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Evaluation of surgically assisted maxillary expansion using acoustic rhinometry and postero-anterior cephalometry

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Abstract. Correction of maxillary transverse deficiencies is a common procedure in adult patients presenting dentofacial anomalies. Nasal characteristics of these patients, as well as the effects of these procedures upon nasal patency, have not been well described yet. In the present study, measurements performed by acoustic rhinometry and frontal cephalometry in 13 patients presenting maxillary deficiencies, before and after surgically assisted maxillary expansion (SARME), were compared with those of 10 individuals with normal dentofacial characteristics and without nasal symptoms. The variables analysed were minor cross-sectional area (MCA) and nasal volume, maxillomandibular transverse index and nasal and maxillary width. The results showed a smaller transverse width and MCA in the patients as compared with normal controls. All measurements showed a tendency to increase after SARME. The nasal volumes did not differ. The nasal width showed wide variation. There was no correlation among the variables. Patients presenting maxillary transverse deficiency seem to have lower values for nasal MCA, with a tendency to increase after SARME.

Key words: maxillary expansion; orthodontics; rhinometry; acoustic; oral surgery.

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Maxillary transverse deficiency presents a uni- or bilateral posterior cross-bite, related to different kinds of malocclusion. Techniques indicated for its correction are variable, according to the severity of the deficiency, type of malocclusion, age of the patient and other facial deformities. The main techniques are rapid maxillary expansion (RME), either orthodontic or surgically assisted, and multisegmental osteotomy.

The benefits attributed to correction by RME in children are improvements in skeletal maxillary anatomy, dental arch shape and correction of malocclusion, as well as an increase in nasal patency, defined as the ability of air to pass through the nasal cavities during breathing, well documented by different subjective[24] and objective measurements[7,10,11,15,18,27]. In adult patients, RME has limited indications. Maxillary expansion requires surgical assistance, such as a segmental technique for smaller deficiencies[2,25] or surgically assisted rapid maxillary expansion (SARME) for greater ones[3,4,17]. Few studies have compared variables related to nasal patency in adult patients showing maxillary transverse deficiencies with those in normal individuals[29], as well as investigating the effects of SARME on nasal patency[1,29].

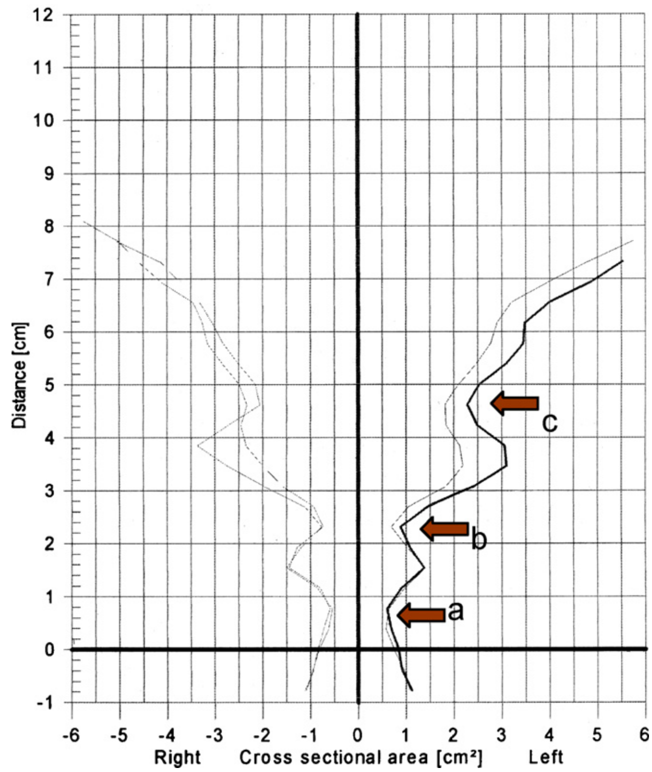

Fig. 1. Computed acoustic rhinometry of a patient of the study sample. The arrows point to the MCA in the regions suggested as the nasal valve (a), the head of inferior turbinate (b) and the third area of narrowing (c).

Acoustic rhinometry is a non-invasive, reliable and quick method that requires minimal patient collaboration[12,19] and measures the nasal cross-sectional area and volume in different regions of the nose, based on acoustic wave reflection on the cavity walls. Measurements are expressed graphically, relating cross-sectional area and distance into the cavity (Fig. 1). Reduction of cross-sectional area increases nasal resistance in a non-linear manner[28]. It is known that minor cross sectional area (MCA) is susceptible to changes by maxillary expansion[15,27]. The volume of this cavity is also used for quantitative studies[1,7,9,29].

Frontal cephalometric analysis is important for diagnosis and treatment design. A number of authors suggest its use for the analysis of maxillary transverse skeletal problems[4,22,26]. Three measurements are useful for evaluation of maxillary transverse defficiencies: the maxillary width (distance from left to right jugale points), the maxillomandibular transverse index (MMTI; difference between effective mandibular width – distance between the left and right antagonist points – and maxillary width, reducing the MMTI expected for ages over 16 years) and the nasal width.

The present study was motivated by a specific question. Is there a relationship between the variation in cephalometric transverse measurements and nasal patency in patients showing maxillary transverse deficiency, before and after SARME? The aims were, in individuals showing normal dentofacial patterns compared with patients presenting maxillary transverse deficiency, before and after SARME: (1) to compare minor cross-sectional areas of the anterior and posterior regions of the nasal cavity; (2) as well as nasal volume, both measured by computed acoustic rhinometry; (3) to compare cephalometric transverse measurements, maxillary width, MMTI and nasal width, in the same individuals under the same conditions; (4) to establish whether there is a relationship between the variations in cephalometric transverse measurements and acoustic rhinometry measurements.

Material and methods

The present study used data obtained from frontal cephalograms and computed acoustic rhinometry obtained from normal individuals and patients presenting dentofacial anomalies. It was approved by the research and bioethics committees of the involved institutions.

Study sample

Thirteen patients operated on between January 2002 and March 2004, and submitted to SARME to correct maxillary transverse deficiency at the Oral and Maxillofacial Surgery Service at Complexo Hospitalar Santa Casa (Porto Alegre, Brazil), were the source of data for the pre-SARME and post-SARME groups. The patients were grouped independently of malocclusion type and sagittal skeletal pattern.

Indication criteria for SARME were based on Betts et al.[4]. The patients showed at least two of the clinical characteristics described by these authors and cephalometric criteria of transverse maxillary deficiency (maxillomandibular differential width greater than 10.0 mm on one side at least or transverse maxillomandibular index greater than 5.0 mm). Data on the pre-SARME group were obtained from preoperative examinations, and post-SARME from 4–12 months' follow-up (mean = 8.2 ± 2.7 months) after the surgical intervention. Data on the control group were obtained from 10 adult volunteers. The inclusion criteria were: acceptance of consent form and presence of an acceptable occlusion with no previous history of orthodontic treatments involving RME, SARME or extractions of permanent teeth (with the exception of third molars), agenesis or previous history of nasal or palatine surgery. Diagnosis was based on clinical and radiographic (lateral and frontal cephalograms) examination and on stone cast study models. All examinations were standardized. The exclusion criteria included current use of topic or systemic medications for nasal obstruction, history of labial or palatal fissure and presence of craniofacial anomalies or any chronic systemic disease.

Surgical technique

Surgical interventions were realized under general anesthesia and nasotracheal intubation. After standard procedures of asepsis, alveolar mucosal incisions were made, followed by muccoperiosteal elevation. Maxillary bilateral osteotomies were performed, extending from the nasal lateral wall up to the maxillary tuber, associated with pterygomaxillary suture fracture. The expansion device (type Haas or Hirax) was then activated (2.0 mm). The intermaxillary suture, exposed through a sagittal incision of the labial frenulum, was fractured. The mucosa was closed as usual. The device was kept activated (1.0 mm) at the end of intervention. From the fourth postoperative day, the expansion screw was activated two times a day (0.25 mm each), until expansion was reached. Maxillary occlusal radiographs and the presence of interincisal diastema confirmed the intermaxillary dysjunction. After expansion there was a period of 4 months retention before the patients received a molar transpalatine bar.

Acoustic rhinometry

Acoustic rhinometry was performed by ENT physicians, using the same device (Rhinometrics™ SRE 2100, Denmark) under standard conditions, prior to the treatment and 4–12 months (mean 8.2 ± 2.7) afterwards. Individuals from the control group were examined only once. Data registered included the minor cross-sectional areas of the anterior (MCA1) and posterior (MCA2) regions, and the volume of the nasal cavity in these regions (Volume 1 and Volume 2), after application of a nasal vasoconstrictor in order to exclude the influence of lining mucosal variations and concentrate the study on skeletal alterations.

Cephalometry

The cephalometric measurements, maxillary width, MMTI and nasal width, were obtained from standard frontal cephalograms using the software Radiocef 3.0 (Radio Memory, Belo Horizonte, MG, Brazil). For pre and post-SARME groups, pre- and postoperative cephalograms were used; for the control group, a single one was necessary. Fig. 2 shows a frontal cephalogram from the study sample containing representatives of the landmarks chosen.

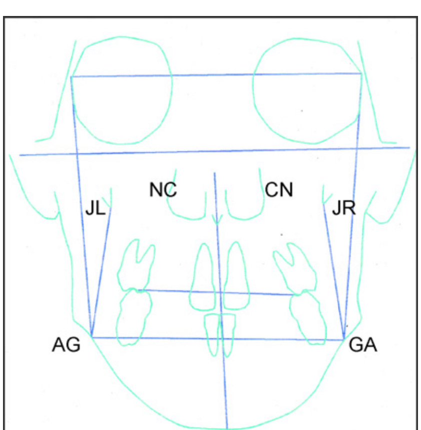

Fig. 2. Frontal cephalogram with representatives of the landmarks used.

Table 1. Demographic data: age (years) of the sample

Control (n = 10)	Pre (n = 13)	Post (n = 13)	P
26.10 ± 4.68	25.15 ± 6.93	25.85 ± 6.85	>0.05*

* Student's t-test.

Table 2. Demographic data: gender of the sample

Control (n = 10) (%)	SARME (%)	P
F = 6 (60)	F = 9 (69)	>0.05*
M = 4 (40)	M = 4 (31)	

* χ^2-square test.

Statistical analysis

The results were analysed using parametric methods (Student's t-test) for dependent (pre and post-SARME) and independent (control group measurements versus pre and post-SARME) samples and on quantitative variables (MCA1, MCA2, nasal volume, maxillary and nasal widths, MMTI). The correlations among these variables were submitted to Pearson's correlation test. Gender frequency distribution among the groups was tested by the χ^2-test. The confidence interval was stipulated as 5%.

Results

Tables 1 and 2 give the age and gender data of the sample. There were no differences among the groups. MCA1 was not different among the groups. MCA2 was smaller in pre-SARME, with significant differences when compared with the control group. An increase in MCA2 was observed in the post-SARME group. Although without reaching control values and not statistically significant, the difference from pre- to post-SARME, P = 0.06 on the Student's t-test, may be considered a borderline value. There were no differences among results for nasal volumes. A progressive increase of this variable was noticed from pre-SARME to control groups. The cephalometric measurements showed more consistent alterations, suggesting the capacity for enlargement of the maxilla using SARME, in adult patients. The maxillary width and the maxillomandibular transverse index showed an increase from pre- to post-SARME, reaching values closer to control. An increase in nasal width was also observed, but surprisingly the control group had lower values. Table 3 presents a summary of the results of the comparisons between groups on rhinometry and cephalometry. There was no correlation among cephalometric and rhinometric measurements.

Discussion

SARME is a safe and efficient procedure with low morbidity, allowing gain of space at the anterior region of the arch and helping to solve crowding and minimize extractions. Periodontal damage is less often seen than with segmental techniques, and stability is greater[17]. The osteotomy designs used are in accordance with Bell & Epker[3] and Betts et al.[4], among others, and allow intermaxillary suture opening in all cases. Discussion concerning osteotomy design for SARME[13,14,21] is intense. Comparison studies are necessary for a complete understanding of this issue[13].

Most of the effects of SARME on nasal patency previously described are based on clinical notes and subjective methods[8,23], as well as on insufficiently precise[19] methods. The studies by Wriedt et al.[29] and Babacan et al.[1] used a quantitative approach and precise tests, showing an increase in variables related to nasal patency, using different osteotomy designs.

Acoustic rhinometry was chosen because it is a reliable, non-invasive, quick and low-cost method. It is comfortable and requires minimal collaboration of the patient[6,12,19]. The variables selected were the MCA and nasal volume, measured after

Table 3. Comparison between rhinometry and cephalometry measurements

	Control (n = 10)	Pre (n = 13)	Post (n = 13)
MCA1 (0.0–2.2)	1.17 ± 0.15[a]	1.03 ± 0.23[a]	1.05 ± 0.23[a]
MCA2 (2.2–5.4)	1.61 ± 0.41[b]	1.24 ± 0.35[a]	1.56 ± 0.64[a]
Volume 1 (0.0–2.2)	4.05 ± 0.60[a]	3.62 ± 0.56[a]	3.80 ± 0.56[a]
Volume 2 (2.2–5.4)	15.19 ± 3.4[a]	13.47 ± 4.46[a]	14.63 ± 5.64[a]
Nasal width	30.27 ± 3.58[a,b]	31.13 ± 3.34[a]	32.18 ± 3.86[b]
Maxillary width	70.15 ± 4.81[b]	60.50 ± 4.08[a]	64.92 ± 4.29[b]
MMTI	1.64 ± 3.50[b]	7.64 ± 4.14[a]	1.01 ± 1.79[b]

Different letters means significant difference.

use of a nasal vasoconstrictor, in accordance with previous researchers[9,15,18]. Measurement of the MCA permits inference of the nasal resistance, because it is proportional to the nasal resistance in an inverse and non-linear relationship[28]. Treatments that increase the nasal cross-sectional area lead to a reduction in resistance; SARME seems to be one of them.

Acoustic rhinometry showed lower MCA2 values in the pre-SARME group compared with control individuals. MCA2 was higher after SARME, and although the $P = 0.06$ observed was higher than the confidence interval, it suggests a tendency to increase. Future studies, with larger groups of patients, should elucidate this question. Considering the lower MCA2 values for pre-SARME patients, the results contribute to the understanding of chronic nasal obstructions, snoring and OSHAS commonly found in patients presenting maxillary defficiencies.

Frontal cephalometry is an excellent method for the diagnosis of face transverse deformities[4,26]. Although it is widely employed by orthodontic and surgical practitioners, few research papers have used it for this purpose, as this technique has been more commonly indicated for the study of frontal asymmetries than deficiencies in facial diameter. A frontal cephalogram may be used not only as a preoperative estimation of the transverse maxillary width but also as a complementary postoperative exam. The present results showed significant differences in maxillary width and MMTI between the control and pre-SARME groups and a significant increase in the post-SARME group suggesting a maxillary increase. The values for the latter group were close to those of the control group. Data on maxillary increase should be interpreted with care, as suggested by Byloff & Mossaz[5], who found a small and widely variable maxillary improvement, caused probably by translation of the two maxillary halves during expansion. Although showing an increase from pre- to post-SARME, the results for nasal width could be interpreted with little confidence due to their wide variance. Other studies[22] reported similar observations, reinforcing the importance of other methods to evaluate the nasal repercussion of orthodontic, functional orthopedic and surgical–orthognatic techniques.

Significant correlations among cephalometric and acoustic rhinometric variables were not observed in this study. This may suggest that the increase of the maxilla in the anterior region of the nose is not well observed in frontal cephalograms. Acoustic rhinometry was effective in showing this variation, reinforcing its importance to document rhinologic alterations in the treatment of maxillofacial deformities.

Several conclusions can be drawn from the results of this study. (1) The MCA measured by computed acoustic rhinometry, on the anterior most aspect of the nose, did not differ between individuals showing normal dentofacial patterns and those presenting maxillary transverse deficiency, both previous to and after SARME. In the posterior region, the MCA was smaller in patients showing transverse deficiencies, and a tendency to increase occurred after SARME. (2) The nasal volume did not differ between groups, in any of the areas of the nose. (3) The cephalometric measurements of maxillary width and MMTI were smaller in patients showing transverse deficiency than in normal individuals, with an approximation to normal values after SARME, and nasal width showed a large variation. (4) There was no correlation among cephalometric and rhinometric measurements.

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