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N-butanol olfactory threshold and nasal patency before and after palatal expansion in children. A preliminary study☆

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ABSTRACT

Objectives: Olfaction is based on the function of the nasal olfactory receptors. Children can well detect and respond to odors in order to have information about food and environment.

Rapid maxillary expansion seems to improve dental class and increase nasal patency correcting oral respiration in children. Nevertheless, there are no studies demonstrating that expansion in pediatric patients could influence olfactory sensitivity. The aim of this study was to evaluate olfactory threshold and nasal patency in children aged from 6 to 12 years before and after rapid maxillary expansion.

Method: N-butanol olfactory thresholds, anterior active rhinomanometry, and peak nasal inspiratory flow were measured in 12 children (6–12 years) before (T0), 20 days (T1), and 6 months after rapid maxillary expansion application (T2).

Results: A significant lower olfactory threshold was found comparing T2 and T0 N-butanol olfactory threshold values ($p = 0.038$). Peak nasal inspiratory flow showed a significant improvement both at T1 and T2, with respect to T0 values ($p = 0.043$ and $p = 0.0001$, respectively). T2 nasal resistances showed a trend towards a significant reduction when compared with T1 values ($p = 0.15$).

Conclusion: This pilot study suggested that rapid maxillary expansion may lead to improved N-butanol olfactory thresholds, at least 6 months after palatal expansion. Furthermore, rapid maxillary expansion seems to improve peak nasal inspiratory flow values, and finally although with lower sensitivity, reduce nasal resistances as measured by rhinomanometry.

1. Introduction

Animal noses have developed the ability to detect an infinite array of odors at minute concentrations, in fact olfaction is very important to perform functions such as orientation, feeding, and individuation of dangers. The basis of this sensitivity are the olfactory receptors (ORs), a large class of G protein-coupled receptors (GPCRs) that function together combinatorially to allow the discrimination between a wide range of volatile and soluble molecules [1]. All human olfactory receptors (hOR) are integral membrane proteins with seven trans-membrane domains [2,3].

Like other mammals, human infants react to odors from birth, and use them in early social discrimination [4]. It has been demonstrated, in fact, that quality and intensity discrimination is already present in the neonatal period and improves from years 3 to 12 [5]. Children can detect, discriminate, and respond to odors in order to have information about food, social partners, and the environment at large [6].

There are different olfactory tests available to evaluate olfactory sensitivity in humans. One of the most known and used in European countries is the Sniffin' Sticks battery test (Burghart Medical Technology, Wedel, Germany). Sniffin' Sticks, whose results are also available in literature for subjects aged 6 years or older [6], consists of three subtests which allow to study odor threshold, odor discrimination, and odor identification respectively. Each subtest result is summed up to a composite score, known as TDI score, which allows to define the patient olfaction capacity [7].

The measurement of nasal patency is of considerable importance. Rhinomanometry (RM) is still regarded as gold standard for

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the measurement of nasal airway resistances [8]. Anyway, peak nasal inspiratory flow (PNIF) has been shown to be reproducible in the evaluation of nasal airway obstruction and as good an indication of objective nasal patency as formal RM [9]. Furthermore, PNIF is a cheap, simple, and easily performed method to assess nasal patency [10] also in pediatric population [11].

It has been demonstrated that some orthodontic appliances indicated in evolutive age could determine variations of maxillary and nasal structures [12–14]. Palatal expansor is an orthodontic appliance utilized to resolve skeletal cross-bite. [15] Rapid maxillary expansion (RME) improves not only dental occlusion, but also nasal structures conformation, increasing nasal patency, and correcting oral respiration [16,17].

Although previous studies have demonstrated that applying RME in evolutive age can improve nasal patency [18], there are no studies, so far, demonstrating that expansion in pediatric patients could influence olfactory capacity.

The aim of the present study was to evaluate for the first time the N-butanol olfactory thresholds together with nasal patency, measured by means of anterior active rhinomanometry (AAR) and PNIF, in a group of children aged from 6 to 12 years before and after RME.

2. Material and methods

At the Dental Clinic of Padova University 12 patients aged 6–12 years (4 boys and 8 girls) (mean age 7.6 ± 1.5 years; range 6–11) were selected. These patients underwent a preliminary orthodontic evaluation including radiographic examination such as orthopantomography and teleradiography.

Including criteria were unilateral or bilateral skeletal cross-bite with a discrepancy consisting of at least 4 mm of transverse diameter between upper jaw and mandible (grade 3c or 4c of IOTN, Index of Treatment Needs) [19]. The first permanent molars had to be erupted. Transverse deficit has been quantified as the difference between transverse diameter of upper jaw and mandible.

For each patient intra- and extra-oral photographic documentation was collected (Fig. A1 A, B).

At the enrolment into the study, parents together with the children were administered a SNOT 22 questionnaire [20] in order to exclude occlusal adenoid hypertrophy or any nasal pathology. Furthermore, all subjects included had not undergone any previous surgery on adenoids and/or paranasal sinuses. All the children enrolled scored < 1 on the SNOT 22 and were considered to have "healthy noses."

The present investigation was conducted in accordance with the 1996 Helsinki Declaration and was approved by an internal committee. Written informed consent was obtained from all children' parents before undertaking any study-related procedures.

Once enrolled, all nasal procedures, such as PNIF, AAR, and olfactory threshold measurements, were performed at ENT Clinic, Department of Neurosciences of Padua University, before RME application (T0), at the completion of the expansion, after 20 days RME application (T1), and after 6 months RME application (T2).

2.1. Olfactory test

All children underwent a quick olfactory screening with the Nez du Vin test, which involves identifying six aromas (lemon, mint, strawberry, pine, vanilla, smoke) by giving multiple-choice answers, according to McMahon and Scadding (1996) [21]. The test was further simplified with cards showing pictures-related odors. As they all revealed a normal sense of smell (scores of 5 or 6), they were then studied to ascertain their odor threshold for N-butanol (Burghart Medical Technology, Wedel, Germany), using the Sniffin' Sticks® test as already described [22].

2.2. Nasal patency evaluation

A portable Youlten peak flow meter (Clement Clark International) was used for the measurement of PNIF. PNIF measurements were conducted as previously reported [8,10].

Nasal patency was also evaluated using AAR (Rhinolab, Rendsburg, Germany) as previously described [23]. AAR values were expressed in Pascal (Pa).

2.3. Rapid maxillary expansion

After maxillary impression for each child a Rapid Expander like Hyrax was installed, constructed with bands on permanent molars, a 11 mm expansion screw (Leone S.p.A., Sesto Fiorentino, Firenze) and palatal arms resting on deciduous molars or canines [24,25] (Fig. A2 A, B).

The expanders were cemented with light-curing cement *Transbond Plus*™ for bands and parents were instructed concerning the way to activate the screw, prescribing a quarter turn a day for 20 days. Each quarter turn corresponded to 0,2 mm for a total of 4 mm of expansion.

2.4. Statistical analysis

Two-tailed paired *t*-test was used for comparing PNIF, AAR, N-butanol olfactory threshold and SNOT 22 results obtained before RME application (T0), at the completion of the expansion, after 20 days RME application (T1), and after 6 months (T2) RME application. Holm correction has been then used for multiple tests [26]. Furthermore, pairwise Wilcoxon test was used for comparing SNOT 22 for nasal obstruction (22nd question) and for smell (21st question) results at T0, T1, and T2.

A p value < 0.05 was considered statistically significant. Values in the range of $0.15 > p \geq 0.05$ were considered as indicating a statistical trend.

The R: a language and environment for statistical computing (R Foundation for Statistical Computing, Vienna, Austria) was used for all analyses.

3. Results

None of the children enrolled was lost during the 6-month follow-up.

The mean PNIF values, nasal resistances, and N-butanol olfactory thresholds before (T0), at 20 days (T1) and after 6 months (T2) from the treatment are shown in Table A1.

When PNIF values at T0 were compared with those at T1, we found a statistically significant improvement of PNIF values ($p = 0.043$). When T2 PNIF values were compared with respectively T1 and T0 values, we again found a significant PNIF improvement in both cases ($p = 0.043$ and $p = 0.0001$, respectively) (see Fig. A3a).

Analyzing AAR values at T0 and comparing those with nasal resistances at T1, we did not find a statistically significant improvement of nasal resistances ($p = 0.18$); anyway when T2 nasal resistances were compared with those at T1, a trend towards a statistically significant reduction of nasal resistances was observed ($p = 0.15$). Finally, comparing T2 and T0 AAR values, no statistically significant reduction of nasal resistances was observed ($p = 0.18$) (see Fig. A3b).

While N-butanol olfactory threshold values did not prove to change significantly between T0 and T1 ($p = 0.240$), a trend towards a statistical significant lower olfactory threshold was observed comparing T2 with T1 olfactory threshold values ($p = 0.112$). Comparing T2 N-butanol olfactory threshold values with T0 values, a statistically significant lower olfactory threshold, that means higher olfactory performance, was found ($p = 0.038$) (see Fig. A3c).