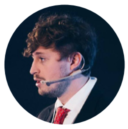
Primary Headache Relief in Paediatric Patients Following Rapid Maxillary Expansion: a Prospective Study and Cephalometric Changes Analysis



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Abstract

Background Primary headaches (PH) are a group of disorders greatly impairing quality of life, highly prevalent in growing population. Previous studies suggested a rhinogenic involvement in PH episodes. Modifications of nasal cavities and septum take place during rapid maxillary expansion (RME). This study aims to investigate the role of skeletal modifications due to RME on PH episodes.

Methods Sixty-eight growing patients (30/38 MF 7-12 y.o 9.2 ± 1.3 SD) were enrolled. All the selected sample patients reported at least 12 PH episodes in the previous year and were diagnosed with maxillary constriction to be treated with RME. Changes in PH episodes before and after this orthodontic procedure were analysed using paired t-tests. Correlations between age and PH episodes were assessed using Spearman correlation coefficients. Correlations between cephalometric changes and PH episodes were investigated using paired t-tests.

Results RME had a significant impact on reducing the monthly PH episodes (t-student = 6.38, degrees of freedom = 65 (number of pairs - 1), $p < 0.001$).

Conclusions RME produces significant modifications in maxillary and nasal width and lower nasal length and decreased monthly episodes of PH significantly. It can be supposed and inferred that RME has beneficial effects on PH in growing patients.

KEYWORDS Headache, Maxillary expansion, Nasal Septum, Orofacial Pain, Primary Headache.

Introduction

Primary headaches (PH) are a group of Headache Disorders (HD) distinguished by a primary or idiopathic diagnosis [Headache Classification Committee of the International Headache Society, 2018; Olesen, 2018]. In this group, headache is not a symptom of an underlying disease or condition, but it is generally caused by inflammation of pain-sensitive parts of the body in and around the neck and head, including nerves, blood vessels and muscles in the absence of an underlying pathologic process, disease, or traumatic injury [Mier and Dhadwal, 2018]. PH pain can be classified as either chronic or episodic, with varying degrees of intensity, and it can be defined using an algorithmic system outlined by the International Headache Society [International Headache Society Guidelines 2023]. In children, adolescents, and growing patients it is described as an overall remarkably high prevalence finding, despite the lack of clarity regarding the distribution among subgroups to a recent systematic review [Onofri et al., 2023]. This study pointed out a pooled prevalence of 62% [95% CI: 53–70%], overall primary headache in children and adolescents especially on females, 38% [95% CI: 16–66%], rather than males 27% [95% CI: 11–53%]. While some symptoms can be mild, PH can lead to a decrease in the quality of life affecting psychological, physical, and social functioning [Langeveld et al., 1996; Nodari et al., 2002]. The target age of the PH prevalence suggests that adolescent and children seeking for orthodontic treatment might have suffered from PH before during or after the orthodontic treatment. While no direct correlation can be retrieved from the literature, past studies suggested a possible correlation between a multitude of primary headaches and rhinogenic involvement due to reduced volume of the ethmoidosphenoidal subcribriform chamber according to the haemoangiokinetics of this area [Bonaccorsi, 1995; Bonaccorsi, 1996; Farronato et al., 2008]. To recover from this situation, some authors proposed nasal septum correction by a surgical treatment, resection of the middle concha, ethmoidectomy, and sphenoidectomy with good results [Novak and Makek, 1992; Novak, 1995]. Bandara in 2021 described how involvement in nasal and paranasal sinus might be associated with nitric oxide and carbon monoxide concentration that can be sucked with immediate relief in acute migrain [Bandara et al., 2021]. While the diagnosis can be differential, the treatment for sinus and rhinogenic headaches can require surgical intervention [Patel et al., 2013]. Another potential association between PH and rhinogenic involvement is the contact between the nasal septum and inferior or middle turbinates. A deviation in the nasal septum results in the convex side of the septum coming into contact with the mucosa along the sensory nerve's endpoint, the peripheral nasal wall of the inferior or middle turbinate, or the lateral nasal wall of the septum. This mucosal contact point may induce pain [Kwon et al., 2020; Shaikh et al., 2021; Swain, 2022]. While the exact involvements between the sinus, the nasal structures and their classification are still under evaluations it can be assumed that some patients requiring orthodontic treatment might present PH and a sinus/nasal haemoangiokinetic involvement [Mehle, 2014]. When sinus infection and acute or chronic rhinosinusitis is present it is classified as secondary headache, but not always an infective origin can be identified, thus the headache is classifies as "Primary" [Cady and Schreiber, 2002]. Similarly while a direct correlation between allergic rhinitis and malocclusion has been confirmed, many authors agree to suggest a possible comorbidity [Farronato et al., 2020].

During and after rapid expansion treatment it has been demonstrated how volumetric changes in the upper airways occur in growing patients but the question on the effects on a population potentially target of primary headaches that overlaps with children needing orthodontic therapy remains [Mehle, 2014]. The aim of this study is to investigate the effects of rapid maxillary expansion on PH headaches.

Materials and methods

A longitudinal clinical trial was conducted at the University of Milan, Fondazione IRCCS Cà Granda. Patients suffering from PH were recruited among growing patients in the Orthodontic Department between 15 March 2016 and 10 July 2023. The study design was outlined following Helsinki Declaration, and was approved by the Ethical Committee of the University of Milan, Fondazione Cà Granda (protocol n. 421, 09/03/2016).

Participation in the study was voluntary. For each underage patient, both parents were thoroughly informed regarding the study design and methods, and a written informed consent was obtained. As a threshold, according to the literature was set to a minimum of 12 PH episodes per year, growing patients having suffered from moderate to severe PH at least 12 PH episodes in the last year were included the study [Mier and Dhadwal, 2018]. All the mild episodes or with a duration less than 30 minutes was excluded. The PH onset was monitored during the 30 days before treatment and during the 30 days after the removal of the appliance. The selected patients were referred from their personal paediatrician or by a Headache neurologic specialistic centre. To avoid confounders, we excluded all the patients under PH treatment. The sample was recruited according to the following inclusion criteria:

- Transverse maxillary deficiency (discrepancy between maxillary and mandibular arches of a minimum of 3 mm and maximum of 6 mm).
- Growing patients with cervical maturation index of (CVMS) less than 3.
- Mixed dentition.
- No previous orthodontic treatment.
- Suffering from PH with at least 12 episodes in the last year.

Exclusion criteria

- Caries or pathologic conditions.
- Syndromes.
- History of facial or nasal trauma.
- Diagnosed headache disorders.
- One or more agenesis.
- Impacted teeth.
- Cleft lip or palate.

Study design

The posterior transverse discrepancy was obtained on dental cast based on the difference between the maxillary intermolar width (distance between the central fossae of right and left first maxillary molars) and the mandibular intermolar width (distance between the mesiobuccal cusps of right and left first mandibular molars) and through postero-anterior radiographs (distance between the two cephalometric Mx points) [Lanteri et al., 2020]. Patients eligible according to inclusion criteria and enlisted for treatment were given a questionnaire to register their updated PH episodes and frequency. The questionnaire contained a calendar to fill with PH episodes at the end of the day for one month prior to the orthodontic treatment. The same questionnaire was subministered at the end of the treatment (after the removal of the palatal expander).

Treatment protocol

The orthopaedic device used was a Hyrax rapid maxillary expander (RME), with bands on upper second deciduous or first permanent molars and extensions to the canine area.

The activation protocol consisted of 2 activations (1 activation = 1/4 turn of the screw) per day until moderate hypercorrection was achieved (upper first molar palatal cusp touching the most coronal third of the lingual incline of lower first molar buccal cusp). Once the active expansion phase was concluded, the device was passively kept in place for a stabilization phase for at least 6 months, and finally removed.

Cephalometric evaluation

For each study participant, the posterior-anterior cephalometric radiograph was recorded at three different timepoints:

- T0: diagnostic evaluation, prior treatment.
- T1: after the end of active expansion;
- T2: at the end of the stabilisation phase.

All cephalograms were traced by one operator (C.M.). In order to assess reproducibility, 10 radiographs were randomly selected and traced by the same operator again after one month; moreover, another operator (M.F.) independently performed the tracings of 10 cephalograms to verify inter-operator reliability. Intra-operator and inter-operator reliability were investigated using intraclass correlation coefficients (ICC).

The reference system was set on the cephalograms as follows: the reference axis was traced passing through right and left CON points; finally, the symmetry axis was drawn perpendicular to the axis of reference and intersecting the highest point of the occipital foramen (Table 1). Afterwards, landmarks were traced (Table 1).

The following cephalometric measurements were identified:

- Skeletal Maxillary width: linear distance between right and left MX points;
- Dental Maxillary width: linear distance between right and left CVM points;
- Upper nasal septum length: linear distance between X and SNM points;
- Lower nasal septum length: linear distance between SNM and SNAC points;

X	Point identified by the intersection of the ethmoidal plate and the anterior cranial fossa
CON	Crossing point between the contour of the inferior condyle of the occipital bone and the occipital foramen. CON homologous points are marked on the right and left, respectively: CON-R and CON-L
Reference axis	Axis passing through CON-R and CON-L
Symmetry axis	Axis drawn perpendicularly to reference axis, intersecting the occipital foramen in its highest point
MX	Crossing point between zygomatic arch and maxillary tuber. MX-R and MX-L are marked.
CVM	Most buccal point of mesial-buccal cusp of the upper first molar. CVM-R and MX-L are marked.
SNM	Middle point of the horizontal segment drawn in correspondence of the maximum diameter of the middle third of the nasal septum
SNI	Middle point of the horizontal segment drawn in correspondence of the maximum diameter of the lower third of the nasal septum
SNAC	Anterior nasal spine
NL	Most lateral point of the nasal cavity. NL-R and NL-L are marked

TABLE 1 Cephalometric landmarks

	episode pre	episodes post
max	20	8
dv st	4.36	1.34
mean	4.74	0.59
min	2	0
T Student	6.38	0.001

TABLE 4 Headache episoded statistics

- Nasal septum deviation: geometric distance of SNI from the symmetry axis;
- Nasal width: linear distance between right and left NL points.

Statistics

A sample size calculation was performed to detect the mean change in PH episodes before and after palatal expansion. With a significance level (α) of 0.05 and a power of the study (1-β) of 0.80, the calculation considered an estimated standard deviation of the paired differences based on preliminary data from previous studies [Farronato et al., 2008; Maspero et al., 2019]. Under such premises, the needed sample study was estimated to be equal to 57.49 recruited patients. In order to improve the robustness of the data, and in consideration of potential patients' dropout or lack of compliance with RME activations, a total of 68 subjects was recruited in the study.

	N	Mean Age (y)	SD
Female	38	9.21	1.20
Male	30	9.63	1.41
Overall	68	9.40	1.30

TABLE 2 Patients' demographics

	T0		T1		T2		T1-T0	T2-T0
	Mean	SD	Mean	SD	Mean	SD	p	p
Skeletal maxillary width (mm)	63.62	5.33	67.79	5.57	66.84	5.29	<0.001	<0.001
Dental maxillary width (mm)	58.18	4.78	64.00	4.84	64.68	4.90	<0.001	<0.001
Upper nasal septum length (mm)	27.54	3.49	27.60	3.53	28.44	3.93	0.74	<0.001
Lower nasal septum length (mm)	21.62	3.04	23.09	2.93	23.27	2.74	<0.001	<0.001
Nasal width (mm)	27.82	3.04	30.13	3.28	30.79	3.36	<0.001	<0.001

TABLE 3 Maxillary and nasal modifications after maxillary expansion

The statistical analysis was carried on and descriptive statistics to summarise participant characteristics. Categorical data analysis revealed the distribution of participants' gender. Changes in primary headache episodes before and after palatal expansion were analyzed using paired t-tests, and correlations between age and PH episodes were assessed using Spearman correlation coefficients. Additionally, cephalometric modifications were explored using paired t-tests, and correlations between cephalometric and PH episodes changes were investigated.

Results

Sixty-eight patients referred to the Orthodontic Department of the University of Milan, Fondazione IRCCS Cà Granda were enrolled to participate in the study. The recruited patients were aged between 7 to 12 (avg. 9.2 ± 1.3 SD) with female prevalence (38 f and 30 m) (table 2). All patients complied with the treatment and no dropouts were recorded; therefore, statistical analysis was performed on the whole study sample (N=68).

Cephalometric tracings displayed high consistency both between operators (ICC=0.89) and within the same operator (ICC=0.90). After rapid maxillary expansion, maxillary width significantly increased (p<0.001), as skeletal measurement went up from 63.62±5.33mm to 66.84±5.29mm and dental measurements from 58.18±4.78mm to 64.68±4.90mm. Similarly, nasal width displayed a significant improvement (p<0.001), varying from 27.82±3.04mm to 30.79±3.36mm (Fig. 1, Table 3).

Moreover, nasal septum underwent significant modifications under a vertical point of view (p<0.001). In

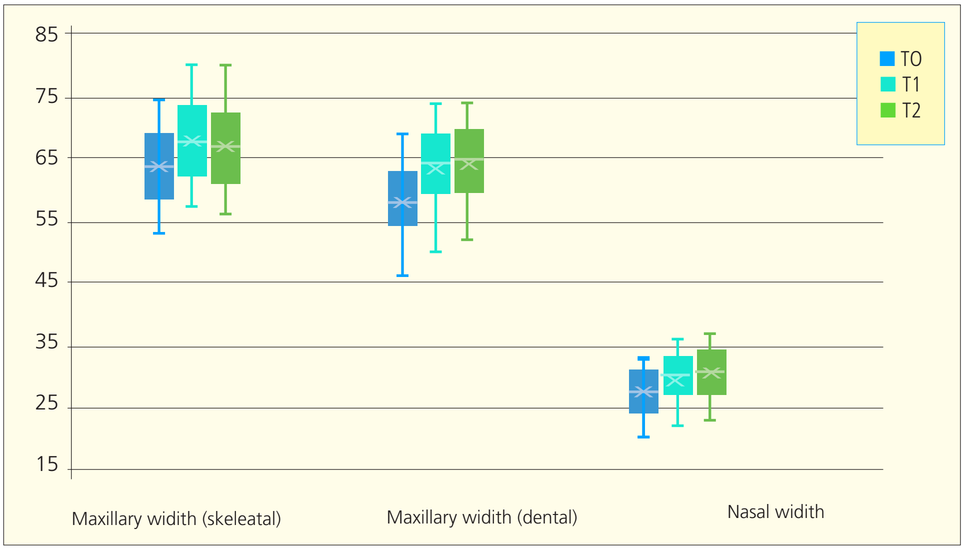

FIG.1 Maxillary and nasal width. Box and whiskers plot of maxillary modifications

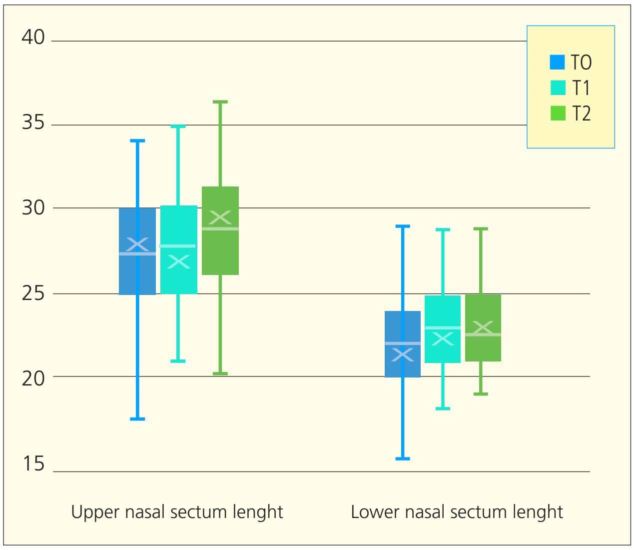

FIG.2 Upper and lower nasal septum. Box and whiskers plot of nasal sectum modifications

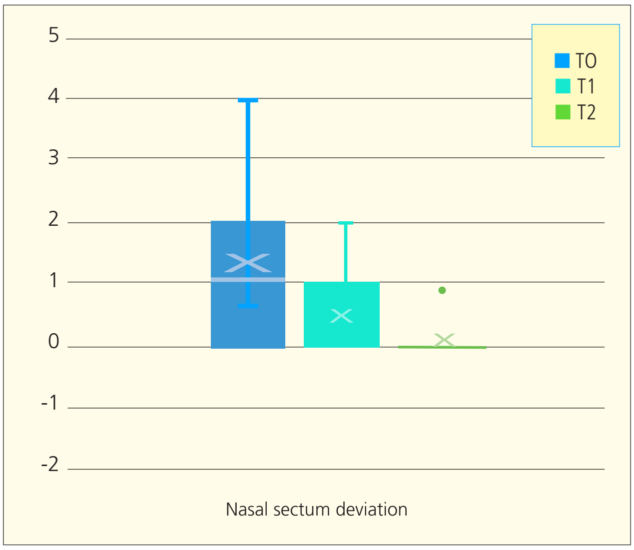

FIG.3 Nasal septum deviation. Box and whiskers plot of nasal sectum deviation

fact, upper nasal septum length increased from 27.54±3.49 mm in T0 to 28.44±3.93mm in T2, whereas lower nasal septum length improved from 21.62±3.04mm to 23.27±2.74mm (Fig. 2, Table 3). It is interesting to notice that, whether the difference in upper septum length was not significant at the end of active expansion phase (p=0.74), but it reached statistical significance after the stabilization period ($p<0.05$) (Table 3).

In T2, the deviation of nasal septum was corrected in most of the study sample (Figure 3) (mean residual deviation in T2 equal to 0.10mm; median: 0mm; Q1: 0 mm; Q3: 0mm).

After RME, the number of headache episodes dropped drastically ($p<0.001$), decreasing from an average of 4,74 reported episodes per month (min: 0; Q1: 1; median: 4; Q3: 8; max: 20) to 0.59/month (min: 0; Q1: 0; median: 0; Q3: 1; max: 8). The data suggests that palatal expansion had a statistically significant impact on reducing the monthly episodes of primary headache being the p value < 0.05 (t-student = 6.38, Degrees of freedom = 65 (number of pairs - 1), p-value < 0.001) (Table 4).

Discussion

Children and adolescents are frequently affected by PH from 5% among children 5 to 10 years old to approximately 15% among teens with a peak around 13 years of age [Victor et al., 2010]. The specific age group is commonly seeking orthodontic treatment , and it is a common finding to visit patients affected by PH. Currently, there are no data regarding the beneficial effects of the orthodontic therapy on this disorder as only few past studies [Maspero et al., 2019; Farronato et al., 2012] pointed out the direct responsibility of sinus/nasal involvement with haemoangiokinetic [Bernichi et al., 2021] and, if neglected, in the sever cases might lead to corrective surgery of mucosal contact points or middle turbinate concha bullosa [Sollini et al., 2019]. The corrective surgery, or nasal surgery, is one of the most common operations performed by otolaryngologists and has been described as having effects on headaches but only in selected patients. However, in this systematic review it was not described if the patients underwent previous orthodontic/

orthopedic treatment, and it was not considered as a possible confounder [Farmer et al., 2018].

The increase in maxillary width following rapid maxillary expansion observed in this study is consistent with previous literature demonstrating the orthopedic effects of this procedure on the maxillary skeletal structures that shares an intimate position with the nasal structure such as the septum [Maspero et al., 2020; Farronato et al., 2022] as previously observed in a CBCT study [Maspero et al., 2019; Cenzato et al., 2021; Lanteri et al., 2020]. Being the maxillary width the most significant, among with the nasal width and the nasal septum length as observed after the end of the expansion, possibly reducing the septal-turbinate contacts. While the upper septum length was significantly increased only after the retention period. This expansion likely contributed to improve the transverse dimensions of the upper structures that might orchestrate the insurgence of the PH. Additionally, the significant improvements in nasal width and septal dimensions suggest a concomitant enhancement in nasal airflow, which may play a role in mitigating headache symptoms. In general, the collective increase in the cephalometric values indicates more favourable conditions in the morphology [Maltagliati et al., 2020].

These findings highlight the complex interplay between the palatal expansion, craniofacial morphology, and headache pathophysiology which should always be considered before orthodontic/orthopaedic therapy [Angiero et al., 2018].

The clinical implications are manifold and relevant both for the orthodontic treatment and for the PH affected patient management. The orthodontic therapy should not be considered an alternative to conventional PH treatment before further studies, but it should be considered safe in PH patients and eventually beneficial and non-invasive not limiting a possible interdisciplinary approach with the neurologist. This study also opens the question on future studies regarding the subgroups of PH such as tension-type headache, migraine, and cluster headache to propose different approaches and tailored on factors such as the age and gender [Farronato et al., 2020b].

Limitations of this study should be addressed. Although, initially, it was considered recruiting a control group, during later stages of the study it was decided not to include it because PH was not observed in controls, and insurgence in healthy patients is not documented after palatal expansion in the literature to out best knowledge, therefore it was not considered relevant to the scopes of the study a healthy arm. Another potential confounder of the study is the variability and etiologic nature of PH, that is, in fact a very heterogenous condition, in general, for future studies, a multidisciplinary approach with a longer time span might be beneficial to reach consensus. Also, it was not possible to evaluate behavioral or psychologic factors. Another limitation is the exclusion of all the patients undergoing pharmacological treatment for the PH, as it would have represented a bias for the study, therefore excluding potentially the most severely affected pool of patients. Furthermore to exclude turbino-septal synechiae the golden standard would be a CBCT, but the norm for orthodontic patients is a latero-lateral teleradiography, therefore we opted no to perform 3D radiography for this study [Romero-Reyes and Bassiur, 2024].

According to these results it was observed that a sample of paediatric patient affected by PH was successfully treated by maxillary expansion with increased maxillary width after the active palatal expansion. Furthermore, after the expansion a significant increase in other parameters such as nasal width, and lower nasal length was observed. After retention upper nasal length increased. The monthly episodes of primary headache registered after the expansion were statistically lower than before therapy supposing safety and even beneficial effects of the palatal expansion on paediatric patients affected by Primary Headaches.

Conclusions

- Rapid maxillary expansion results to effectively increase nasal and maxillary width and nasal length;
- the number of PH episodes per month decreases after maxillary expansion;
- growing patients suffering from PH may greatly benefit from RME.

Ethics approval and consent to participate

This study was designed according to Helsinki declaration. The study protocol was approved by IRCCS Ca' Granda Ethical Committee (protocol n. 421, 09/03/2016).

Participation in the study was voluntary. Both parents of underage participants were thoroughly informed regarding the study design and methods, and written informed consent was obtained.

Authors' contributions

MF and CM conceived the study design and collected the data; MF and RC analysed and interpreted the data; MF, RC, FCT and AB contributed to writing the manuscript; CM reviewed the manuscript. All authors read and approved the final draft.

Founding

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List of abbreviations

PH: primary headaches
HD: headache disorders
RME: rapid maxillary expansion
CBCT: cone beam computed tomography

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