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The impact of rapid palatal expansion on children's general health: a literature review

ABSTRACT

Aim The original indication for rapid palatal expansion was to treat skeletal maxillary constriction. As positive effects were clinically proven, the number of indications for rapid palatal expansion has continuously grown. The purpose of the present article was to review the literature and to evaluate the effect of rapid palatal expansion on nose breathing, natural head position, obstructive sleep apnoea syndrome, nocturnal enuresis and conductive hearing loss.

Conclusion It can be concluded that rapid palatal expansion is predominantly recommended in children with maxillary constriction. In those with normal occlusion, maxillary expansion can be considered as the really last choice of treatment when other treatment options in patients with nose breathing, obstructive sleep apnea syndrome (OSAS), nocturnal enuresis and conductive hearing loss (CHL) have failed. Therefore, collaboration between paediatricians, otolaryngologists, paediatric dentists and orthodontists will lead to the best treatment outcomes in the future.

Keywords Conductive hearing loss; Enuresis; Nose breathing; OSAS; Rapid palatal expansion.

Introduction

In the extensive literature of lateral maxillary expansion with midpalatal suture opening, often referred to as rapid maxillary expansion (RME) or

rapid palatal expansion (RPE), the earliest commonly cited report is that of E.C. Angell, published in the *Dental Cosmos* in 1860 [Angell, 1860]. After initially falling to disrepute because of impeded oral hygiene and uncontrolled force application, the technique was reintroduced in the middle of the last century and made widely popular by Andrew Haas [1961, 1965]. He extensively studied clinical short-term effects of rapid expansion on patients treated only with an expansion appliance during the late mixed and permanent dentitions, as well as repercussions on the craniofacial complex. As a consequence of improvements in the development of dental materials, the application of force could be specified, and the appliance's size reduced. After scientific evidence of positive clinical effects [Biedermann, 1968, Mossaz-Joelson and Mossaz, 1989] was proved, RPE was established in orthodontics. Today RPE with various modifications and designs is routinely used and generally accepted as a relatively simple and predictable orthodontic therapy to treat patients with maxillary constriction and posterior crossbites. All potentially negative impact of placing palatal expanders, including pain and discomfort, disruption of speech production, and chewing and swallowing problems are discussed as mild, transitory, and independent of appliance design, sex, or age [De Felipe et al. 2010]. Remarkable adaptation to the devices can be expected by the end of the first week. In addition, the patients' speech acceptability is reported to be better after than before treatment [Stevens et al., 2011]. Because of various positive side effects on patients' general health, the number of indications for RPE has continuously grown.

The aim of this literature review was to evaluate the impact of rapid palatal expansion on nose breathing, natural head position, obstructive sleep apnoea syndrome (OSAS), nocturnal enuresis and conductive hearing loss (CHL).

Search methodology

In order to identify relevant studies about the impact of rapid palatal expansion on children's general health, a computerized database search was conducted using the Medline database (Medline/Pubmed). The search covered the period up to February 2013. The terms used in the search were 'rapid palatal or maxillary expansion' in combination with 'general health', 'breathing', 'head posture', 'OSAS', 'OSA', 'nocturnal enuresis', 'conductive hearing loss' and 'speech'. A total of 120 references were retrieved from the database search, among them 6 duplicate references. Both authors screened the publications found in the database. Agreement whether the publications were relevant to the topic of this review was reached.

The retrieved studies with the highest available evidence were finally included in the literature review (Table 1).

Review of the literature

Nose breathing and natural head position

Nasal respiration is needed for ideal development of the nasomaxillary complex and it provides the preparation of the air before reaching the lungs by adjusting the temperature, humidification and removing particles. It can be constrained by respiratory infection, cold, asthma, allergic rhinitis, enlarged tonsils and other possible reasons for nasal obstruction. Nasal obstruction inducing mouth breathing results in different tongue and lip positions, in an open mouth posture, constricted upper dental arch, downward and backward rotated mandible and higher incidence of posterior crossbite [Behlfelt et al., 1990; Corruccini et al., 1985]. RPE is a recommended therapy to treat constricted upper dental arches and posterior crossbites in growing patients.

The maxillary bones form the anatomical base of the nasal cavity. Therefore, expansion of the maxilla also affects the geometry of the nasal cavity. The maxillary width and the nasal cavity width increase as the maxillary halves separate during RPE. Baratieri et al. [2011] qualified in their systematic review the evidence

of long-term effects of RPE on airway dimensions and functions. Only the eight following articles met their inclusion criteria and were of moderate methodological quality. In these studies, airway dimensions were either measured two-dimensionally using posteroanterior or lateral cephalometric radiographs or three-dimensionally using a CBCT. Cameron et al. [2002] found a significant increase in nasal cavity width which remained stable five years after RPE. Baccetti et al. [2001] demonstrated a larger increase in the early treatment group (cervical vertebral stage 1-3) compared to the late treatment group (cervical vertebral stage 4-6) and recommended treatment before the pubertal peak to achieve more effective long-term changes. Other studies [Tecco et al., 2007; Compadretti et al., 2006; Monini et al., 2009] using a two-dimensional measurement method revealed also a significant increase in nasopharyngeal airway adequacy, but two of these studies did not include a control group.

Investigating the craniocervical angle on lateral radiographs, McGuinness and McDonald [2006] concluded that nasal airflow increased and nasal respiration improved one year after maxillary expansion.

	Positive side effect of RPE			Level of evidence		
	Yes	Unclear	No	High	Moderate	Low
Nose breathing						
Baccetti et al. 2001	x				x	
Cameron et al. 2002	x				x	
McGuinness et al. 2006	x				x	
Compadretti et al. 2006	x				x	
Tecco et al. 2007	x				x	
Monini et al. 2009	x				x	
De Felippe et al. 2009			x		x	
Zhao et al. 2010			x		x	
Obstructive sleep apnea syndrome (OSAS)						
Cistulli et al. 1998	x					x
Pirelli et al. 2004	x				x	
Villa et al. 2007&2011	x					x
Nocturnal enuresis						
Timms et al. 1990	x					x
Kurol et al. 1998	x					x
Schütz-Franson&Kurol 2008	x				x	
Usumez et al. 2009	x					x
Conductive hearing loss (CHL)						
Laptook et al. 1981	x					x
Ceylan et al. 1996		x				x
Taspinar et al. 2003		x			x	
Villano et al. 2006	x				x	
Kilic et al. 2008	x					x

TABLE 1 Summary of the included studies.

In contrast to these two-dimensional findings, Zhao et al. [2010] used CBCT as a three-dimensional measurement method and did not find any significant differences in airway volume between treatment and control group. Functional measurement methods such as rhinomanometry and acoustic rhinometry revealed improved nasal breathing that remained stable after RPE [Compadretti et al., 2006]. In contrast, De Felippe et al. [2009] did not find any significant differences in improvement of nasal breathing between test and control group.

Baratieri et al. [2011] concluded in their systematic review that there is a low to moderate evidence that RPE improves the conditions for nasal breathing and that the results can be expected to be stable for at least 11 months. Because of the ambiguous findings in the literature, RPE cannot be recommended to treat patients having breathing problems with normally developed maxillary arches.

Natural head posture is influenced by nasal breathing function. Children with nasal obstruction show an increased craniocervical angulation. Wenzel et al. [1983] evaluated the effect of topical steroids on nasal respiratory resistance and head posture in children with nasal obstruction and asthma. Rhinomanometric and cephalometric analyses were performed to compare the treatment group with the placebo group. After one month of treatment, nasal resistance and craniocervical angulation significantly decreased in the treatment group. In a randomised clinical trial by Tecco et al. [2005] analysing 55 mouth breathing girls with maxillary constriction, RPE led to a significant decrease in the craniocervical angulation, to a significant increase of the cervical lordosis angle and to a significant flexion of the head. This can be expected to be stable in the 12-month follow-up [Tecco et al., 2007]. But it is uncertain if these changes in natural head posture are clinically relevant. On the contrary, Yagci et al. [2011] could not find a significant difference in natural head position when the test subjects after RPE were compared to the control group without RPE.

Obstructive sleep apnoea syndrome (OSAS)

OSAS is common, affecting approximately 2-3% of children [Lumeng and Chervin, 2008]. Its highest incidence occurs between 2 and 8 years of age, probably due to the relative size of lymphoid tissue to airway diameter. Its prevalence is expected to increase with rising obesity in children and adolescents. OSAS is described by upper airway collapse during sleep as a consequence of an imbalance between upper airway structural load due to factors such as adenotonsillar hypertrophy or obesity, and upper airway neuromotor tone [Marcus et al., 2005]. Untreated OSAS is associated with significant morbidity such as growth failure, systemic and pulmonary hypertension, and endothelial dysfunction [Gozal et al., 2007; Marcus et al., 2005;

Miman et al., 2000]. Therefore, untreated OSAS can result in a significant health burden for patients.

Contrary to popular belief, a meta-analysis of the current literature demonstrates that paediatric sleep apnoea is often not cured by tonsillectomy and adenoidectomy [Friedman et al., 2009]. A success rate of 66.3% indicates that a large number of children have residual disease. Although complete resolution is not achieved in most cases, tonsillectomy and adenoidectomy still offer significant improvements in apnoea-hypopnoea index, making it a valuable first-line treatment for paediatric OSAS. Villa et al. [2007] assessed the impact of RPE on OSAS children with high and narrow palate. A significant decrease in the apnoea-hypopnea index, hypopnoea obstructive index, arousal index and a decrease of the subjective symptoms were found. In the three-year follow-up [Villa et al., 2011], the hypopnoea index remained stable and the clinical symptoms resolved. As the studies by Villa et al. [2007, 2011] included only a treatment group of 14 and 10 patients respectively without a control group, these studies represent low evidence and must be considered with caution. Other studies [Cistulli et al., 1998, Pirelli et al., 2004] reported a general improvement of the nasopharyngeal function and a new tongue posture. However, because of low patient numbers and missing control groups, these studies represent a low level of evidence.

Nocturnal enuresis

Nocturnal enuresis is common in children below the age of five years, but persistent bedwetting must be considered abnormal. The prevalence of persistent nocturnal enuresis is reported to be 10% in six years old patients and 5% at the age of ten [Neveus et al., 2000]. Different treatment methods are recommended for children suffering from nocturnal enuresis: wetness alarm, fluid restrictions, medication (antidiuretics) and others. Different studies referred nocturnal enuresis as a symptom among children having breathing problems due to large tonsils, adenoidal hypertrophy or anterior nasal stenosis. Tonsillectomy and adenoidectomy have been recommended to improve bedwetting as a side effect [Guilleminault and Stoohs, 1990; Weider and Hauri, 1985]. Since constriction of the nasal area can be partly reduced by RPE, different studies investigated the effect of RPE on nocturnal enuresis. Timms [1990] reported in his retrospective study an association between RPE and a decline in nocturnal enuresis. Kurol et al. [1998] evaluated in their prospective study the effect of RPE on palatal width, airway obstruction and nocturnal enuresis. RPE was used in ten patients, expanding 3 to 5 mm, although nine patients showed a normal occlusion before treatment. Nocturnal enuresis improved in seven patients. Similar results were shown by Usumez et al. [2003]. In their follow-up study, Schütz-Fransson and Kurol [2008] evaluated the long-term effects: 50%

of the treated patients showed an improvement of nocturnal enuresis after RPE which remained stable at the 10-year follow-up. The overexpanded arches relapsed to normal transversal occlusion within one year. The cause of the partial treatment success in children with nocturnal enuresis who are resistant to medical therapy is still unknown. An improvement in airflow due to the widening of the upper dental arch and the nasal structures, higher oxygen saturation, shorter periods of deep sleep due to the irritating orthodontic appliance or a placebo effect are discussed. Schütz-Fransson and Kuroi [2008] recommend a certain sequence of treatment approaches: The first choice of treatment in patients with bedwetting is medication after examination of urinary function; the second treatment approach would be to evaluate the indication for tonsillectomy or adenoidectomy and the last choice of treatment would be orthodontic expansion. Nevertheless, this recommendation is based on low to moderate evidence.

Conductive hearing loss (CHL)

Hearing loss can be divided into two categories depending on the site of disease in the auditory system: conductive and sensorineural hearing loss. The degree of the conductive hearing loss greatly depends on the severity and the type of the physical changes imposed on the mechanical system of the outer or middle ear. It is known that transversal maxillary deficiency and high palatal arches have close relationship with conductive hearing loss [Rudolph, 1977, Laptook, 1981]. For example, Rudolph [1977] reported that Eustachian tube malfunctions were found more frequently in children with high palatal arches and malformations of the palate and nasopharynx that may predispose them to otitis media. Braun [1966] stated that palatal constriction was one cause of nasal stenosis and oral respiration and that the aberration from normal breathing pattern could even affect the Eustachian tube and the middle ear, and result in hearing loss.

Both short and long-term studies evaluated the effect of RPE on CHL. Short-term studies reported improved hearing levels in young patients after treatment with tooth-borne expanders [Laptook, 1981; Timms, 1990, Ceylan et al., 1996]. Patients suffering from recurrent serous otitis media and CHL showed functional improvement after treatment and retention of RPE. In all of these studies, tooth-borne RPE appliances were used to expand the maxillary arch.

Ceylan et al. [1996] found that hearing levels were significantly improved during the active maxillary expansion period, although some relapse in hearing levels occurred during the retention period. Such relapse was also found by Taspinar et al. [2003]. In a long-term study of Kilic et al. [2008], RPE was performed with tooth-tissue-borne appliances. Hearing levels and middle ear functions were improved after an active expansion period, and remained relatively stable during the long-

term observation period. The function of the Eustachian tube in patients with transverse maxillary deficiency and CHL was improved after RPE. In another study performed on 25 subjects having recurrent serous otitis media and CHL, Villano et al. [2006] found a functional improvement in all patients at the end of the retention period of 8 months.

Based on low to moderate evidence, hearing levels and middle ear function can be improved in patients with constricted maxillary arches.

Conclusion

It has been well accepted in the literature that rapid palatal expansion has positive skeletal and dental effects. Positive side effects on patients' general health are often reported, but controversially discussed. As there are only a few studies with high-level evidence on the impact of RPE on general health, their results have to be considered with caution. RPE should predominantly be considered in patients with maxillary constriction. In those with normal occlusions, maxillary expansion can be considered as the really last choice of treatment when other treatment options in patients with nose breathing, OSAS, nocturnal enuresis and conductive hearing loss (CHL) have failed. As a consequence, collaboration between paediatricians, otolaryngologists, paediatric dentists and orthodontists will lead to the best treatment outcomes in the future.

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