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Effects of Maxillary Expansion on Hearing and Voice Function: An Overview

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Abstract

Maxillary transverse deficiency is commonly associated with posterior crossbite, crowding, nasal obstruction, and altered craniofacial development. Rapid maxillary expansion (RME) and slow maxillary expansion (SME) are established orthodontic procedures used to correct transverse discrepancies. In recent years, increasing attention has been directed toward the influence of maxillary expansion on hearing and voice because of the close anatomical and functional relationship between the maxilla, nasal cavity, nasopharynx, Eustachian tube, and vocal tract.

This review summarizes current evidence regarding the effects of maxillary expansion on auditory and vocal functions. Expansion of the maxilla increases nasal cavity width and improves nasopharyngeal dimensions, which may enhance Eustachian tube function and middle ear ventilation. Several studies have reported improvements in conductive hearing loss, tympanometric findings, and air-conduction thresholds in children with pre-existing middle ear disorders following RME. However, studies involving individuals without baseline auditory impairment often demonstrate minimal or no significant changes.

Maxillary expansion may also influence voice production and resonance by altering the dimensions of the oral and nasal cavities. Reported effects include temporary increases in nasalance and minor alterations in acoustic parameters such as formant frequencies. Most voice-related changes are transient and tend to normalize due to neuromuscular adaptation. Evidence regarding long-term vocal effects remains inconsistent.

Although existing literature suggests potential benefits of maxillary expansion on hearing and voice, limitations such as small sample sizes, methodological variability, and insufficient long-term data prevent definitive conclusions. A multidisciplinary approach involving orthodontists, otolaryngologists, and speech therapists is recommended when managing patients with associated auditory or speech concerns.

Introduction

Maxillary transverse deficiency is a common craniofacial problem associated with posterior crossbite, dental crowding, nasal obstruction, mouth breathing, and altered facial growth. Maxillary expansion, especially rapid maxillary expansion (RME), has been used for years to fix these width problems. Recently, researchers have become more interested in how maxillary expansion might affect hearing and

voice, since the maxilla, nasal cavity, nasopharynx, Eustachian tube, and vocal tract are closely connected in both structure and function [1–3].

This review brings together current research on how maxillary expansion affects hearing and voice. It focuses on the main mechanisms, clinical findings, debates, and what these mean for different medical fields.

Anatomical and Functional Basis

Maxilla, Nasal Cavity, and Eustachian Tube Relationship

The maxilla forms a major portion of the nasal floor and lateral nasal walls. Transverse constriction of the maxilla results in reduced nasal cavity width, increased nasal resistance, and altered airflow patterns [4]. The Eustachian tube, which extends from the middle ear to the nasopharynx, plays a vital role in equalizing pressure and ventilating the middle ear. Its function depends on patency and muscular opening, primarily mediated by the tensor veli palatini and levator veli palatini muscles [5].

Maxillary expansion alters the shape of the nasopharynx and the pterygoid area, which may help these muscles function better and make it easier for the Eustachian tube to open [6].

Maxillary Expansion Techniques

Rapid Maxillary Expansion (RME)

RME uses strong, on-and-off forces (0.3–0.5 mm per day) with devices attached to teeth or bone to open the midpalatal suture [7]. This type of expansion works best in children and teens, but adults may need surgery to help the process.

Slow Maxillary Expansion (SME)

SME uses light forces over a longer time, which mostly affects the teeth and surrounding bone rather than causing much skeletal change [8]. Most studies on hearing and voice focus on RME because it has a bigger effect on the skeleton.

Effects of Maxillary Expansion on Hearing Function

Eustachian Tube Dysfunction and Hearing Loss

According to Fingeroth, maxillary deficiency frequently results in decreased nasal permeability with mouth breathing, and within this environment, a CHL may develop [9].

Eustachian tube dysfunction (ETD) is a major etiological factor in otitis media with effusion (OME) and conductive hearing loss, particularly in children. Chronic nasal obstruction and altered craniofacial morphology have been implicated in ETD pathogenesis [10]. Several authors have postulated that transverse maxillary deficiency contributes to ETD by altering nasopharyngeal anatomy and impairing tubal muscle activity [11].

Audiological Outcomes Following Maxillary Expansion

Pure-Tone Audiometry

Multiple studies have reported improvement in air-conduction thresholds following RME in children with pre-existing middle ear pathology [12–14]. Pirelli et al. demonstrated significant hearing threshold improvements in children with recurrent OME after RME, suggesting enhanced middle ear ventilation [12]. The mean hearing improvements reported ranged from 2.85 dB to 19.12 dB after maxillary expansion and from 2.21 dB to 19.12 dB after the retention or follow-up period [15,16].

In contrast, studies involving subjects without baseline auditory impairment have not demonstrated statistically significant changes in pure-tone thresholds, suggesting that auditory benefits are condition-dependent rather than universal [17].

Tympanometry and Middle Ear Pressure

Tympanometry tests often show better results after RME. For example, some patients' results change from type B or C to type A, which means their middle ear pressure has returned to normal [18,19]. This improvement is thought to be due to improved Eustachian tube function, facilitated by a larger nasopharyngeal space and stronger muscles [20].

Proposed Mechanisms for Hearing Improvement

1. **Increase in Nasal Cavity Volume:** RME significantly increases nasal cavity width and volume, reducing airway resistance and improving nasal breathing [4,21].
2. **Enhanced Tensor Veli Palatini Function:** Skeletal expansion alters the orientation of palatal muscles, facilitating more effective tubal opening during swallowing and yawning [6,20].
3. **Reduction in Nasopharyngeal Obstruction:** Improved airflow reduces the incidence of upper respiratory infections, indirectly decreasing middle ear pathology [22].

Conflicting Evidence and Limitations

Although several studies report positive outcomes, randomized controlled trials and systematic reviews often conclude that the evidence is inconclusive due to small sample sizes, lack of blinding, and heterogeneity in study designs [17,23]. Furthermore, the long-term stability of auditory improvements is insufficiently documented.

Effects of Maxillary Expansion on Voice Function

Voice Production and Resonance

Voice production involves phonation at the laryngeal level, modulated by supraglottic resonating cavities—the oral, nasal, and pharyngeal spaces. Changes in the dimensions of these cavities can influence resonance, nasalance, and acoustic formant structure [24].

Changes in Nasalance and Resonance

Nasalance reflects the ratio of nasal to total acoustic energy during speech. Studies have demonstrated temporary increases in nasalance scores following maxillary expansion, likely due to increased nasal cavity volume and altered velopharyngeal dynamics [25,26].

In most cases, these changes are transient, with nasalance values returning to baseline as neuromuscular adaptation occurs [27].

Acoustic Analysis of Voice Parameters

Acoustic studies evaluating fundamental frequency (F0), jitter, shimmer, and formant frequencies (F1, F2) have yielded mixed results:

- Some authors report significant alterations in F1 and F2, reflecting changes in oral cavity dimensions after expansion [28].
- Others report no clinically significant differences, suggesting that compensatory tongue and soft palate movements mitigate structural changes [29].

Speech Intelligibility and Articulation

In patients with narrow maxillary arches and associated articulation disorders, expansion may facilitate improved tongue posture and articulation space. However, improvements in speech intelligibility are often attributable to concurrent speech therapy rather than expansion alone [30].

Proposed Mechanisms for Hearing Improvement

1. **Resonance Chamber Changes:** Increased maxillary width alters the dimensions of the oral cavity, influencing resonance [24].
2. **Nasalance Alterations:** Altered nasal cavity volume changes acoustic energy distribution between the nasal and oral passages [25].

Limitations and Mixed Outcomes

The voice adaptations post-expansion are often subtle and transient, as vocal tract muscles adapt over time [27]. Some studies have failed to demonstrate statistically significant alterations in acoustic measures, highlighting inter-individual variability [29].

Clinical Implications

Orthodontics

- Maxillary expansion may provide ancillary benefits in patients with transverse deficiency and associated ENT symptoms.
- Orthodontists should be careful not to exaggerate possible hearing or voice benefits and should use an evidence-based, team approach.

Otolaryngology

- RME may be considered as an adjunctive treatment in children with ETD and maxillary constriction.
- An ENT evaluation is essential before recommending expansion solely for hearing concerns.

Speech and Voice Therapy

- Temporary resonance changes should be anticipated.
- Baseline and follow-up nasometric and acoustic evaluations are advisable in professional voice users.

Conclusion

Maxillary expansion produces measurable effects on hearing and voice function, primarily through anatomical and functional modifications of the nasal cavity and nasopharyngeal region. Evidence supports its beneficial role in improving middle ear ventilation for patients with pre-existing Eustachian tube dysfunction, whereas voice changes are typically mild, transient, and adaptive. A multidisciplinary, patient-specific approach is essential for optimal clinical outcomes.

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