Effects of surgically assisted rapid maxillary expansion on nasal dimensions using acoustic rhinometry

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Objective. The objective of this study was to evaluate the effects of surgically assisted rapid maxillary expansion (SARME) on nasal dimensions using acoustic rhinometry.

Study design. Twenty-seven patients ranging in age from 18 to 53 years were evaluated as having a maxillary transverse deficiency larger than 7 mm, a bilateral cross-bite, and no evidence of nasal obstruction. All patients underwent evaluation of the nasal cavity by acoustic rhinometry both before and 6 months after SARME. The Wilcoxon test was used to evaluate minor cross-sectional areas (MCA) and the nasal volume of the right and left nasal cavities, and these parameters were measured with and without the application of topical nasal decongestant before and after SARME.

Results. In comparison with preoperative measurements, minor cross-sectional areas and nasal volumes were significantly larger after SARME. There was a statistically significant difference associated with the use of nasal decongestant; the minor cross-sectional areas and nasal volume of the right and left nasal cavities were smaller when nasal decongestants were not used.


Transverse maxillary deficiency is clinically characterized by a uni- or bilateral posterior cross-bite, dental crowding, lingual oral inclination of the teeth, narrow dental arch shape, ogive palatum, and difficulty associated with nasal breathing. Other characteristics include nasal base narrowing, a deep nasolabial groove, and zygomatic and paranasal hypoplasia. Transverse maxillary deficiency occurs in isolated cases or is associated with vertical and sagittal dentofacial deformities.

Treatment for transverse maxillary deficiency involves the use of rapid maxillary expansion (RME) in patients who have not yet reached skeletal maturity. This treatment was proposed by Angell (1860) and consolidated by Haas (1961).

The treatment for adult patients with complete skeletal maturity consists of surgically assisted rapid maxillary expansion (SARME), which is accomplished by diminishing the bone’s resistance to palatal expansion via the use of osteotomies in the walls and pillars of the maxillary, as well as orthopedic devices (Haas or Hyrax) installed before surgery.

RME promotes enlargement of the nasal cavities and lowering of the palate. Patients presenting greater respiratory difficulty notice respiratory improvement, suggesting an increase in the intranasal space. The maxillary fragments move as the palatal mucosa moves downward, which levels the palate. The walls of the nasal cavity move laterally to increase its volume and, as a consequence, patients report improvements in breathing.

The methods used to evaluate the nasal cavity, which have been used for the purpose of making nasal obstruction a measurable symptom, range from questionnaires assessing quality of life to small procedures carried out during physical examination of the patient. With the purpose of estimating nasal resistance, exhaled condensed water vapor was analyzed by reflection of the vapor in a Glatzel mirror surface. The use of topical decongestants followed by anterior rhinoscopy and fiber-optic examinations makes it possible to cal-
alculate nasal permeability and geometry. However, this method is biased since the examination depends on the experience and impressions of the examiner and does not adequately quantify nasal obstruction.3,6

Complementary examinations, such as simple radiograph, computerized CT scan, or magnetic nuclear resonance imaging, have been used in an attempt to better evaluate nasal permeability. However, these procedures are not routinely performed because of their high financial costs. Additionally, these exams do not supply information regarding mucosal alterations.6

Acoustic rhinometry is a method used for studying nasal dimensions. It is a static test that obtains measurements independent of nasal airflow and provides information about nasal geometry. It is a quick, noninvasive method that is relatively simple to perform and requires minimal patient cooperation. In addition, it is used as an unbiased evaluation of the nasal cavity. It also allows the examiner to relate the cross-sectional area of the nasal cavity to the distance into the cavity. This method is based on analysis of acoustic wave reflection on the nasal cavity walls.6

Two investigators7,8 performing SARME and acoustic rhinometry have shown that these procedures reduce nasal airway resistance and increase nasal volume. Baraldi et al.9 did not find improvement in nasal airway resistance or nasal volume. Wriedt et al.7 observed improved nasal flow associated with an increase in nasal volume when comparing preoperative and post-SARME surgical values. Eighty patients underwent paramedian osteotomy of the palate, osteotomy of the maxillary zygomatic buttress, anterior wall of the maxillary sinus until the piriform opening without release of the pterygomaxillary suture. Babacan et al.8 found a significant mean volume increase with reduced nasal resistance in adult patients and children. The changes in nasal volume were similar in both groups, and they did not differ in a statistically significant manner with or without the use of topical nasal decongestant. The surgical procedure consisted of horizontal osteotomy, pterygomaxillary disjunction, and separation of the midpalatal suture and was performed under sedation and local anesthesia.

The objective of this study was to evaluate the effects of surgically assisted rapid maxillary expansion on the dimensions of the nasal cavity using acoustic rhinometry.

METHODS

This project was approved by the research and ethics committee of the Federal University of São Paulo.

Twenty-seven patients (11 male and 16 female) with maxillary transverse deficiency were submitted to SARME. The patients ranged from 18 to 53 years of age (mean: 28.03 years).

Patient operations were performed by the same surgeon at the Division of Plastic Surgery, Craniomaxillofacial Section, at the Federal University of São Paulo.

Patients in our study accepted the consent form before participation. Inclusion criteria were (1) maxillary transverse deficiency larger than 7 mm; (2) bilateral posterior cross-bite; and (3) no previous history of agenesis, nasal, or palatine surgery, or orthodontic treatments involving RME or SARME.

Patients with turbinate hypertrophy occupying more than half of the nasal vestibule lumen on each side, current use of topical or systemic medications for nasal obstruction, tumors, nasal polyps, lack of anterior septal deviation, septal perforation, craniofacial anomalies, or any chronic systemic disease were excluded from our study.

The physical examination comprised an inspection of the oral cavity and oropharyngeal surface under headlight illumination with the assistance of a tongue depressor. Anterior rhinoscopy was performed under headlight illumination with the assistance of a Cottle’s nasal speculum. The 27 patients used the expander appliance Hyrax, cemented by bands placed on the first upper premolars and first upper molars (Fig. 1).

All patients underwent general anesthesia and were submitted for the Le Fort I subtotal type osteotomy carried out by the same surgeon (M.D.P.). The osteotomy was performed in all walls, including the bilateral pterygomaxillary disjunction. After release of the midpalatal suture, the expansion device was activated by 8 quarter turns (i.e., 1.6 mm). The soft tissues were sutured at the same position. Beginning on the fourth postoperative day, patients were guided to activate the expansion screw with 2 quarter turns every day (1 quarter turn in the morning and 1 quarter turn at night).
until the planned expansion was achieved. Thereafter, the device was fixed with steel wire and retained for 4 months, at which time patients received a molar transpalatine bar.

**Acoustic rhinometry**

Acoustic rhinometry was performed by the same physician using the same Rhino Scan 2.5 model device (Rhinometrics Electronics, Assens, Denmark) (Fig. 2).

All 27 patients were submitted for an acoustic rhinometry examination before and 6 months after the end of SARME. Examinations were performed on patients seated with their heads supported during a respiratory pause. Patients were not allowed to speak or swallow during the examination.10

As indicated in the acoustic rhinometry standardization procedure, patients remained at room temperature (20 to 22°C) with a relative air humidity of between 40% and 55% for at least 20 minutes.11 The device was calibrated during this period according to the manufacturer’s instructions.

Rhinograms for the right and left nasal cavities were performed without decongestant and 10 minutes after the use of decongestant nasal spray. Two spurts of 0.5 mg/mL oxymetazoline chloridrate were used in each nostril.12,13

Initially, 5 pre-decongestant curves each for the right and left nasal cavities were obtained. Later, 5 post-decongestant curves each for the right and left nasal cavities were acquired. The mean of the 5 curves was obtained for all 108 preoperative rhinograms. The same procedure was repeated after SARME for the 27 patients (108 more rhinograms).

The graphs were analyzed to obtain the minor cross-sectional area (cm²), which is the smaller of the 2 cross-sectional areas irrespective of the structure represented. The volume of the nasal cavity was between 0 and 5.4 cm³ for the right and left nasal cavities, which were measured separately with and without nasal decongestant.

**Statistical analyses**

The Wilcoxon signed rank test was used to evaluate the preoperative and postoperative area and volume of the nasal cavities with and without decongestant.

To compare the values of the nasal area and volume with and without decongestant, the Wilcoxon signed rank test was used with the following formula:

\[ \Delta \% = \left( 1 - \left( \frac{\text{pre} - \text{post}}{\text{pre}} \right) \right) \]

The confidence level was stipulated as 5%.

**RESULTS**

There was a statistically significant increase in the minor cross-sectional area (MCA) and nasal volume (VOL) of the right and left nasal cavities 6 months after SARME with and without the use of decongestant (Tables I and II).

The increase in minor cross-sectional area (MCA) with decongestant was greater than that without decongestant for both the right and left nasal cavities (Tables III and IV).

The increase in nasal volume with decongestant was greater than that without decongestant for both the right and left nasal cavities (Tables V and VI).

**DISCUSSION**

Transverse maxillary deficiency can occur alone, but it is generally associated with alterations in the vertical and sagittal planes. When maxillary transverse deficiency is present in adults, the treatment of choice is SARME.1

RME and SARME2,3,6 can cause displacement of the maxilla. This widens not only the dental arch, but also the nasal cavity, leading to an increase in nasal permeability. Major deformities of the nasal cavity occur in the anterior part of the inferior turbinate and inferior meatus owing to their proximity to the bone. Therefore, the presence of stenosis in the nasal valve region can be favored by the expansion of the maxilla.13

Acoustic rhinometry, introduced by Hilberg et al.,6 is an objective method that evaluates nasal geometry through the use of sound waves. This noninvasive method is simple to perform and requires minimal cooperation of the patient. Since its description, it has been applied for pre- and postoperative evaluation of maxillary atresia.7-9,14,15

The 27 adult patients in this study ranged from 18 to 53 years of age (mean: 28 years, and 3 months). Our results are in accordance with those obtained by Betts et al.,1
who demonstrated that the transverse dimensions of the maxilla and mandible grow incrementally until 16 years of age.

Indication criteria for SARME were based on those by Betts et al. Diagnosis was based on clinical facial examination, radiographic (lateral and frontal cephalograms) examination, and stone cast study models. All patients were evaluated via acoustic rhinometry before surgery, before and after the use of topical vasoconstrictor, and reevaluated 6 months after SARME.

Postoperative acoustic rhinometry was carried out in all patients after removal of the expansion device, which was used for retention and maxillary stability.

The smaller area present in the right or left nasal cavity significantly increased with and without vasoconstrictor before and after surgery. These results are similar to those found by Wriedt et al. Baraldi et al. found that the MCA showed a tendency to increase after SARME but not statistically significantly. We infer that the significant increase in MCA means that (1) surgical manipulation affected the region of the nasal valve and (2) SARME promoted opening of the midpalatal suture in the antero-inferior region of the nasal cavity. Opening of the midpalatal suture was proven by computed tomography.

Table I. Minor cross-sectional area (MCA) in cm² and volume (VOL) in mm³ of the right (R) and left (L) nasal cavities, before expansion (Pre) and 6 months after expansion (Post) without the use of decongestant (SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean Pre</th>
<th>Minimum value Pre</th>
<th>Maximum value Pre</th>
<th>Mean Post</th>
<th>Minimum value Post</th>
<th>Maximum value Post</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R MCA</td>
<td>0.48</td>
<td>0.09</td>
<td>0.18</td>
<td>0.76</td>
<td>1.03</td>
<td>4.46*</td>
<td></td>
</tr>
<tr>
<td>L MCA</td>
<td>0.42</td>
<td>0.11</td>
<td>0.23</td>
<td>0.70</td>
<td>0.95</td>
<td>4.54*</td>
<td></td>
</tr>
<tr>
<td>R VOL</td>
<td>4.03</td>
<td>1.95</td>
<td>2.12</td>
<td>6.69</td>
<td>13.00</td>
<td>4.37*</td>
<td></td>
</tr>
<tr>
<td>L VOL</td>
<td>3.65</td>
<td>1.62</td>
<td>3.00</td>
<td>5.48</td>
<td>8.510</td>
<td>4.54*</td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon Test. MCA R PRE X POST (SD) MCA L PRE X POST (SD).

*P < .001. VOL R PRE X POST (SD) VOL L PRE X POST (SD).

Table II. Minor cross-sectional area (MCA) in cm² and volume (VOL) in mm³ of the right (R) and left (L) nasal cavities, before expansion (Pre) and 6 months after expansion (Post) with the use of vasoconstrictor (WD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean Pre</th>
<th>Minimum value Pre</th>
<th>Maximum value Pre</th>
<th>Mean Post</th>
<th>Minimum value Post</th>
<th>Maximum value Post</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R MCA</td>
<td>0.53</td>
<td>0.09</td>
<td>0.20</td>
<td>0.83</td>
<td>1.00</td>
<td>4.28*</td>
<td></td>
</tr>
<tr>
<td>L MCA</td>
<td>0.46</td>
<td>0.12</td>
<td>0.26</td>
<td>0.76</td>
<td>1.09</td>
<td>4.54*</td>
<td></td>
</tr>
<tr>
<td>R VOL</td>
<td>4.43</td>
<td>2.14</td>
<td>2.43</td>
<td>7.35</td>
<td>14.99</td>
<td>4.54*</td>
<td></td>
</tr>
<tr>
<td>L VOL</td>
<td>4.01</td>
<td>1.78</td>
<td>3.45</td>
<td>6.02</td>
<td>9.75</td>
<td>4.54*</td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon Test MCA R PRE X POST (WD) MCA L PRE X POST (WD).

*P < .001. VOL R PRE X POST (WD) VOL L PRE X POST (WD).

Table III. Percentage values of the minor cross-sectional of the right nasal cavity (RMCA) with decongestant (WD) and without decongestant (SD); percentage values were calculated from the pre-post/pre difference

<table>
<thead>
<tr>
<th>RMCA WD</th>
<th>n</th>
<th>Mean</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>41.83</td>
<td>0.00</td>
<td>142.42</td>
<td>-3,892*</td>
<td></td>
</tr>
<tr>
<td>RMCA SD</td>
<td>27</td>
<td>34.55</td>
<td>0.00</td>
<td>133.33</td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon test R MCA WD x R MCA SD.

*P < .001.

Table IV. Percentage values of the minor cross-sectional of the left nasal cavity (LMCA) with decongestant (WD) and without decongestant (SD); percentage values were calculated from the pre-post/pre difference

<table>
<thead>
<tr>
<th>LMCA WD</th>
<th>n</th>
<th>Mean</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>64.47</td>
<td>5.71</td>
<td>225.00</td>
<td>-4,541*</td>
<td></td>
</tr>
<tr>
<td>LMCA SD</td>
<td>27</td>
<td>46.85</td>
<td>2.33</td>
<td>209.09</td>
<td></td>
</tr>
</tbody>
</table>

Wilcoxon test L MCA WD x L MCA SD.

*P < .001.
were performed under sedation and local anesthesia.

maxillary dysjunction, and midpalatal suture separation) surgical procedures (i.e., horizontal osteotomy, pterygo-

and the training of the otorhinolaryngologist. The stud-

amount of rest time allowed during the measurements,

may be attributed to the fact that volume measurements

skeletal alterations.

The use of decongestant produced a statistically sig-

for evaluating the geometry of the nasal cavity in patients

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REFERENCES


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The total volume of the nasal cavity (calculated by adding the volumes of the right and left nasal cavities) with and without vasoconstrictor before and after the surgery ranged between 0 and 5.4 cm of anterior-posterior distance. There was a statistically significant increase in the distances in the right and left nasal cavities, which were similar to those demonstrated by Wriedt et al. and Babacan et al.

The use of decongestant produced a statistically significant difference in the volume of the nasal cavity. This finding again shows the responsiveness of the nasal mucosa to topical decongestant in the studied individuals. These results are in accordance with the values observed by Doruk et al. Babacan et al. found an increase in nasal volume with and without vasoconstrictor before and after SARME, but it was not statistically significant. This failure to reach significance may be attributed to the fact that volume measurements depend on factors like the position of the head, of the amount of rest time allowed during the measurements, and the training of the otorhinolaryngologist. The studied sample consisted of only 10 patients, and the surgical procedures (i.e., horizontal osteotomy, pterygopalatine suture, and midpalatal suture separation) were performed under sedation and local anesthesia.

Baraldi et al. found no differences in volume in this sample.

Table V. Percentage values of the right nasal cavity volume (RVOL) with decongestant (WD) and without decongestant (SD); percentage values were calculated from the pre-post/pre difference

<table>
<thead>
<tr>
<th>n</th>
<th>Mean</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVOL WD</td>
<td>27</td>
<td>59.97</td>
<td>5.00</td>
<td>318.14</td>
</tr>
<tr>
<td>RVOL SD</td>
<td>27</td>
<td>46.85</td>
<td>3.83</td>
<td>298.98</td>
</tr>
</tbody>
</table>

Wilcoxon test R VOL WD x R VOL SD. *P < .001.

Table VI. Percentage values of the left nasal cavity volume (LVOL) with decongestant (WD) and without decongestant (SD); percentage values were calculated from the pre-post/pre difference

<table>
<thead>
<tr>
<th>n</th>
<th>Mean</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVOL WD</td>
<td>27</td>
<td>64.94</td>
<td>0.50</td>
<td>216.29</td>
</tr>
<tr>
<td>LVOL SD</td>
<td>27</td>
<td>58.56</td>
<td>1.61</td>
<td>202.47</td>
</tr>
</tbody>
</table>

Wilcoxon test L VOL WD x L VOL SD. *P < .001.

Anterior portion of nasal turbinate. We used topical nasal decongestant to exclude the influence of mucosal lining variations and concentrate our study on skeletal alterations.

The total volume of the nasal cavity (calculated by adding the volumes of the right and left nasal cavities) with and without vasoconstrictor before and after the surgery ranged between 0 and 5.4 cm of anterior-posterior distance. There was a statistically significant increase in the distances in the right and left nasal cavities, which were similar to those demonstrated by Wriedt et al. and Babacan et al.

The use of decongestant produced a statistically significant difference in the volume of the nasal cavity. This finding again shows the responsiveness of the nasal mucosa to topical decongestant in the studied individuals. These results are in accordance with the values observed by Doruk et al. Babacan et al. found an increase in nasal volume with and without vasoconstrictor before and after SARME, but it was not statistically significant. This failure to reach significance may be attributed to the fact that volume measurements depend on factors like the position of the head, of the amount of rest time allowed during the measurements, and the training of the otorhinolaryngologist. The studied sample consisted of only 10 patients, and the surgical procedures (i.e., horizontal osteotomy, pterygo-maxillary dysjunction, and midpalatal suture separation) were performed under sedation and local anesthesia.

Baraldi et al. found no differences in volume in this sample.

CONCLUSION

Surgically assisted rapid maxillary expansion increases the minor cross-sectional areas and volume of the nasal cavities. The minor cross sectional areas and total volume of the nasal cavities were larger after the use of topical decongestant. Acoustic rhinometry is an objective method for evaluating the geometry of the nasal cavity in patients with transverse maxillary deficiency.


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