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Changes in the nasal airway and nose morphology after miniscrew-assisted rapid palatal expansion in young adults

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감사의 글

본 학위논문이 나오기까지 교정학에 첫 발을 내딛게 도와주시고 학문적인 부분뿐 아니라 인생의 큰 가르침을 주신 박영철 명예 교수님, 세심한 지도와 많은 가르침을 주신 최윤정 교수님, 그리고 따뜻한 격려와 언제나 지혜로운 조언으로 이끌어주신 유형석교수님께 진심으로 감사 드립니다. 또한 제가 교정학에 몸을 담고 배울 수 있는 기회를 주신 백형선 명예 교수님, 황충주 교수님, 김경호 교수님, 이기준 교수님, 차정열 교수님, 정주령 교수님, 그리고 최성환 교수님께도 깊이 감사 드립니다.

바쁘고 힘들 수 있었던 의국 생활에서 웃음을 주고 힘이 되어준 동료 서승원, 서희주, 송한솔, 한병희, 한송이 선생, 그리고 치과대학의 긴 시간 동안 언제나 함께하고 믿고 의지할 수 있었던 이상희, 왕서미 선생에게도 깊은 감사를 드립니다. 뿐만 아니라 의국 선배로서 많은 도움과 실질적인 조언을 아낌없이 해준 이영우 선생님, 임현묵 선생님, 그리고 화목한 섹터 분위기와 여러 도움을 준 의국후배 김규남, 한서연, 정희규 선생에게도 감사의 마음을 전합니다.

마지막으로 어떠한 길을 가더라도 한결같이 응원해주며 아낌없는 지지를 보내주신 어머니와 아버지께 깊은 감사의 마음을 전합니다. 제가 가는 길을 격려해주신 시부모님, 늘 변함없이 든든한 남편과 사랑스러운 윤재와 이 기쁨을 함께 나누고 싶습니다.

2018년 저자 씀

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Abstract

Changes in the nasal airway and nose morphology after miniscrew-assisted rapid palatal expansion in young adults

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Department of Dentistry

(Directed by Professor Hyung-Seog Yu, D.D.S., M.S., Ph.D.)

Maxillary expansion can affect hard and soft tissue of nasomaxillary complex as well as teeth. We evaluated changes in the volume and cross-sectional area of the nasal airway after nonsurgical miniscrew-assisted rapid palatal expansion (MARPE) in young adults. Furthermore, we measured changes in the nose width and height after MARPE.

Fourteen patients (mean age, 22.7 years; 10 women and 4 men) with a transverse discrepancy who underwent cone beam computed tomography (CBCT) before (T0), immediately after (T1), and 1 year after (T2) nonsurgical MARPE were included in this study. Three landmarks [anterior nasal spine (ANS), choanae, and the third cervical vertebra (C3)] and four reference planes (two horizontal and two vertical) were used as landmarks to obtain measurements for volume and area. Seven landmarks and six linear distances were used to measure the nose.

The volume of the nasal cavity and nasopharynx, the cross-sectional area of the anterior, middle, and posterior segments of the nasal airway, and the nose width and height were measured and compared among the three time points using paired *t*-tests.

The volume of the nasal cavity showed a significant increase at T1 and T2 ($P < 0.05$), while that of the nasopharynx increased only at T2 ($P < 0.05$). The anterior and middle cross-sectional areas significantly increased at T1 and T2 ($P < 0.05$), while the posterior cross-sectional area showed no significant change throughout the observation period ($P > 0.05$).

Overall width and height of the nose and nostrils did not change significantly. Nose height decreased immediately after MARPE, but it was recovered to the initial height one-year after expansion. The width of the nose increased 1.2 mm during T0-T2 ($P < 0.05$). There were no differences for other measurements during T1-T0, T2-T1, and T2-T0 ($P > 0.05$).

Our results demonstrate that the volume and cross-sectional area of the nasal cavity increased after MARPE and were maintained at 1 year after expansion. Therefore, MARPE may be helpful in expanding the nasal airway. Furthermore, the width of the nose was the only measurement that showed significant changes one year after MARPE, although the amount was clinically insignificant. This result suggests that MARPE has little clinical effects on the morphology changes of the nose and nostrils.

Key words: miniscrew assisted rapid palatal expansion(MARPE), cone beam computed tomography(CBCT), expansion, nasal airway, nose width and height

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I. Introduction

Rapid palatal expansion (RPE) is an orthodontic treatment modality for correcting transverse discrepancy. However, in adults, conventional RPE can produce side effects such as buccal crown tipping, root resorption, failure of suture separation, and marginal bone loss.(Rungcharassaeng et al., 2007) To minimize these undesirable effects, expansion of the basal bone would be required.

Miniscrew-assisted rapid palatal expansion (MARPE) in adult was introduced by Dr. KJ LEE et al. in 2008.(Lee et al., 2010) The MARPE appliance maximizes skeletal expansion and minimizes dental side effects. According to the recent study, MARPE can be a clinically acceptable and stable treatment modality for maxillary constriction in young adults.

Patients with maxillary constriction tend to have narrow airways compared with normal individuals.(Seto et al., 2001) As V-shaped expansion of the maxilla directly affects the nasal floor, the nasal cavity volume would change after the expansion.(Deeb et al., 2010; El and Palomo, 2014) In previous studies, it was found that maxillary expansion through conventional RPE contributed to an increase in the airway volume in children with obstructive sleep apnea (OSA).(Villa et al., 2014; Villa et al., 2011) Adults with OSA have also shown maxillary constriction; however, it remains unclear whether maxillary constriction is a primary etiological factor for OSA.(Souki et al., 2009)

An increased airway volume of the nasal cavity has also been reported in adults treated with surgically assisted rapid palatal expansion (SARPE),(Nada et al., 2013; Wriedt et al., 2001) although the clinical significance of this finding is considered questionable because of measurement errors associated with the acoustic rhinometry(AR) technique and variability in individual response.(Kunkel and Hochban, 1994) Furthermore, because a surgical procedure can affect the airway volume, the findings of SARPE cannot be directly applied to MARPE. Children are also different from adults in that they continue to grow. Therefore, additional studies are necessary for the accurate evaluation of airway changes after MARPE in adults.

Even though the nasal cavity is directly affected by maxillary expansion, three-dimensional (3D) research is lacking, and most studies have focused on the pharyngeal airway because of technical difficulties in obtaining nasal cavity measurements.(Chang et al., 2013) The complex structure of the nasal cavity is more accurately observed on 3D images than on two-dimensional (2D) images. It is difficult to measure volumetric dimensions and changes in various cross-sectional areas using lateral or posteroanterior (PA) cephalograms.(El and Palomo, 2014)

There are studies that RPE affects appearance of the face in children. It affects hard and soft tissues around the nose. Some researches correlated the nasal soft tissue changes with changes in skeletal nasal width using cephalograms. (Berger et al., 1998) Most studies reported the effect of RPE on soft tissue using two-dimensional techniques such as lateral cephalograms and frontal photo by direct measurements.(Berger et al., 1999; Johnson et al., 2010) However, CBCT images can be used to measure 3D changes more accurately that are difficult with landmark identification. The errors caused by direct measurement could reduce using CBCT.

From the above perspectives, CBCT was used to evaluate the null hypothesis that 1) the volume and cross-sectional area of the nasal cavity and nasopharynx would not show significant differences before, immediately after, and 1 year after MARPE, and 2) there is difference in measurements of the nose width and height before, immediately after, and 1 year after MARPE in young adults.

II. Materials and methods

1. Subjects

Data for 14 patients (10 women, 4 men) who had undergone MARPE at the Department of Orthodontics, Yonsei University Dental Hospital between January 2012 and December 2015 were retrospectively collected. The mean age of patients was 22.7 ± 3.3years (range, 18.3-26.5 years). The inclusion criteria were as follows: young adults (>18 years of age) with a transverse discrepancy,(Vanarsdall, 1999) successful opening of the midpalatal suture, non-extraction treatment, and availability of CBCT images obtained before expansion (T0), immediately after expansion (T1), and 1 year after expansion (retention period; T2), with a field of view(FOV) covering the entire nasal cavity. The exclusion criteria were as follows: a history of orthodontic treatment, requirement of orthognathic surgery, presence of craniofacial anomalies or systemic diseases.

In the evaluation of the nose width and height after MARPE, the number of samples reduced because the tip of the nose was not exactly visible on the CBCT in some patients. The additional inclusion criteria in the nose study were as follows: identification of all soft tissue landmarks. Therefore, only ten patients were involved in second study. (mean age, 21.5; 5 females, 5 males).

The MARPE appliance was fabricated by modifying the conventional four-banded Hyrax RPE appliance.(Lee et al., 2010) Orthodontic miniscrews (Orlus™, Ortholusion, Seoul, Korea) with a 1.8 mm collar diameter and 7 mm length were placed at the center of the helical hooks. Maxillary expansion was initiated the day after placement of the MARPE appliance, which was activated once a day (0.2 mm/turn) until the required expansion was achieved. The mean duration of expansion was 28 days (range, 18-35 days), and the mean amount of expansion was 6.8mm (range, 4.8-8.8 mm). CBCT was performed before expansion and within 5 weeks (mean, 10.71 days; range, 0-35 days) and approximately 14 months (mean, 14.0 months; range 12.0-15.3 months) after the completion of expansion. The third set of CBCT images were obtained either for presurgical diagnosis or as post-treatment records. The MARPE appliance was maintained for an average of 15.1 weeks after the completion of expansion.

The CBCT device (Alphard VEGA, ASAHI Roentgen IND, Kyoto, Japan) was set at 8.0 mA and 80 kV, and images were captured for 17 s with a 0.3 mm voxel size (FOV, 154 ×154 mm^2).In the lateral view, patients were scanned in an upright position with the Frankfort horizontal (FH) plane parallel to the ground and their midlines aligned with the vertical axis of the machine.(Kim et al., 2010; Park et al., 2010) In the frontal view, the head was oriented with the orbital floor parallel to the ground. Volume rendering program of the Ondemand software (Cybermed Co., Seoul, Korea) was used to visualize the 3D images and obtain measurements.

2. Measurements

Three landmarks [anterior nasal spine (ANS), choanae,(Pagano and Laitman, 2015) and the third cervical vertebra (C3)] and four reference planes(two horizontal and two vertical) were used as landmarks to obtain measurements(Table 1 and Fig 1).(Kim et al., 2010) The volumes of the nasal cavity and nasopharynx were separately measured, and the total volume was calculated as the sum of the two volumes using the following procedure. The airway is a space bound by hard and soft tissues. Our software used a sculpting procedure to eliminate the hard and soft tissues and preserved the required region by deleting unnecessary structures. Then, threshold values were adjusted to eliminate imaging artifacts and refine the selected region.(Chang et al., 2013) Consequently, the airway volume could be measured in cubic millimeters.

The nasal cavity was defined as the region bound superiorly by the FH plane, anteriorly by the ANS-perp. plane, and posteriorly by the choanae plane.(Wetmore and Mahboubi, 1986) The nasopharynx was bound superiorly by the choanae plane and inferiorly by the C3 plane.(Park et al., 2010) In addition, we measured the cross-sectional area of the airway in three different planes: ANS-perp. plane, choanae plane, and C3 plane (Fig 1C, D, and E). Each area was measured using the smart pen, which is a measuring tool provided by the software manufacturer.

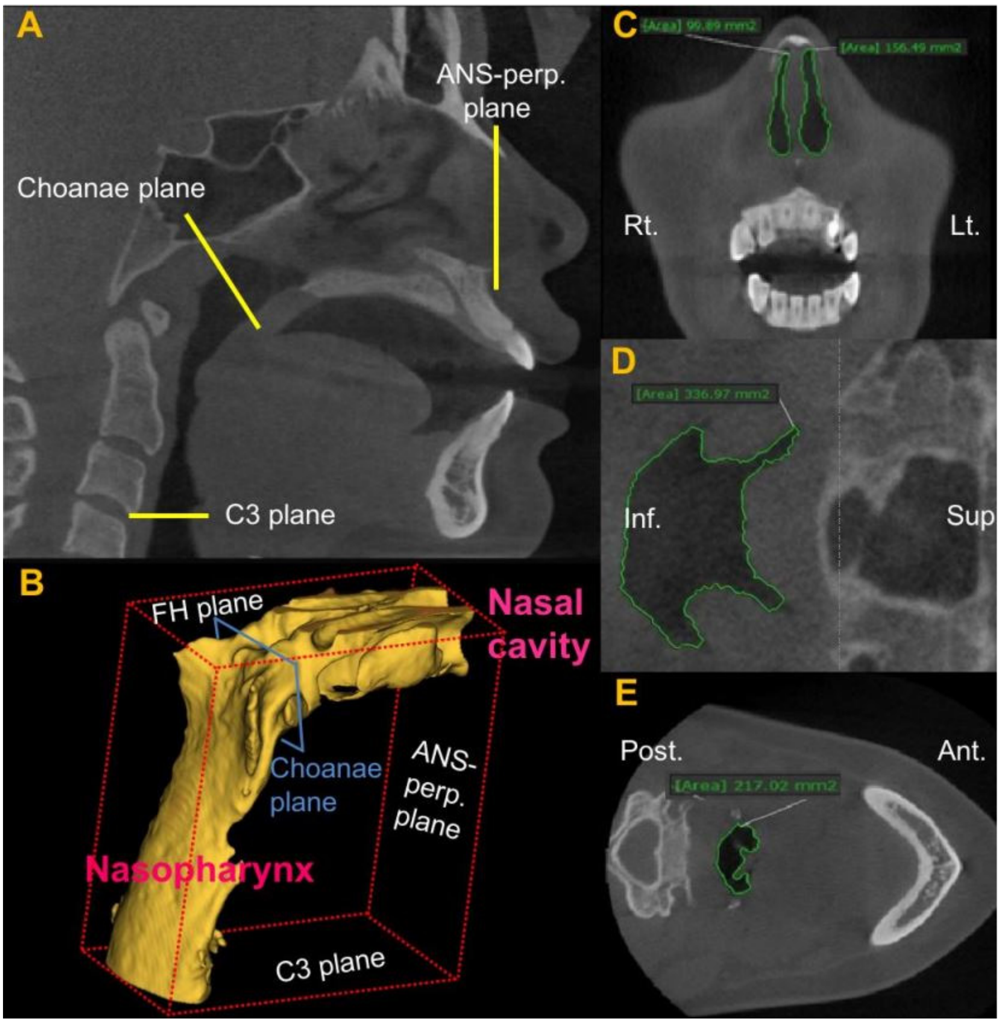


Figure 1. Measurements of the volume and cross-sectional area of the nasal airway using cone beam computed tomography in patients who underwent miniscrew-assisted rapid palatal expansion

A: reconstructed two-dimensional lateral cephalogram for the identification of landmarks and reference planes, B: volume of the airway, C, D, and E: cross-sectional area in the ANS-perp., choanae, and C3 planes, respectively. Please refer to Table 1 for definitions of each landmark and reference plane.

Table 1. Definition of landmarks and reference planes used for the assessment of changes in dimensions of the nasal airway after miniscrew-assisted rapid palatal expansion

Definition	Description
Landmarks	
ANS	Anterior nasal spine: a bony protrusion extending forward at the base of the nasal aperture
Choanae	The choanae are bounded medially by the vomer, inferiorly by the horizontal plate of the palatine bone, laterally by the medial pterygoid plate, and superiorly by the body of the sphenoid bone(Pagano and Laitman, 2015)
C3	The most inferior and anterior point on the third cervical vertebra
Reference planes	
FH plane	Frankfort horizontal plane, which is determined by both porions and left orbitale
C3 plane	Parallel to the FH plane and passing through C3
ANS-perp. plane	Perpendicular to the FH plane and passing through ANS
Choanae plane	The plane along the choanae

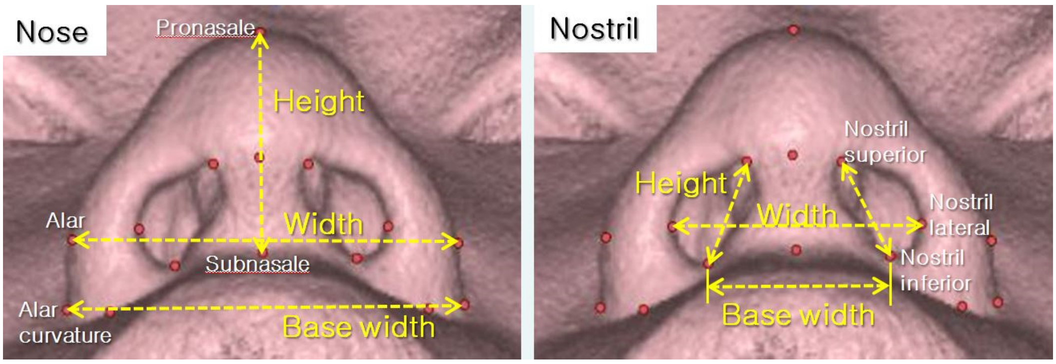
ANS, choanae, C3, FH plane, C3 plane, ANS-perp. plane, and choanae plane were identified on two-dimensional lateral cephalograms reconstructed from three-dimensional cone beam computed tomography images.

CBCT data of ten patients were used for the measurement of the nose width and height. The transversal plane is defined by right and left porion, and averaged coordinates of right and left orbitale. The frontal plane is perpendicular to the transversal plane, through right and left porion. The sagittal plane is perpendicular to the transversal and frontal planes, through nasion. Seven landmarks [pronasale, subnasale, alar, alar culvature, nostril superior, nostril inferior, and nostril lateral] were used to measure linear distances (Table 2 and Fig 2). Six linear measurements are as follows: nose height, nose width, nose base width, nostril height, nostril width, and nostril base width.

3. Statistical analysis

One examiner performed all measurements. To estimate the intra-examiner reliability, seven randomly selected data were re-evaluated after a week. The intra-class correlation coefficient (ICC) showed high reliability (ICC > 0.90). The Shapiro-Wilk test was used to determine normality of the data. As all data showed normal distribution, paired *t*-tests were used to compare changes from T0 to T1, T1 to T2, and T0 to T2.

A *P*-value <0.05 was considered statistically significant. SPSS version 20.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analysis.



(A) (B)

Figure 2. Landmarks and measurements for the assessment of changes of the nose (A) and nostrils (B) after miniscrew-assisted rapid palatal expansion

Table 2. Definition of landmarks and measurements for the assessment of changes of the nose and nostrils after miniscrew-assisted rapid palatal expansion

Definition	Description
Landmarks	
Pronasale	the most anterior midpoint of the nasal tip
Subnasale	the midpoint on the nasolabial soft-tissue contour between the columella crest and the upper lip
Alar	the most lateral point on each alar contour
Alar curvature	the point located at the facial insertion of each alar base
Nostril superior	the most superior points of the nostril
Nostril inferior	the most inferior points of the nostril
Nostril lateral	the most lateral points of the nostril
Measurements	
Nose height	distance between pronasale and subnasale
Nose width	distance between right and left alar
Nose base width	distance between right and left alar curvature
Nostril height	distance between nostril superior and nostril inferior
Nostril width	distance between right and left nostril lateral
Nostril base width	distance between right and left nostril inferior

III. Results

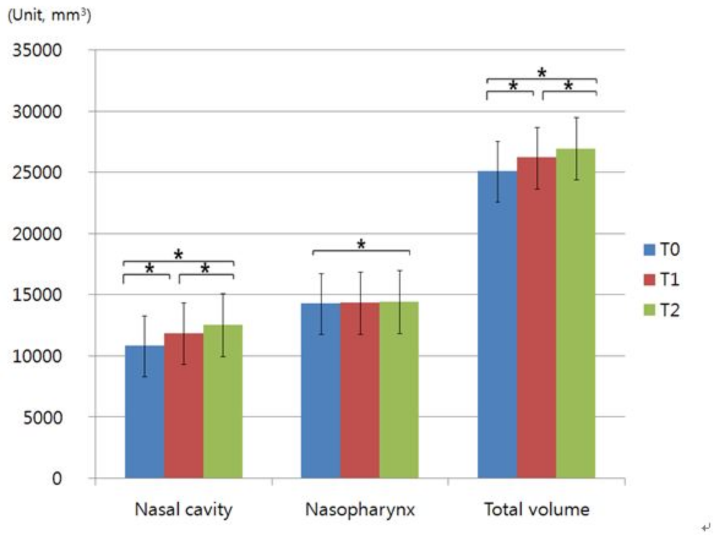
The volume of the nasal cavity increased by 1061.6 mm^3 immediately after expansion ($P < 0.05$), with an additional increase of 648.6 mm^3 during the 1 year after expansion ($P < 0.05$)(Table 3 and Fig 3A). Consequently, the nasal cavity volume increased by 1710.2 mm^3 from T0 to T2 ($P < 0.05$). Even though the nasopharynx volume did not show a statistically significant increase from T0 to T1 and from T1 to T2 ($P > 0.05$), the increase of 942.4 mm^3 from T0 to T2 was statistically significant ($P < 0.05$). The total volume of the airway increased by 1575.0 mm^3, 1077.7 mm^3, and 2652.6 mm^3 from T0 to T1, T1 to T2, and T0 to T2, respectively ($P < 0.05$).

The cross-sectional area of the airway in the anterior (ANS-perp.) and middle (choanae) segments showed a significant increase of 14.6 mm^2 and 31.6 mm^2, respectively, from T0 to T1 ($P < 0.05$)(Table 3 and Fig 3B). The increase from T0 to T2 was also significant ($P < 0.05$). The cross-sectional area of the posterior segment showed no significant changes throughout the observation period ($P > 0.05$).

There was little displacement at the nose (Table 4 and Fig 4). All nose widths increased slightly in numerical terms from T0 to T1, from T1 to T2, and from T0 to T2. However, only from T0 to T2 width of the nose statistically significant increased (*$P > 0.05$*).

Nose height decreased immediately after MARPE, but it was recovered to the initial height one-year after expansion. Consequently, there was no significant change between before and one-year after expansion. There were no differences for base width, nostril width, nostril height, and nostril base width (*$P > 0.05$*).

(A)



(B)

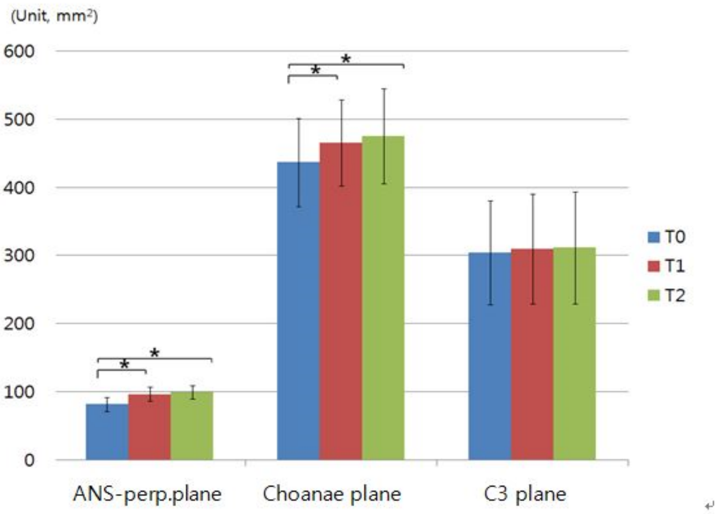


Figure 3. Changes in the volume (A) and cross-sectional area (B) of the airway as measured using cone beam computed tomography before (T0), immediately after (T1), and 1 year after (T2) miniscrew-assisted rapid palatal expansion in young adults

Table 3. Changes in the volume and cross-sectional area of the nasal airway before (T0), immediately after (T1), and 1 year after (T2) miniscrew-assisted rapid palatal expansion

	n = 14	Δ T1-T0	Δ T2-T1	Δ T2-T0
Volume (mm^3)	Nasal cavity	1061.6 ± 613.9*	648.6 ± 827.2*	1710.2 ± 881.6*
	Nasopharynx	513.3 ± 727.8	429.1 ± 817.2	942.4 ± 821.0*
	Total volume	1575.0 ± 881.8*	1077.7 ± 923.7*	2652.6 ± 221.2*
Area (mm^2)	ANS-perp. plane	14.6 ± 17.5*	7.4 ± 12.6	22.0 ± 15.4*
	Choanae plane	31.6 ± 34.9*	12.6 ± 45.5	44.2 ± 47.8*
	C3 plane	9.0 ± 83.3	20.0 ± 49.6	29.0 ± 89.7

Data are presented as means ± standard deviations.

Please refer to Table 1 and Figure 1 for the definition of each measurement.

Paired *t*-tests were used for each measurement. *$P < 0.05$.

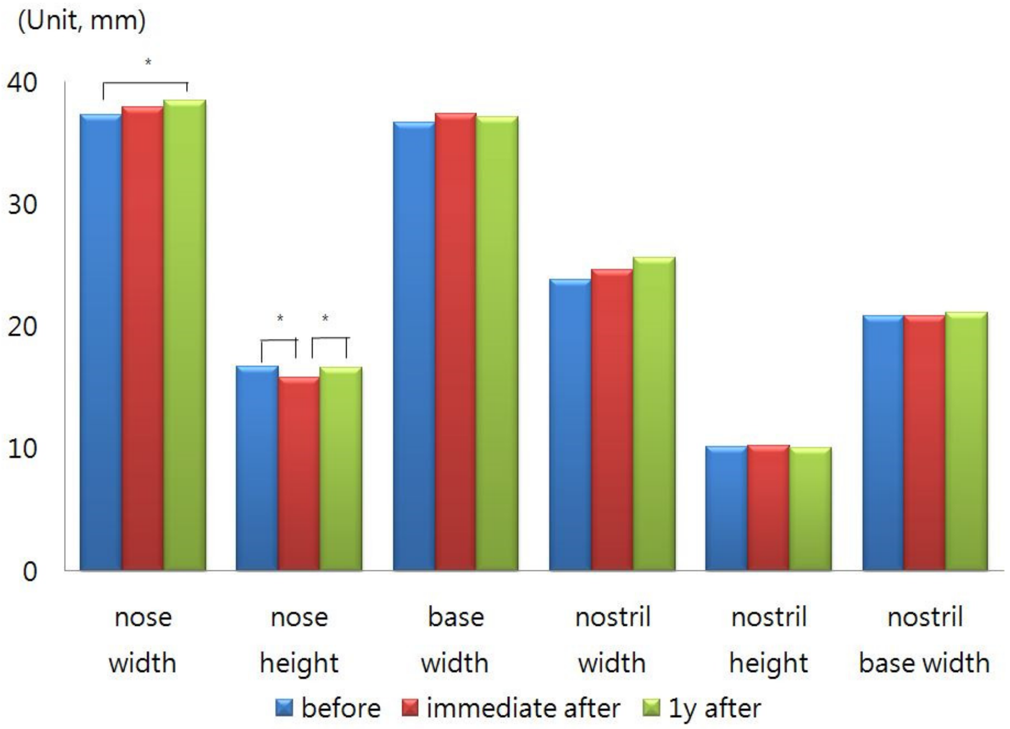


Figure 4. Changes in height and width of the nose and nostrils before (T0), immediately after (T1), and 1 year after (T2) miniscrew-assisted rapid palatal expansion in young adults

Table 4. Changes in height and width of the nose and nostrils after miniscrew-assisted rapid palatal expansion

(unit : mm)

		Δ T1-T0	Δ T2-T1	Δ T2-T0
nose	nose width	0.67	0.53	1.20*
	nose height	-0.15*	0.13*	-0.02
	base width	0.71	-0.22	0.49
nostril	nostril width	0.73	1.06	1.79
	nostril height	0.01	-0.12	-0.11
	nostril base width	-0.02	0.20	0.18

T0, before expansion; T1, immediately after expansion; T2, one year after expansion

Paired *t*-tests were used for each measurement. *$P < 0.05$.

IV. Discussion

MARPE has been proven effective for skeletal and dental expansion in young adults, and the skeletal changes were maintained even after removal of the appliance.(Choi et al., 2016; Lin et al., 2015) Therefore, we could assume that airway changes caused by MARPE would also be stable. The present study demonstrated that maxillary expansion contributed to an increase in the volume and cross-sectional area of the nasal airway in young adults. The volume and area mainly increased in the nasal cavity, and this increase was maintained for 1 year after expansion; in contrast, the increase in the nasopharynx was not evident.

Maxillary constriction is a clinically significant factor for OSA because a low tongue position may cause narrowing of the pharynx.(Katyal et al., 2013; Linder-Aronson, 1970; Villa et al., 2011) In previous studies, the apnea-hypopnea index values decreased after conventional RPE in children, with a stable outcome at the 12-year follow-up.(Pirelli et al., 2004, 2015) Several studies have shown that even minor changes in the anterior nasal volume can contribute to a decrease in the respiratory airway resistance.(Deeb et al., 2010; Wriedt et al., 2001) Furthermore, an increase in the cross-sectional area can facilitate easy breathing.(Warren et al., 1987) MARPE, which was performed for young adults in the present study, appeared to have similar effects on the nasal cavity and airway.

Previously, 2D analyses based on lateral cephalograms have been used to measure airway changes primarily in the pharyngeal area.(Zhao et al., 2010) With 2D modality, volumetric measurement, which plays a crucial role with regard to airway flow, is not feasible. In addition, assessment of the anterior nasal airway is barely possible. Some studies have investigated changes in the volume and cross-sectional area of the nasal airway using AR.(Babacan et al., 2006; Mitsuda et al., 2010) However, the data obtained by AR may not be reliable because of possible errors caused by temperature, surrounding noise, or decongestants.(Mitsuda et al., 2010) CBCT, which is not influenced by these factors, can demonstrate the structures of the nasal airway more accurately. Because of the complex structure of the nasal cavity, previous studies using CBCT images have evaluated changes in the posterior pharyngeal airway, not the anterior segment.(Chang et al., 2013; Park et al., 2010) Even though computed tomography (CT) images were used to measure the volume of the nasal cavity after SARPE, the total volume was calculated by integration of each cross-sectional area,(Deeb et al., 2010) which may be a less accurate method compared with direct assessment. In the present study, we delineated the airway structures in the nasal cavity and nasopharyngeal area by manually deleting all hard tissues; this is probably more reliable than the previous methods.

In the present study, the volume of the nasal cavity and nasopharynx increased after MARPE and was maintained during the retention period. While the nasal cavity volume increased by 9.9 %, 5.5 %, and 15.4 % from T0 to T1, T1 to T2, and T0 to T2, respectively, that of the nasopharynx increased by 6.4 %, 4.1 %, and 10.5 %, respectively. The additional increase during the retention period seems to be a result of adaptation of the lateral walls of the nasal cavity, which were displaced immediately after expansion.

It should be noted that the increase in volume was evident in the nasal cavity, not in the nasopharynx. This is probably because the position of the appliance, which was below the nasal cavity, would have directly influenced changes in the nasal cavity. Conversely, the nasopharynx volume would not be directly affected because of resistance from the zygomatic buttress and pterygo maxillary junction.(Kilic et al., 2013) The increase in the cross-sectional area showed a similar trend; the anterior segment showed a greater increase compared with the posterior segment, with a T0-T2 increase of 31.3 %, 9.5 %, and 6.1 % in the anterior, middle, and posterior segments, respectively (Fig 5).

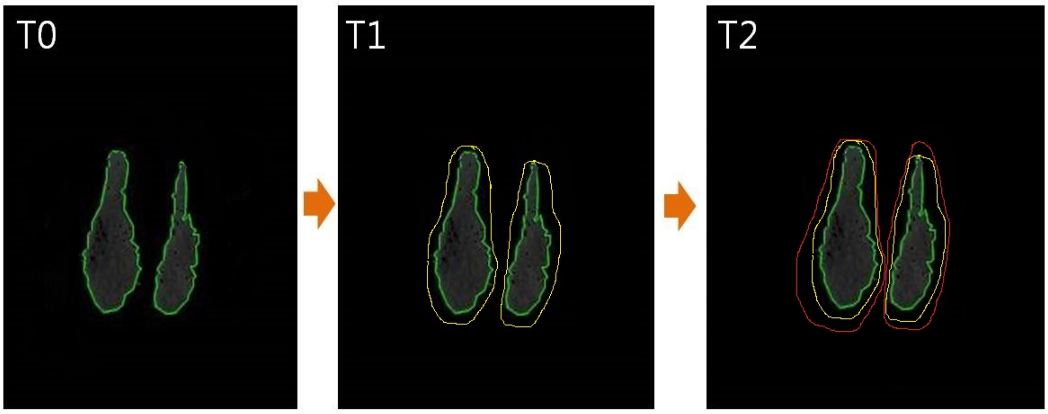


Figure 5. Changes in the anterior cross-sectional area of the airway as measured using cone beam computed tomography before(T0) (green line), immediately after(T1) (yellow line), and 1 year after(T2) (red line) miniscrew-assisted rapid palatal expansion in young adults

After SARPE, the nasal cavity volume was found to increase by 17.9 – 23.3 % when measured using AR(Kunkel and Hochban, 1994; Wriedt et al., 2001) and 5.1 % when measured using CT.(Babacan et al., 2006; Deeb et al., 2010) In the present study, the increase measured on CBCT was 15.3 % after MARPE. These discrepancies can be attributed to differences in the expansion modality, measurement tool, definition of the nasal cavity volume, and duration of retention. Similar to that after MARPE, the increase in the nasopharynx area after SARPE was not significant.(Pereira-Filho et al., 2014; Seeberger et al., 2010) However, conventional RPE led to a 25.9 % increase in the pharynx volume,(Chang et al., 2013) probably because of growth and differences in patient age.

The second objective of this study is to assess changes in the nose following MARPE in young adult. We measured nose width and height before expansion, immediately after expansion, and 1 year after expansion. There are many researches that after conventional RPE in children, nasal tissue changed such as flattening of the nasal tip and an increase in nasal base width.(Altorkat et al., 2016) Johnson found less than 1.5 mm increase in nasal base width after 7 mm of appliance expansion.(Johnson et al., 2010) Baccetti et al. described similar changes in lateral nasal width for prepubertal and postpubertal patients following RPE.(Baccetti et al., 2001)

Furthermore, previous studies used 2-dimensional modality such as cephalogram and direct measurement of the soft tissue. These direct measurements could cause errors of the distortion of the landmarks. 3D analysis using CBCT can accurately measure the nose height and width without these limitations.

The present study showed that MARPE might be helpful in improving breathing through an increase in the airway dimensions, which is maintained even after removal of the appliance. Furthermore, the changes in the nose were practically insignificant although the width of the nose slightly increased after MARPE in young adults. However, there are some limitations. First, we could not enroll a control group because of ethical issues. Second, the sample size was small, and measurements could not be analyzed according to age or sex, even though the data showed normal distribution. Third, we demonstrated morphometric changes in the airway, which may not be directly related to functional aspects. Furthermore, there was insufficient consideration of the patients with nasal disease such as rhinitis and nasal inflammation. Future prospective studies should investigate the kinetic aspect of changes in the airway after maxillary expansion in young adults.

V. Conclusion

In conclusion, the null hypothesis proposed for this study was rejected. After maxillary expansion in young adults, the volume and cross-sectional area of the nasal cavity showed a significant increase, with an additional increase in volume during the 1 year retention period. Moreover, the volume of the nasopharynx showed a significant increase at 1 year after the completion of expansion. The increase in the nasal cavity was larger than that in the nasopharynx through out the observation period. Collectively, these results suggest that MARPE can be a helpful modality to improve breathing in young adults with maxillary constriction.

The width of the nose was the only measurement that showed significant changes one year after MARPE, although the amount was clinically insignificant. This result suggests that MARPE has little clinical effects on the morphology of the nose and nostrils.

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국문요약

젊은 성인에서 미니스크류를 동반한 급속구개확장 후

비강과 비인두의 변화 및 코의 형태 변화

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성장기 아이들에서 상악골의 확장은 치아뿐만 아니라 코의 연조직에도 영향을 미칠 수 있다. 본 연구에서는 젊은 성인에서 미니스크류를 동반한 상악골 확장(miniscrew-assisted rapid palatal expansion, MARPE)을 시행하여 비강을 포함한 기도영역에서 부피와 단면적의 변화를 평가하였다. 뿐만 아니라 MARPE후 코의 너비와 높이 변화도 분석하였다.

이 연구는 횡적 부조화가 있고 MARPE를 시행한 14명의 환자(평균 연령 22.7세; 여자 10, 남자 4)를 대상으로 하였으며, MARPE 직 전(T0), 직 후(T1), 그리고 1년 지난 후(T2) 콘빔 컴퓨터 단층 촬영(conebeam computed tomography, CBCT)을 시행하였다. 코의 변화 계측에는 7개의 좌표와 6개의 계측항목이 사용되었다. 비

강(nasal cavity)과 비인두(nasopharynx)의 부피, 비기도(nasal airway)의 앞, 중간, 뒤의 단면적 그리고 코의 너비와 높이는 측정 후 paired t-test를 이용하여 세 시점에서 비교되었다.

비강의 부피는 T1과 T2때 모두 증가하였고($P < 0.05$), 비인두의 부피는 단지 T2에서만 의미있게 증가하였다($P < 0.05$). 비기도의 앞쪽과 중간의 단면적은 T1과 T2 때 모두 증가하였다($P < 0.05$). 반면에 뒤쪽 단면적은 모든 기간 동안에 의미있는 변화는 없었다($P > 0.05$).

코와 콧구멍의 너비와 높이에서 의미있는 변화는 거의 없었다. MARPE 직후에 코의 높이는 감소하였으나, 확장 후 1년 되었을 때에는 원래의 높이를 회복하였다. 코의 너비는 T0에서 T2동안 1.2 mm 증가하였다. 다른 측정값들은 모든 기간 동안 의미있는 변화는 없었다($P > 0.05$).

결과적으로 MARPE 이후 비강의 부피와 단면적은 증가하고 확장 후 1년 뒤에도 유지되었다. 이러한 결과는 MARPE가 비기도의 확장에 도움을 줄 수 있는 가능성을 제시한다. MARPE 이후 코의 형태변화는 단지 너비가 약간 증가한 것 외의 다른 수치변화는 없었다. 이는 MARPE가 코와 콧구멍의 형태에 임상적으로는 거의 영향이 없다는 것을 보여준다.

핵심 되는 말 : 미니스크류를 동반한 급속구개확장, 콘빔 컴퓨터 단층 촬영, 확장, 비강, 비인두, 코의 너비와 높이