ORIGINAL ARTICLE

Changes in nasal volume after surgically assisted bone-borne rapid maxillary expansion

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Introduction: The purposes of this study were to detect, locate, and examine the changes in transverse nasal width, area, and volume from bone-borne, surgically assisted rapid maxillary expansion (SARME) with the Dresden distractor by using computer tomography (CT). **Methods:** Sixteen patients (average age, 28.7 years) underwent axial CT scanning before and 6 months after SARME. They also underwent CT fusion on specific bony structures. The nasal bone width was examined in the coronal plane. The cross-sectional images of the nasal cavity were taken of the area surrounding the apertura piriformis, the choanae, and in between. We calculated cross-sectional areas and nasal volume according to these data. **Results:** All but 2 patients had an increase in nasal volume of at least 5.1% (SD, 4.6%). The largest value of 35.3% (SD, 45.8%) was measured anteriorly on the nasal floor, decreasing cranially and posteriorly. This correlated with the V-shaped opening of the sutura palatina. There was no significant correlation between increase in nasal volume and transversal expansion. **Conclusions:** Because most of the air we breathe passes over the lower nasal floor, SARME is likely to improve nasal breathing. (Am J Orthod Dentofacial Orthop 2010;137:782-9)

Rapid maxillary expansion (RME) is indicated in treating transverse maxillary deficiency orthopedically. RME, with a history of more than 145 years, was introduced by Angell.[1] After initially falling into disrepute, it was reintroduced in the middle of the last century by Haas.[2]

Its primary goal is to maximize orthopedic and to minimize orthodontic tooth movements. Tooth-borne expansion appliances were used initially; they were banded or bonded at the maxillary first premolars and molars.

RME exerts high forces that can easily split the midpalatal suture in young patients, forcing the maxillary halves apart.[3,4] Separation becomes difficult after the midpalatal suture interlocks in late adolescence and even more difficult after fusion in adults because synchondrosis does not occur.[5] But the greatest resistance associated with palatal expansion is because of the progressive ossification and thus increased rigidity of the entire viscerocranium.[6] Consequently, in adults, preference is given to presurgical bilateral osteogenesis and fracture of the midpalatal suture. In these patients, the expansion procedure is based on distraction osteogenesis after surgical assistance.

There are reports of loss in vitality, extrusion, root resorption, buccal attachment loss, and serious tipping of the anchor teeth associated with tooth-borne RME.[2,3,7,8] Presurgical osteotomy cannot completely eliminate these negative side effects.[9] An alternative to the tooth-borne procedure is bone-borne fixation of the hyrax screw to the palatal bone with no interference of the teeth.

The bone-borne Dresden distractor (DD) has proved to be an effective device that prevents the negative side effects associated with tooth-borne RME.[10]

Several experimental and clinical studies show no orthodontic advantages of RME, such as correction of dental crossbites only.[2,11-13] RME also eliminates the effects of nasal obstruction on facial form, reduces the susceptibility to infections, and often leads to improved nasal breathing.[12-19]

RME and surgically assisted RME (SARME) cause not only dentofacial but also craniofacial structural changes such as enlargement of the nasal cavity width[8,12,13,20-22] and nasal volume.[8,13,15,16,19,20,23]

The traditional explanation for the influence of RME and SARME on the nasal cavity is based on the separation of the nasal cavity's lateral walls. The increase in the distance between the nasal cavity's lateral walls enlarges the cross-sectional area and increases nasal volume, facilitating breathing. Transverse maxillary

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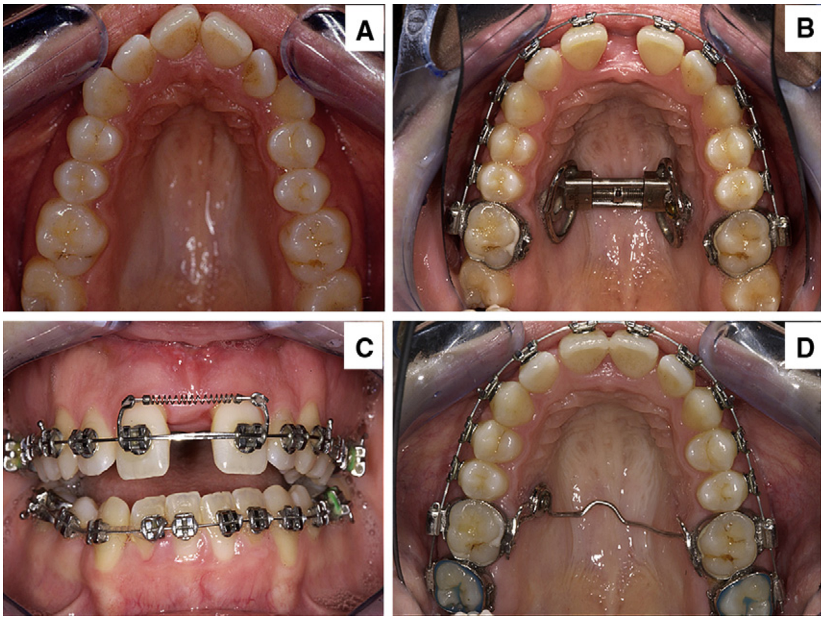

Fig 1. A, Initial diagnosis of a 24-year-old patient with maxillary transverse narrowness and open bite; **B,** DD in place, directly fixed to the bone with an implant (*left*) and osteosynthetic screw (*right*), appearance of a central diastema, and expansion of 8 mm after 12 days; **C,** anterior guidance of the maxillary halves by using crossed segmented archwires and a coil spring for symmetric space opening; **D,** implant-borne transpalatal arch for transversal, sagittal, and vertical anchorage.

deficiency can reduce nasal dimensions and cause mouth breathing.

Documented evidence is still lacking of the effects of surgically assisted bone-borne dental arch expansion and associated transversal nasal airway dimensions on the number and location of the changes. Intercanine and intermolar width changes due to orthodontic treatment that would be relatively easy to measure cannot be extrapolated to changes in human nasal airway dimensions.[15]

Evaluation of the nasal cavity became possible with lateral and posteroanterior cephalometric radiography.[24] Although these methods were useful in determining obstructions in the nasal and pharyngeal areas, they are inadequate for measuring nasal resistance, airflow, and nasal area dimensions.

Rhinomanometry is another method to characterize nasal respiration objectively.[25] From the applied data, we can derive an airway-resistance value from the airflow and the minimum cross-sectional area of the nasal airway—ie, the nasal valve.

Acoustic rhinometry (AR) was introduced by Hilberg[26] in 1989 as a simple, painless, noninvasive, and reliable method for measuring the cross-sectional area and nasal cavity volume.

In dentistry, computed tomography (CT) has stood the tests for localizing displaced teeth, implant planning, difficult endodontic and complex surgical issues, and various applications in orthodontics.[27] Timms et al[28] first used CT to assess bone changes associated with RME.

The purposes of this study were to examine and detect the increases in transversal nasal width and the changes in nasal area and volume from bone-borne SARME with the DD by using CT.

MATERIAL AND METHODS

Sixteen patients (6 male, 10 female) from 17 to 36 years of age (mean, 28 years 8 months) underwent SARME with the DD. There were no dropouts or appliance failures. Initial diagnostic findings in all patients showed maxillary transverse constriction combined with Class II or Class III malocclusion or open bite, and no previous history of nasal disease (Fig 1, *A*).

All patients underwent an axial spiral CT scan with the Somatom Sensation 16 (Siemens, Forchheim, Germany).

The scans were taken immediately before (T1) and an average of 6 months (SD, 2.5) after (T2) a bone-borne implant-supported RME device with the DD was placed.

The patients were positioned so that the occlusal plane was perpendicular to the horizontal plane. The area imaged was between margo infraorbitalis cranially and gnathion caudally. The image data were then converted into axial layers 0.5 to 0.8 mm thick. Three-dimensional (3D) reconstructions, image fusions, and measurements were done on workstations by using a software program (Syngo VX49B image fusion, Leonardo workstation VD10B, Siemens).

The CT scans were originally produced for the 3D evaluation of the DD's effects on skeletal structures and teeth.[10]

The surgical assistance according to Glassman et al[3] and expansion-appliance placement were done during 1 operation with the patients under general anesthesia.

According to the method of Glassman et al,[3] a bilateral osteotomy of the lateral walls of the maxillary sinus was performed 5 mm from above the apices of the apertura piriformis toward the pterygomaxillary fissure to break the resistance of the maxillary tuberosity and the contact between the maxilla and the zygomatic bones.[29,30] To prevent irregular fractures of the alveolar ridge of the maxillary central incisors, we "preformed" the premaxilla above the central incisors with a chisel.

It was unnecessary to split the midpalatal suture surgically. The hyrax screw was activated intraoperatively to monitor the amount of surgical assistance required.

The expansion appliance consisted of a hyrax screw (Forestadent, Pforzheim, Germany) directly attached to the hard palate on 1 side with an implant (EO implant, Straumann, Freiburg, Germany; length, 4.0 mm; diameter, 3.5 mm; diameter of abutment, 5 mm) and with a self-drilling osteosynthesis miniscrew (Martin, Tuttlingen, Germany; length, 9-13 mm) on the other side. It was positioned between the roots of the second premolar and the first molar (Fig 1, *B*).

The distraction device was attached only on 2 points, although a physical, parallel movement of the maxillary halves took place. Segmented archwires with a tension coil spring in the anterior part of the vestibule were used to open space in the incisor region with a 3-point support (Fig 1, *C*). We thus incorporated the multi-bracket appliance for preparation, just before the SARME with the DD.

Three days after surgery, the patients were told to activate the screw 4 times a day (twice in the morning, twice in the evening) for 8 days (± 2 days) with 29 quarter rotations (24-36) of 0.25 mm each, for an average expansion of 7.25 mm.

The planned expansion was achieved with some overcompensation (0.5-1 mm) to neutralize the tooth-tipping effect and prevent relapse. The appliance was kept in place for 3 to 6 months to permit bone mineralization. After removing the expansion device, the implant was left in place and used for further retention and anchorage (Fig 1, *D*).

The transverse dimension measurements and the CT-Osteo-3D-Fusions of the CT scans were taken by 1 person. The CT images and their evaluation were standardized.

Each patient's T1 and T2 CT scans were superimposed by using specific anatomic superimposition points: the foramen spinosum left and right (circumference), the anterior margin of the foramen magnum, and ELSA (the intersecting point of the line connecting the 2 foramina spinosa) (Fig 2, *A*).[31] We located and superimposed them using sagittal, coronal, and transversal reference levels (Fig 2, *B*).

T1 and T2 bony nasal widths between the lateral walls of the nasal cavity were examined in the coronal plane starting from the nasal floor upward in 3-mm steps ($W_1 \ldots W_k$). The height ranged from nasal floor (height 0) to the highest measurable nasal width.

The cross-sectional images of the nasal cavity were taken in the anterior vicinity of the apertura piriformis, behind the choanae region, and in between (Fig 3).

To calculate nasal volume, we took transverse measurements as described above. Using this data, we calculated the 3 cross-sectional areas of the front (A_{ant}), middle (A_{mid}), and back (A_{post}) ($A = 0.5^*[W_1 \ldots W_k]^*\text{height}$).

The distance between these figures (X_1, X_2) was used as a third dimension to determine the skeletal nasal volume (V): $V = 0.5^*([A_{ant} + A_{mid}]^*X_1 + [A_{mid} + A_{post}]^*X_2)$. All cross-sectional areas and volumes of each patient were calculated before and after expansion with the DD (Excel, Microsoft, Redmond, Wash).

The data were analyzed with Excel. We measured each patient's 3 cross-sectional areas and nasal volume and then calculated the mean values and standard deviations in our sample to identify differences in areas and volumes between T1 and T2.

Stochastic error was monitored, since 1 investigator (W.D.) repeated a patient's CT-Osteo-3D-Fusion and retook the measurements of the T1 and T2 CT scans 15 times to determine the reproducibility of the linear nasal transversal measurements. The extension of the stochastic error of 1 linear measurement into the calculated volumes was considered to estimate their statistical significance.

The nonparametric paired Wilcoxon signed rank test was used to assess the statistical significance of width and cross-sectional areas before and after expansion. The level of significance was set at $P < 0.05$.

The *t* test ($\alpha < 0.05$) was used to determine the correlation between transversal expansion of the DD and transversal dimension changes in the nose.

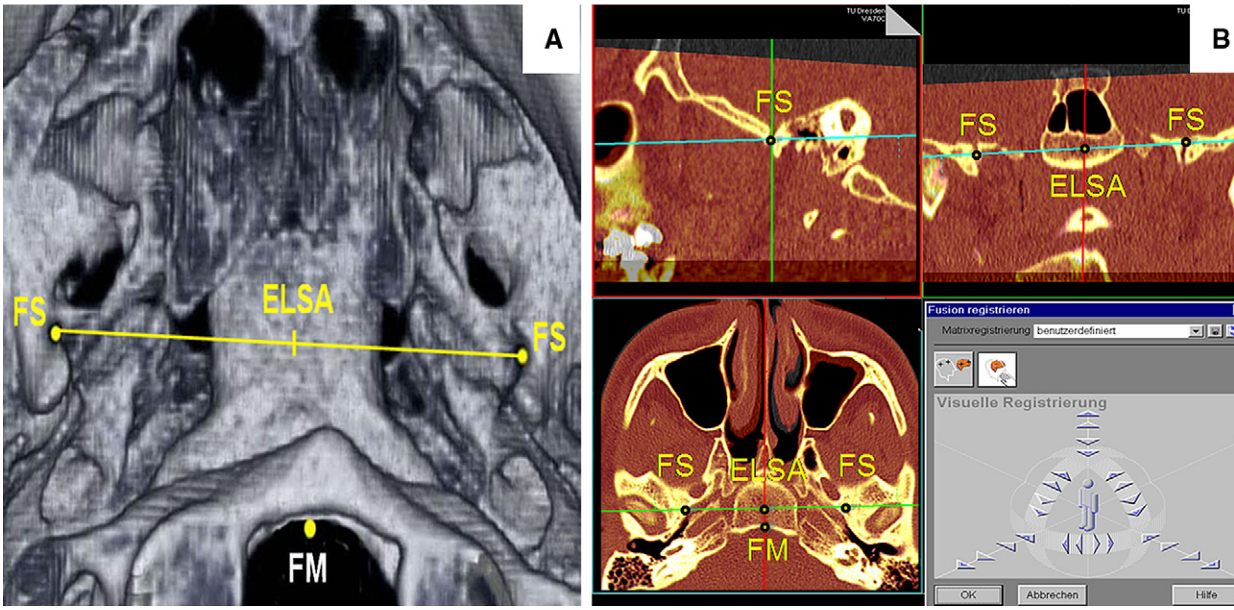

Fig 2. A, Superimposition points: foramina spinosae (*FS*) and ELSA, the anterior margin of the foramen magnum (*FM*); **B,** CT-Osteo-3D-Fusion of T1 and T2 CT scans by using the reference points with the help of the sagittal, coronal, and transverse reference levels.

RESULTS

The stochastic error of 1 transversal measurement was 0.06 cm ($P < 0.05$). All T1 vs T2 transverse dimensions and cross-sectional area measurements showed high significance ($P < 0.05$) according to the paired Wilcoxon signed rank test.

Because of the mathematical calculation of the cross-sectional areas and nasal volume of the transverse nasal cavity dimension, there was a direct correlation between them. Consequently, the change of cross-sectional areas and nasal volumes correlated directly or indirectly with changes of transverse cavity dimensions.

The transverse nasal cavity dimension changes and thus also the nasal volume enlargement decreased from the nasal floor in the cranial and dorsal directions (Fig 3).

The largest expansion, 35.3% (SD, 45.8%), was observed on the anterior nasal floor (Table I). We observed relative and absolute differences in width, particularly in the transversal plane.

The average increase in the coronal cross-sectional area decreased from anterior to posterior according to the transverse measurements (Fig 3).

The anterior cross-sectional area increased significantly by 8.1% (SD, 12.3%) as did the middle by 3.6% (SD, 3.6%) and the posterior by 2.1% (SD, 1.9%).

Total expansion amounts were 59% in the anterior, 26% in the middle, and 15% in the posterior regions (Table II).

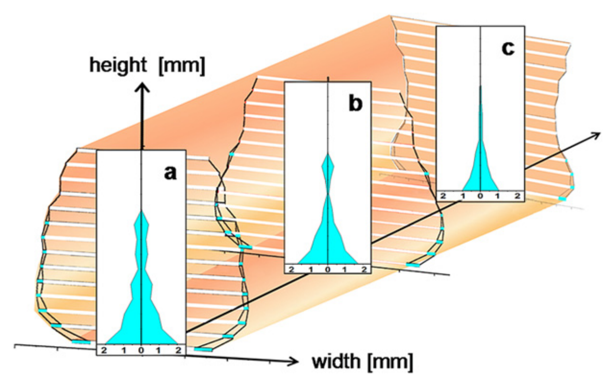

Fig 3. Average transversal width, cross-sectional area, and volume increases: apertura piriformis (*a*), choanae (*c*), bony nose in between (*b*).

We observed great interindividual variability among the changes in volume, between –1.5% and 12.8% (Table III). Fourteen patients showed an average 6.0% (SD, 4.1%) increase in nasal volume. Nasal volume fell by 1.5% (SD, 0.1%) in just 2 patients.

Average nasal volume increased absolutely by 0.74 cm^3 (SD, 0.66 cm^3) and relatively 5.1% (SD, 4.6%). Only 10 of 16 patients had a significant change in volume.

We noted no correlations between changes in nasal volume and amount of transversal expansion of the DD.

Table I. Transverse dimension measurements

	Height (mm)	Mean width (cm)		T2-T1			
		T1	T2	cm	SD (cm)	%	SD (%)
Anterior	39	1.53*	1.53	0	0	0	0
	36	1.78*	1.78*	0	0	0	0
	33	1.91*	1.91*	0	0	0	0
	30	1.92*	1.92*	0	0	0	0
	27	2.17*	2.17*	0	0	0	0
	24	2.18*	2.26*	0.08*	0.20*	2.99*	7.92*
	21	2.29*	2.34*	0.05*	0.15*	1.84*	5.94*
	18	2.26*	2.32*	0.07*	0.14*	2.70*	5.50*
	15	2.34*	2.38*	0.04*	0.13*	1.72*	5.30*
	12	2.34*	2.46*	0.12*	0.35*	9.46*	30.14*
	9	2.38*	2.48*	0.10*	0.24*	5.27*	12.84*
	6	2.25*	2.44*	0.19*	0.22*	8.29*	9.04*
	3	1.90*	2.13*	0.23*	0.30*	12.97*	17.12*
	0	1.23*	1.64*	0.41*	0.47*	35.29*	45.79*
Middle	39	1.99*	1.99*	0	0	0	0
	36	2.13*	2.13*	0	0	0	0
	33	2.35*	2.35*	0	0	0	0
	30	2.36*	2.36*	0	0	0	0
	27	2.39*	2.39*	0	0	0	0
	24	2.53*	2.53*	0	0	0	0
	21	2.72*	2.79*	0.07*	0.09*	2.46*	2.90*
	18	2.85*	2.88*	0.03*	0.08*	0.88*	2.75*
	15	3.04*	3.04*	0.01*	0.02*	0.30*	0.81*
	12	3.16*	3.21*	0.05*	0.06*	1.45*	2.06*
	9	3.17*	3.24*	0.07*	0.10*	2.13*	2.93*
	6	3.06*	3.21*	0.15*	0.18*	4.62*	5.44*
	3	2.80*	3.01*	0.20*	0.31*	6.79*	11.21*
	0	2.21*	2.57*	0.35*	0.35*	15.18*	15.64*
Posterior	36	3.00*	3.00*	0	0	0	0
	33	2.83*	2.83*	0	0	0	0
	30	2.84*	2.84*	0	0	0	0
	27	2.60*	2.60*	0	0	0	0
	24	2.57*	2.58*	0.01*	0.02*	0.42*	1.02*
	21	2.47*	2.48*	0.01*	0.01*	0.26*	0.61*
	18	2.49*	2.51*	0.02*	0.08*	0.49*	2.53*
	15	2.49*	2.52*	0.02*	0.04*	0.86*	1.57*
	12	2.59*	2.61*	0.02*	0.06*	0.78*	2.41*
	9	2.81*	2.87*	0.06*	0.07*	2.11*	2.56*
	6	2.98*	3.06*	0.08*	0.07*	2.72*	2.33*
	3	2.98*	3.09*	0.12*	0.11*	3.83*	3.50*
	0	2.61*	2.82*	0.21*	0.23*	8.04*	9.41*

*$P < 0.05$.

Table II. Cross-sectional area measurements

	Anterior		Middle		Posterior	
	Mean	SD	Mean	SD	Mean	SD
T2-T1 absolute (cm^2)	2.9*	3.2*	2.1*	2.0*	1.1*	0.9*
T2-T1 relative (%)	8.10*	12.3*	3.60*	3.6*	2.10*	1.9*
Change (%)	59*		26*		15*	

*$P < 0.05$.

Table III. Volume measurements

Patient	T1 (cm^3)	T2 (cm^3)	T2-T1 (cm^3)	T2-T1 (%)
1	17.96*	18.74*	0.77*	4.3*
2	13.44*	15.16*	1.72*	12.8*
3	22.83	23.03	0.21	0.9
4	19.61*	21.01*	1.40*	7.2*
5	14.20	14.58	0.38	2.7
6	18.85	19.02	0.17	0.9
7	15.88*	17.43*	1.55*	9.8*
8	21.08*	22.93*	1.84*	8.7*
9	12.66*	13.29*	0.63*	5.0*
10	11.93*	12.86*	0.93*	7.8*
11	22.53	22.22	−0.31	−1.4
12	8.87*	10.01*	1.14*	12.8*
13	8.38	8.25	−0.13	−1.5
14	10.71	10.81	0.10	1.0
15	10.70*	11.49*	0.79*	7.3*
16	20.47*	21.09*	0.62*	3.0*
Mean	15.63	16.37	0.74	5.1
SD	4.90	4.94	0.66	4,6

*$P < 0.05$.

DISCUSSION

The bone-borne DD has proved to be effective for preventing the negative side effects associated with tooth-borne RME such as extrusion, loss of pulp vitality, root resorption, bony dehiscence, and buccal tipping of the anchor teeth.[10]

Tooth- and bone-borne RME including surgical assistance seem to result in similar skeletal changes. But there is a difference in how the palatal suture opens. When the tooth-borne method is used, the expansion force is reduced by the periodontal ligament's shock-absorber function. Therefore, it is necessary to overcompensate to neutralize the tooth-tipping effect and prevent relapse. With the bone-borne method, the expansion force leads to immediate opening of the palatal suture without the tipping side effects.

Furthermore, the comparison of the orthodontic and orthopedic effects—alveolar bone tipping and dental tipping—between the 2 types of SARME in the bone-borne method with the DD, in contrast to the tooth-borne method, showed greater expansion in the premolar and molar regions measured at the alveolar bone rather than at the teeth.

This can be attributed, on the 1 hand, to the direct transfer of expansion forces to the palatal bone bypassing the teeth and, on the other hand, to the lingual torque effect of the rectangular wires in the straight-wire bracket slots.[10]

We used CT because of its precision for measuring nasal cavity enlargement after RME. Two-dimensional imaging with a frontal or lateral cephalogram has

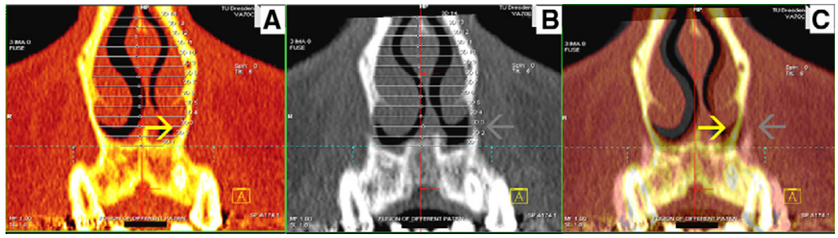

Fig 4. Three-dimensional depiction of the morphologic changes in a 24-year-old patient near the apertura piriformis at T1 and T2 of a bone-borne RME with the DD: **A,** CT scan at T1 (*yellow arrow*); **B,** CT scan at T2 (*arrow* shows growth); **C,** superimposition of CT scans from T1 and T2 (*yellow* and *grey arrows* show CT-Osteo-3D-Fusion).

Table IV. Literature review: Change of nose volume

Study	*Change of nose volume*	*Expansion method*	*Examination method*
This study	0.73 cm^3, resp 5.1%	SARME	CT
Babacan et al[23]	3 cm^3, resp 17.86%	SARME	AR
Wriedt et al[19]	0.8 cm^3, resp 23.3%	SARME	AR
Kunkel et al[16]	0.7 cm^3, resp 18.4%	SARME	AR

Resp, Respiration.

limited use in assessing 3D structures and their movements.[31] Other drawbacks of conventional x-rays are loss of information,[32] overlay effects, projection errors, and artefacts.[33] CT allows visual registration in all 3 dimensions without magnification or distortion.[31]

Moreover, with the CT-Osteo-3D-Fusion, it was easier to locate the measuring points and compare intra-individual changes in 3 dimensions (Fig 4).

The CT method has been used in several studies to monitor the reliability of AR for evaluating nasal airway volume. Doruk et al[34] used both methods to compare nasal cavity geometry and reported no significant differences, whereas Gilain et al[35] and Min and Yang[36] found that measurements in cross-sectional areas were similar only in the anterior nasal cavity. They found no correlation between AR and CT in the posterior part of the nose. In other words, AR failed to permit precise 3D evaluation of the nasal cavity.

Another advantage of measuring the nasal bone is that soft-tissue effects such as cyclic nasal mucosa swelling, nasal polyps, mucosal hyperplasia, allergic rhinitis, and infectious swelling of the nasal cavity can be seen.

Tooth-borne SARME studies with AR reported volume increases between 17.9% and 23.3% (Table IV).[16,19,23] Their expansion results appear to be higher than ours (5.1%). This difference is due to divergent volume measurements. In our procedure, the 15.6 cm^3 reference value reflects the skeletal nose's greater volume, and, when the nasal soft tissue is measured with AR, its reference value is smaller (3.8 cm^3).[19,23] These facts demonstrate the reliability of CT-Osteo-3D-Fusion when measuring changes in skeletal width.

The main results of this study provide evidence that changes occur especially in the transversal plane because the expansion device was most effective on that plane. This finding concurs with those of Wertz and Dreskin[21] and Sandikcioglu and Hazar.[37]

The increase in volume of 0.41 cm^3, or 35.3%, was concentrated in the anterior nasal floor because of the V-shaped horizontal opening movement of the maxillary halves; this also concurs with previous studies.[2,8,11,12,22] The center of rotational of movement of the maxillary halves is located in the dorsal area of the median palatal suture at the level of the third molars (Fig 5, *A*).[11,38]

There is also a V-shaped opening that becomes smaller in the cranial direction in the frontal plane as described in other studies with SARME.[8,11,37] We found the center of rotation in the frontonasal suture area (Fig 5, *B*).[8,12,38] We also observed a ratio of 2 to 1 (0.41-0.21 cm) concerning the nasal floor opening near the apertura piriformis compared with the choanae. The V-shaped opening also becomes apparent when examining the anteroposterior expansion of the nasal cavity: anterior (59%), middle (26%), and posterior (15%). In contrast, a parallel opening of the median suture has been reported.[6,16]

Closing times vary greatly, according to Persson and Thilander.[5] They reported that ossification proceeds from the nasal to the oral areas, and from posterior to anterior, whereas complete ossification does not usually occur in the frontal position. This might restrict expansion and cause rotation.

But the reason for the V-shaped opening is the progressive ossification of the entire viscerocranium and not primarily the palatal suture synostosis.[6]

Fig 5. A, Frontal view: V-shaped rotation of the maxilla after RME with the rotational center near the frontonasal suture; **B,** horizontal view: V-shaped opening of palatum durum after RME, with the rotational center near the third molar.

The main resistance is in the pterygo-, zygomatico- and frontomaxillary sutures, which in turn influence the position of the centers of rotation.[29]

Variations in resistance in the cranial base correlate to morphologic features and the degree of surgical preparation—ie, the various effects of surgical weakening. Thus, as the maxilla gradually separates from the surrounding structures, the expansion forces (resistance) in those areas are also reduced.

The surgical assistance in this study consisted of splitting the maxilla in the anterior part without a down fracture, as in a LeFort I osteotomy.[3] The maxilla remained connected with the dorsal cranial base in the processus pterygoideus. The advantages of incomplete surgical separation of the maxilla are improved blood supply and less risk of uncontrolled bleeding and asymmetric opening.

Variations in resistance cause the centers of rotation to assume different positions during palatal suture opening (Fig 5).

Assuming an identical expansion distance between the maxillary teeth after RME, the more the center of rotation of the maxillary halves moves in the posterior and cranial directions, the greater the increase in nasal volume.

The intraindividual volume changes had great variations, between –1.5% and 12.8% (SD, 4.6%). This was due to differences in resistance and morphology. Hartgenik et al[15] and Berretin-Felix et al[39] made similar findings for tooth-borne RME.

In our study, nasal volume increased significantly in most subjects (10 of 16) by 5.1% on average. Volumetric expansion occurred in the lower anterior nasal cavity, especially where the nasal valve is located. This is the narrowest and most flow-resistant region.[40] According to Wriedt et al[19] and Koudstaal et al,[41] improvement in nasal breathing correlates with enlargement of the nasal valve.

Thus, the improvement in nasal breathing depends on the position of the obstruction. Minor changes in the nasal valve region cause disproportionately large changes in nasal resistance, whereas large changes in the posterior nasal cavity lead to disproportionately small changes in nasal resistance.[42] Another study showed that even the smallest changes in nasal cross-sectional areas can cause a relatively high reduction in respiratory airway resistance.[18]

These facts led us to assume that our study patients will experience improvement in nasal breathing if the obstruction is in the anteroinferior region of the nasal cavity and not at the level of pharynx. Consequently, the localization of etiologic factors—ie, stenosis—should be considered when planning treatment. To verify this hypothesis of the action of SARME with the DD on nasal breathing, further studies are needed.

CONCLUSIONS

1. With the bone-borne DD, the expansion force causes the immediate palatal suture to open without the negative side effects associated with tooth-borne expansion appliances such as buccal tipping of the teeth.
2. CT-Osteo-3D-Fusion permits 3D assessment of skeletal changes in the nose.
3. Despite high resistance from the basal cranium to the expansion forces, nasal volume increases especially in the anterior area of the nasal floor. This is due to the V-shaped opening of the palatal suture in the horizontal and frontal planes.
4. The actual rotation centers are located in the dorsal area of the median palatal suture and near the frontonasal suture.

We expect that most of our patients will experience improved nasal breathing.

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