rapid maxillary expansion in children, so the aim of the present study is to analyze the current literature on rapid maxillary expansion, its effects on anatomical structures, midpalatal suture opening, upper airway and obstructive sleep apnea.

2. Materials and methods
Articles on the subject published through the PubMed, SCOPUS and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using PRISMA guidelines, i.e., identification, review, choice and inclusion.

The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews (AMSTAR-2) [9]. The search was performed using Boolean logical operators AND, OR and NOT. It was realized with the words "rapid maxillary expansion", “mid-palatal suture”, "therapy" and "children". The keywords were used individually, as well as each of them related to each other.

3. Results & Discussion

3.1 Effects on Anatomical Structures

RME treatment increases the transverse size of the maxillary bone [10], from a coronal perspective, a triangular skeletal expansion is observed, with greater dimension in the lower part than in the upper part [11, 12, 13]. In growing patients undergoing RME, the zygomatic bone tends to rotate outward together with the maxilla, with its center of rotation located on the superior side of the frontozygomatic suture and the distance between both zygomatic bones increases, being greater in the anterior than in the posterior direction [14]. Children with RME treatment present short-term bone changes in their condyle-fossa relationship, but not in the position or shape of the articular disc; at the end of treatment the symmetrical intercondylar relationship is maintained or improved [15, 16]. RME is the first therapeutic alternative in children with Eustachian tube dysfunction and maxillary constriction, since in most of them both conditions are restored [17]. The RME gives as a collateral result the increase of the nasal cavity and the intercondylar distance without causing skeletal asymmetry [18]. When its support is dental it shows a similar efficiency whether its anchorage is in primary or permanent teeth [19], during the active phase of expansion, the vestibule-palatal inclination of the root axis of the upper first molar increases due to vestibular movements and during the retention period, it returns almost completely to its initial position [12]. RME causes an increase in the transverse dimension of the maxillary bone, resulting collaterally in an increase in the nasal cavity and in the distance between both zygomatic bones and mandibular condyles, which maintain or improve their symmetrical relationship. Similarly, the root axis of the upper first molar increases during the active phase and returns to its position in the retention period.

3.2 Opening of the Mid Palatal Suture

The RME exerts its function through the opening of the midpalatal suture (MPS), which increases its transverse dimension as the treatment progresses [11]. Bone neoformation is evident in the suture space 7 days after the start of the RME and half of it is found with newly formed bone tissue 30 days after the start of the RME [20]. The ossification of maxillary sutures is very diverse; there is a wide variation in onset times, morphology and degree of ossification. Although aging is proportional to the increase in MPS closure, age is not considered a reliable criterion to determine its open or closed nature [21]. Therefore, in children older than 10 years, a pre-expansion cone beam computed tomography (CBCT) is recommended to help assess the ossification status of the MPS [22] and to obtain a prognosis of the expected outcome with RME [23], thus assessing whether the conditions for a favorable clinical outcome exist [24]. Chronological age, cervical bone maturation [25] and pretreatment midpalatal suture density do not have a good enough relationship with the amount of skeletal expansion that can be achieved through RME to be considered effective predictors [26]. RME promotes the opening of the mid-palatal suture, which increases in size when the appliance is activated and simultaneously there is bone neoformation, its ossification times are diverse and despite being proportional to age a CBCT study is recommended in children older than 10 years to evaluate their status and ability to achieve a favorable clinical outcome through RME.

3.3 Relationship with Upper Airways

Breathing pattern alterations should be modified as soon as they are detected, preferably in infancy. In patients with malocclusions, RME represents an orthopedic therapy that corrects them and with which respiratory advantages are obtained [27], since it stimulates the separation of the MPS by means of expansion screws. These produce small increases in the total volume of the upper airways [28], while increasing the interzygomatic and internasal distance, as well as the oropharyngeal volume [29] and the nasal cavity [30]. A significant increase is observed in the nasal cavity when the palatal width of the MRE exceeds 2mm [31]; this action has been associated with voice changes after MRE [11]. Treatment of maxillary deficiency by MRE in growing patients aged 6 to 14 years results in decreased adenoid dimensions and increased nasopharyngeal area [32], as well as decreased maxillary sinus volume in patients with maxillary transverse discrepancy [33, 34]. Patients with hypertrophic adenoids have a greater increase in nasopharyngeal volume after MRE compared to those with normal-sized adenoids [35]. MRE treatment, in addition to correcting malocclusions by opening the MPS, increases the volume of the upper airway by increasing the nasal cavity, widening the nasopharyngeal area and consequently favoring airflow in patients with hypertrophic adenoids.

3.4 Obstructive Sleep Apnea

RME is an effective treatment for patients with Obstructive Sleep Apnea (OSA) [36], as it can restore and optimize normal nasal airflow in patients with OSA [37]. Among the short-term effects in children with RME therapy, improvements in oxygen saturation and apnea-hypopnea index are observed [38]. Dentists should be part of the transdisciplinary team in the treatment of pediatric OSA, as there are orthopedic managements that can benefit certain patients with OSA, such as RME, which is only indicated in patients with craniofacial discrepancies [39]. All pediatric patients with OSA should be evaluated for maxillary constriction, even those without dental malocclusions [40], as children who undergo MRE have improvements in the apnea-hypopnea index [1]. So this orthopedic treatment approach can be considered as an adjunct in the treatment of children with OSA, whose risk factors include craniofacial anomalies [41]. By correcting imbalances of bony structures in growing children their snoring decreases as well as OSA in some cases [42]. MRE is an effective non-surgical option in the treatment of mild to moderate cases in pediatric patients with sleep apnea-hypopnea syndrome (SAHS), as most of them experience significant improvements as maxillary expansion therapy progresses or ends [7, 43]. Children with OSA have improvements in their apnea-hypopnea index, oxygen saturation, and decreased snoring when undergoing RME, but only patients with craniofacial discrepancies are candidates for this orthopedic treatment.

4. Conclusions

RME is an orthopedic treatment that acts by opening the MPS and results in an increase in the transverse dimension of the maxilla, which in addition to correcting malocclusions,

improves airflow by increasing the volume of the upper airway and is an effective treatment option in patients with OSA who present craniofacial discrepancies.

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