Literature Review

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Effects of rapid maxillary expansion on hearing: a systematic review

Efeitos da expansão rápida de maxila na audição: revisão sistemática da literatura

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ABSTRACT

Purpose: Verifying the effects of rapid maxillary expansion on hearing. **Research strategy:** The search was conducted in the bibliographic collection of the electronic databases MEDLINE, SciELO and *Bibliografia Brasileira de Odontologia* (BBO) in January 2016. The keywords used for the research were: "hearing loss", "hearing", "rapid maxillary expansion" and "palatal expansion technique". **Selection criteria:** Articles in Portuguese, English and Spanish were selected, published up to January 2016, without initial date limitation. Studies related to the rapid maxillary expansion on hearing topic were included in this systematic review. **Results:** The research strategy resulted in the selection of eight articles, which were classified as clinical trials. The studies explains that the rapid maxillary expansion performed on children and/or teenagers improves hearing thresholds and acoustic impedance measurements. **Conclusion:** The rapid maxillary expansion caused hearing improvement, despite the methodological limitations and diversity of the analyzed studies.

Keywords: Maxilla; Hearing loss; Hearing; Palatal expansion technique; Review

RESUMO

Objetivo: Verificar os efeitos provocados pela expansão rápida de maxila na audição. **Estratégia de pesquisa**: Conduziu-se uma busca no mês de janeiro de 2016, usando as palavras-chave "*hearing loss*", "*hearing*", "*rapid maxillary expansion*" e "*palatal expansion technique*" nas bases de dados MEDLINE, SciELO e Bibliografia Brasileira de Odontologia (BBO). **Critérios de seleção:** Foram selecionados artigos em inglês, português e espanhol, publicados até janeiro de 2016, sem limitação de data inicial, cuja abordagem metodológica referisse os efeitos da expansão rápida de maxila na audição. **Resultados:** A estratégia de busca resultou na seleção de oito artigos, classificados como ensaios clínicos. Os estudos constataram que a expansão rápida de maxila realizada em crianças e/ou adolescentes melhora os limiares de audibilidade e as medidas de imitância acústica. **Conclusão:** A expansão rápida da maxila provocou melhora na audição, apesar da diversidade e das limitações metodológicas dos estudos analisados.

Descritores: Maxila; Perda auditiva; Audição; Técnica de expansão palatina; Revisão

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INTRODUCTION

The transverse deficiency of maxilla is characterized as a dentofacial anomaly related to the diameter decrease of the maxillary arch[1,2,3]. This deficiency has, as main causative factors, mouth breathing, harmful habits such as digital and pacifier sucking and adapted/atypical swallowing[1]. The discrepancy of the maxilla in the transversal sense, in relation to the mandible, is also an important factor observed in patients with maxillary atresia, who may present unilateral or bilateral posterior crossbite[4].

Orthodontics uses the therapeutics of orthodontic expanders, which present effective results in treating maxillary atresia in children and teenagers aged less than 15[3]. Rapid Maxillary Expansion (RME) or maxillary disjunction is one of the most used clinical procedures in orthodontics, because of its effectiveness and predictability[5]. The main goal is maxillary disjunction by palatal expanders, in order to improve the transversal dimension of patients affected by maxillary deficiencies[6,7]. Disjunction may be performed by fixed orthodontic expanders, like Haas, which is a tooth-tissue-borne device, Hyrax and McNamara Expander, which are classified as tooth-borne[8]. Expanders have an expanding screw, located parallel to the midpalatal suture, activated so that it accumulates a significant quantity of forces, in order to break the resistance offered by such suture and by the pterygopalatine, frontal maxillary, nasal maxillary and zygomaticomaxillary ones[8].

RME may also bring positive results to the oral and nasopharynx anatomy, as well as beneficial effects to hearing[9]. Many inflammatory conditions in the nasopharynx may damage the performance of the auditory tube[10] and cause changes in the middle ear, which lead to otitis and hearing loss[11]. The absence of ventilation, caused by the negative pressure in the middle ear, leads to the formation of liquid inside it; it may result in conductive hearing loss[12]. After maxillary expansion, the elevator and tensor muscles of the velum palatinum broaden, helping the opening of the pharyngeal orifice and the functioning of the auditory tube. Consequently, a proper ventilation of the medium ear occurs, balancing the pressure on both sides of the tympanic membrane and allowing the tympanic ossicular chain to move and function normally[9,11].

OBJECTIVE

The goal of this systematic review was to verify the effects caused by RME on hearing.

RESEARCH STRATEGY

In order to identify studies about RME expansion and hearing, a research was made among the available publications in MEDLINE, SciELO and *Bibliografia Brasileira de Odontologia* (Brazilian Odontology Bibliography), in order to perform a wide base literature systematic review. The research included studies that were published until January 2016, with no initial date limit. There was no restriction on the types of used procedures, age limit or gender restriction. Used search terms and combinations were: "hearing loss", "hearing", "rapid maxillary expansion" and "palatal expansion technique". Included descriptors were searched in *Descritores em Ciência da Saúde* (DeCS) and Medical Subject Headings (MESH).

SELECTION CRITERIA

Studies were selected according to the following inclusion criteria: publications until January 2016, original studies involving human beings and whose goal was to evaluate RME effects on hearing and studies published in English, Portuguese and Spanish. As for exclusion criteria, studies using the procedure of semi rapid/slow maxillary expansion, or surgical maxillary expansion, studies about bibliographic reviews, editor's letters, case studies and studies not directly related to the theme were excluded.

The selection process of studies included in this systematic review, analyzed by the recommendation Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement[13], is explained in Figure 1.

DATA ANALYSIS

At first, two reviewers analyzed all the studies identified by the combinations of descriptors in the proposed data bases, by verifying the title of the study and the abstract, selecting articles that contained the pre-determined eligibility criteria. After that, articles were searched in their full text. The main data of each article were thoroughly collected, through a standardized table for this study. The analysis of the selected articles considered the following aspects; year and place of publication, characteristic of the sample (number, gender and average age of the participants), evaluated variables, used orthodontic and audiological procedures, as well as obtained results and conclusions.

Reviewers evaluated the complete articles and made their choices according to pre-determined eligibility criteria. Analysis results were compared between two evaluators and the classification of criteria was re-evaluated in a meeting, to analyze the differences.

RESULTS

As the result of the initial search, 13 studies[9,10,11,14,15,16,17,18,19,20,21,22,23] were identified, among which 6[10,16,19,20,21,22] attended inclusion criteria and were considered relevant for this work's sample. Two[24,25] more were added to them, classified as additional references, found in the bibliographic references of the selected studies.

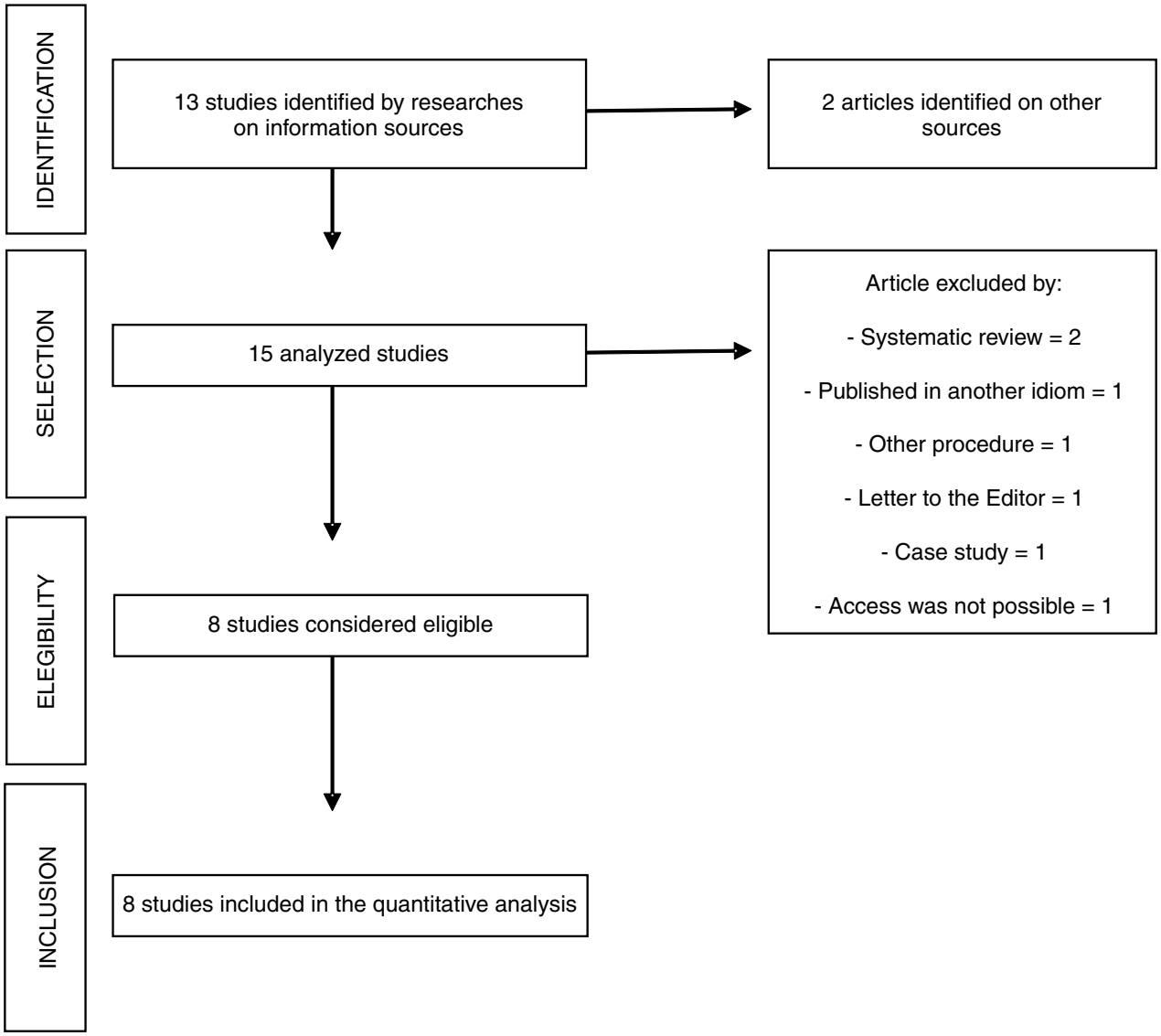

Figure 1. Synthesis of the obtaining process of the selected articles for literature systematic review

Two articles[14,15] were excluded from the search for being systematic reviews, 1 because it used the semi-rapid maxillary expansion[11], 1 because it was impossible to access it[23], 1 because it was a Letter to the Editor[17], 1 case study[9] and 1 because it presented a different language from the ones proposed[18]. On the whole, 8 full articles were included; they attended the proposed criteria for this systematic review. The main characteristics of the included studies, such as authors, year of publication, country of origin, age and gender of the participants, audiological procedures, goal of the studies, as well as the characteristics of its population, are exemplified and described on Chart 1.

Most identified articles were published between 2006 and 2008; the most recent publication is from 2012[24]. All selected studies were written in English. As for the place of publication, Turkey and Italy where the countries that developed more studies on the subject (n=6), followed by Brazil (n=1) and Canada (n=1).

There was no great variation in the sample size, with an average of 12.5 subjects per study. The average age of participants in the research was 6 to 8[10,20,21,24] and 12 to 14[16,22,25]. The population was equally composed by males and females, but in two researches, there was bigger female participation[16,21].

As for the type of dental procedure for RME, in one study[25] the Haas device was used for expansion. However, others used Hyrax[21,22,25] and Butterfly[10] expanders. Three studies did not inform the used device during RME[16,19,20]. As for the activation of the expanding screw, there were differences among the studies. In an Italian study[25], patients were oriented to activate 0.5 mm of screw per day, during 15-20 days. In a study conducted in Turkey[21], 0.2 mm, three times a day, for three days. After the opening of the midpalatal suture and the occurrence of diastema in the medium line, the screw was activated for 0.2 mm twice a day, until eliminating crossbite. Another research, also developed in Turkey[22], used the same method to activate the expander; however, authors did not report how

Chart 1. Characteristics of the included studies

Author (year)	Country of origin	Goal	Population	Gender	Age	Audiological procedures
Micheletti et al. (2012)[24]	Brazil	Evaluating RME effects on the function of the medium ear before, after, 3 months and 1 year after expansion	Patients with otologic surgery, without previous dental treatment and who did not present otitis media during the study	F=9 M=9	Average 8 years and 1 month old	Threshold tonal audiometry (by air, by bones) and tympanometry
Villano et al. (2006)[20]	Italy	Evaluate RME effects on conductive hearing loss and on maxillary constriction	Patients with maxillary constriction, recurring otitis media and conductive hearing loss	F=15 M=10	Average 7 years old	Threshold tonal audiometry (by air) and tympanometry
Kilic et al. (2008)[16]	Turkey	Investigate RME long term effects on conductive hearing loss	Patients with severe maxillary constriction, bilateral crossbite, deep palate and conductive hearing loss.	F=12 M=3	Average 13 years 4 months old	Threshold tonal audiometry (by air and bone) and tympanometry
Ceylan et al. (1996)[21]	Turkey	Determine whether RME has effects on conductive hearing loss	Patients with maxillary transverse deficiency, deep palate and conductive hearing loss.	F=11 M=3	Average 12 years 11 months old	Threshold tonal audiometry (by air) and tympanometry
Stéfano et al. (2009)[25]	Italy	Evaluate RME effects on children with chronic otitis media as a consequence of alterations in the skeletal development and adenoid hypertrophy.	Patients with chronic otitis media associated to adenoid hypertrophy and alterations in the skeletal development.	F=12 M=15	Average 7 years old	Threshold tonal audiometry (by air and bone) and tympanometry
Moura et al. (2008)[19]	Canada	RME effects on the evolution of otolaryngological symptoms in Down-syndrome children.	Patients diagnosed with chromosome 21 trisomy, persistent nasal obstruction and/or recurrent infections at the respiratory tract, with crossbite and/or maxillary constriction. Patients were divided into two groups: the control group, which did not perform the treatment and the group performing rapid maxillary expansion.	F=* M=*	Between 4 and 12 years old	Threshold tonal audiometry (by air) and tympanometry
Taspinar et al. (2003)[22]	Turkey	Evaluate RME effects on conductive hearing loss in a two-year period	Patients with severe maxillary constriction, deep palate and conductive hearing loss.	F=21 M=14	Average 14 years 6 months old	Threshold tonal audiometry (by air and bone)
Cozza et al. (2007)[10]	Italy	Investigate RME effects on the resistance of the nasal airway and on the conductive hearing loss of mouth breathing children, with atypical swallowing and otitis media	Mouth breathing patients, with atypical swallowing and conductive hearing loss resulting from otitis media	F=8 M=16	Average 7 years old	Threshold tonal audiometry

*No information

many millimeters patients were oriented to activate. In another study[20], patients were instructed to activate the screw three times a day, for 7 to 14 days, until the necessary expansion for each individual was concluded. Other authors[16] cited that the expander was activated twice a day, once in the morning and at night, until reaching proper expansion. However, in another study[10], patients were instructed to activate 1/4 of the screw turn, three times a day (morning, afternoon, night), differently from the study conducted in Canada[19], where the screw was activated 0.3-0.5 mm per day, approximately, for 2 to 4 weeks, until obtaining 4-8 mm expansion. However, other researchers[25] activated 1/4 screw in the morning and at night, for 10-12 days, until the palatal cusps of the upper molars are in contact with the vestibular cusps of the lower molars.

Considering diagnostic and evaluative procedures, all studies performed liminar tonal audiometry in order to determine the hearing threshold of the sample subjects. Some researchers[10,16,19,21,24,25] also used tympanometry. In all studies, patients were concomitantly examined by an otolaryngologist and/or had their otolaryngology history investigated.

In all researches, it was verified that the first audiological evaluation occurred before treatment[10,16,19,20,21,22,24,25]. However, the period of the second evaluation differed among studies. In some of them[16,20,24], researchers evaluated again patients right after RME, or 0.83 months after[16], or in 7-14 days[20], or in 3 months[24], or even after a satisfactory opening of the palatal suture[21,22]. It was also observed that the moment of the second evaluation varied among studies. In some of them, it was performed between 3 and 4 months after RME[21,24]. In others, the second evaluation was performed after approximately 6 months from the retention of the expander[10,19,25]. Some researchers also followed their patients for 1 year[24,25] or two years[16,22] after treatment.

Studies performing the research about acoustic measures on their subjects[10,16,20,24,25] observed that RME has significant effects on the function of the auditory tube. Some authors[16], when evaluating the long term effects of RME on conductive hearing loss, verified that the volume of the medium ear significantly increased after maxillary expansion and retention period. However, there was no significant change in the complacency value. A Brazilian study[24] observed that, after RME, all subjects presented acoustic reflexes and type A tympanometric curve. Other authors observed that the tympanic membrane regained its elasticity after the retention period[20].

As for the hearing thresholds of individuals, a research[21] verified a statistically significant difference among them, after satisfactory expansion of the midpalatal suture; however, there was no significant difference between the first hearing assessment and the ossification period of the suture (approximately 4.5 months). Thus, there was an improvement of the hearing thresholds after the activation period and the decrease of the air-bone gap, between the period of expansion and ossification of the suture. Another study[22], however, obtained different results. Authors verified a significant improvement of the hearing thresholds and a decrease in the air-bone gap between the placement of the expander and all the other evaluation periods (after satisfactory expansion of the midpalatal suture, after the retention period and after 2 years from the retention period). In another research[16] an improvement was also observed between the activation period of the expander, after the retention period and after the treatment with a fixed orthodontic appliance (approximately 2 years). However, an Italian study[20] verified an improvement on its patients only after the retention period. Other authors also concluded that after RME there was an improvement in the hearing thresholds of patients with conductive hearing loss[10] and posterior crossbite[24].

A research[21] observed that the average of hearing thresholds of the individuals was worst before the expansion. In the research by air, on the right ear and a 500 Hz frequency, the average was 23.21 dB. After the ossification of the palatal suture (5 to 6 months after), the average was 21.43 dB. There was also an improvement with the other frequencies. As for bone conducted thresholds, at 250 Hz, the average was 23.21 dB and decreased to 20.71 dB. At the frequencies of 500 and 1000 Hz, there was also an improvement of the hearing thresholds. The left ear, in the air and bone conducted research, also presented improvements of the hearing thresholds, at all tested frequencies. Another study[22], which also performed air and bone conducted researches, supports these facts, demonstrating that there was an improvement of the hearing thresholds in both ears, at all frequencies.

In a study[20], the average of 250-1000 Hz, 1000-2000 Hz, 2000-4000 Hz frequencies was grouped in the air conducted research, in both ears. A significant improvement was observed in all groups, such as, for example, in the 250-1000 Hz group, where the average in the right ear was 40.20 dB and, after RME, there was a decrease in the hearing thresholds to 19.8 dB. Another study[25] also researched thresholds by grouping frequencies, according to what was established in the previously mentioned study. In the 250-1000 Hz group, in the right ear, there was a 20 dB improvement. A significant improvement of the thresholds was verified, when compared to the initial and final moment of the research, at all frequencies and in both ears.

In a study conducted on Down-syndrome patients[19], the tritone average before RME was 28.8 dB. Comparing the results of the audiometric examination before and after 6 months from the expansion, a significant improvement in the tritone average was observed, which decreased to 22.1 dB. Other authors[16] also noticed an improvement in the threshold average of frequencies, before the expansion and after its end (2 years). At 250 Hz, the average was 30.33 and after RME, threshold average went to 20.67 dB. At 1000 Hz, the initial average was 21 dB, and after the procedure it went to 17 dB. There was also a significant improvement at the other frequencies. As for bone thresholds, authors also verified changes, mainly at the 1000 Hz frequency, where the initial average was 14.67 dB and,

Chart 2. Methodological classification evaluated by PEDro scale

	External validity (Max = 1)	Internal validity (Max = 8)	Interpretable results (Max = 2)	Total score (Max = 11)
Micheletti et al. (2012)[24]	1	2	2	5
Stéfano et al. (2009)[25]	1	2	2	5
Kilic et al. (2008)[16]	1	2	1	4
Moura et al. (2008)[20]	1	4	2	7
Cozza et al. (2007)[10]	1	2	1	4
Villano et al. (2006)[20]	1	2	1	4
Taspinar et al. (2003)[22]	1	2	1	4
Ceylan et al. (1996)[21]	1	2	1	4

after RME, 8.33 dB. It was verified that RME is an effective procedure, capable of improving hearing thresholds in patients with conductive hearing loss.

In order to verify the scientific evidence of studies, the PEDro scale was used. The goal of the scale is to help researchers to identify whether the clinical outcomes of the applied therapies attend the exposed criteria. There are 11 items in the checklist, investigating internal validity, external validity and results that may be statistically interpreted. All 8 studies were analyzed with this scale. The methodological classification evaluated by the PEDro scale and the articles' scores, in each item of the scale, are available on Chart 2.

DISCUSSION

Orthodontic and orthopedic treatments are generally associated to unexpected therapeutic results in other regions, such as in the respiratory and auditory system[16]. In literature, there are reports of many patients with maxillary deficiencies having a history of respiratory infections since childhood; thus they are affected by conductive hearing loss[10]. In these cases, maxillary expansion can decrease these infections and contribute to a more effective nasal breathing, as well as reducing the occurrence of otitis media and allergies[16].

In a study[20] evaluating patients with conductive hearing loss, it was observed that, after the retention period, patients' auditory tube did not present any obstruction, reducing the occurrence of otitis. The correction of maxillary atresia and posterior crossbite may positively affect on the functions of the medium ear and, consequently, prevent conductive hearing loss[24]. Researchers[25] reported that RME, because of its quick results in patients with skeletal alterations, may be considered an acceptable treatment to prevent recurrent otitis media in children affected by anatomic alterations of the maxilla, since maxillary expansion stretches the elevator and tensor palatine muscles, helping restore the function of the auditory tube, even with the presence of adenoid hypertrophy.

In the study[19] that performed researches on Down-syndrome children, in order to evaluate the effects of RME on otolaryngological disorders, authors concluded that the incidence of otitis media, adenoids and tonsillitis significantly reduced in the group that performed RME. It is important to highlight that this study was the only one using a control sample group in its methodology and it was the one reaching the highest index in the PEDro scale. It was observed in the studies that palatal opening increases the width of the nasal cavity, allowing the decrease of nasal resistance and the increase of the air flow[3]; this method may benefit patients having maxillary transverse deficiencies and dysfunctions of the medium ear and auditory tube.

According to the analysis of publications, it is possible to verify that studies presented different methodologies as for the evaluation period of patients and differences as for the period of the second evaluation. There are no data in literature informing the more suitable period to re-evaluate patients and obtain satisfactory results. However, a study showed that, during the period of the expander activation, there is already an improvement in the hearing thresholds of patients, as well as the decrease in the air-bone gap[16]. Thus, it is suggested that the evaluation after maxillary expansion may already provide satisfactory results about patients' hearing.

It was also observed that the quantity and number of times the expander was activated during the period considerably varied among studies[16,20,21,22,25,26]. In literature, no specific protocol to follow was found, as for the quantity and time of expander activation.

As for the used dental procedure, it was observed that some authors[16,19,20] did not inform the expander type used for RME. According to an author[19], Haas, McNamara and Hyrax expanders are the most famous and accepted ones in the rapid maxillary expansion. Among studies that mentioned the selected type of expander, it was verified that the Hyrax expander was the most used[21,22,25]. This expander applies force on the maxilla through the teeth (tooth-borne) and, therefore, it expands the midpalatal suture[6,23]. Moreover, it is easy to clean[6]. However, in another study[24], the Haas and Butterfly[10] were used.

All studies that presented the average of the obtained values

in the researches on hearing thresholds at different frequencies, in both ears and in different evaluation moments[10,16,19,20,21,22,24,25] verified threshold improvements in both ears at the different evaluated frequencies.

Some limitations in this work may be mentioned, such as the small number of scientific studies on the issue. Moreover, the results found in this research were diverse, due to the methodological variations of studies, which could be highlighted in the result analysis; it needed a detailed discussion for each item. In the PEDro scale, it was observed that few articles attended the checklist criteria. Thus, the general score of studies was quite low, since these did not perform the evaluation and participation of individuals blindly, secret allocation of subjects or random distribution of groups. Studies with representative samples of the population and with uniform criteria are, therefore, recommended to analyze the advantages and consequences of RME on hearing. In spite of the mentioned limitations, it was possible to know the benefits occurring on hearing aspects, when using the RME technique.

CONCLUSION

Most studies mention that RME causes improvements in the hearing thresholds, due to better functioning of the auditory tube and the nasopharynx tissues. Acoustic immitance measures demonstrate proper functioning and integrity of the medium ear, after expansion. However, in spite of the methodological diversity of studies, when using the PEDro scale, limitations for the generalization of the data found became evident.

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