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NASAL CAVITY WIDTH CHANGES FOLLOWING SLOW AND RAPID MINISCREW-SUPPORTED MAXILLARY EXPANSION

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ABSTRACT

Objective: *The aim of the study was to compare the nasal cavity width changes following slow and rapid activation of miniscrew-supported maxillary expander.*

Materials and Methods: *Twenty-four adolescent patients having transverse maxillary deficiency were included in the study. All the patients received a maxillary expander supported on four palatal miniscrews. The patients were equally divided into two groups: Group I (slow expansion, once every other day), Group II (rapid expansion, twice per day). Cone beam computed tomography (CBCT) scans were made before expansion (T1) and at the end of the retention period after removing the expanders (T2). Measurements were performed on coronal cuts of the CBCT. Statistical analysis was performed.*

Results: *Both activation rates resulted in a significant increase of the nasal cavity width. No significant difference was found between the two groups.*

Conclusion: *Both slow and rapid activation protocols of miniscrew-supported maxillary expanders are effective in increasing the nasal cavity width.*

Key words*: Rapid Maxillary Expansion; Slow Maxillary Expansion; Miniscrew-supported expansion; Activation protocol*

INTRODUCTION

Transverse maxillary deficiency, presenting in the form of unilateral or bilateral posterior cross bite or maxillary dental crowding, is a common finding among patients seeking orthodontic treatment.[1-3] If the transverse maxillary deficiency is left untreated in growing patients, it may result in a number of problems, including altered tongue posture, mouth breathing, and narrowing of the nasal airway.[4]

Maxillary expansion is considered a common treatment modality for transverse maxillary deficiency cases.[5] The maxilla can be expanded using different types of appliances, and using different rates of expansion.[6-8] Tooth-bone-borne maxillary expanders (ME), utilizing miniscrews in addition to the anchor teeth,[9] and bone-borne ME, supported using miniscrews without banding any teeth,[10] were proposed to reduce the unfavorable dento-alveolar effects commonly encountered with conventional expansion appliances.[11-16]

The outcomes of maxillary expansion extend beyond merely opening the mid-palatal suture because the maxilla articulates with other bones of the face including the nasal bone and the inferior nasal concha.[17] Accordingly, miniscrew-supported ME have been shown to have a positive effect on the nasal airway such as increasing the volume of the nasal cavity,[18-20] increasing the cross-sectional area of the nasal cavity,[19] and increasing the volume of the nasopharynx.[18] In addition, miniscrew-supported ME have been shown in a recent randomized clinical trial to increase the nasal airflow and to reduce the nasal airway resistance,[21] Moreover, respiratory tests performed on mouth breather patients showed an increase in respiratory

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muscle strength 5 months post-expansion using miniscrew-supported ME.[20]

The choice to use rapid or slow activation protocol for maxillary expansion is debatable and mostly depends on the practitioner's clinical experience and personal preference since there is no conclusive evidence to favor the use of one expansion protocol over the other.[7, 22] The activation protocols reported in the published literature regarding the miniscrew-supported ME vary widely,[9, 10, 23] but the most commonly reported expansion protocol was found to be rapid activation twice per day.[20, 24-29] Other authors advocated using a slow activation rate to reduce discomfort and allow dissipation of stresses.[10, 23, 30, 31]

A comparison between slow and rapid activation protocols of miniscrew-supported ME has not been previously described in the literature.[32] Hence, the aim of this study was to compare the effect of slow and rapid activation protocols of miniscrew-supported ME on the nasal cavity. The null hypothesis of the current study was that there was no difference between the two activation protocols of miniscrew-supported ME.

MATERIALS AND METHODS

The current study was conducted following the guidelines of the institutional review board of the Faculty of Dentistry, Alexandria University (IRB:00010556-IORG:0008839). Approval was obtained from the research ethics committee in the Faculty of Dentistry, Alexandria University. Before the onset of the study, an oral assent was obtained from the patients and a signed informed consent was obtained from their parents.

Twenty-four adolescent patients aged 12 to 16 years old were recruited at the outpatient clinic, Faculty of Dentistry, Alexandria University. Inclusion criteria included having permanent dentition and having transverse maxillary deficiency warranting skeletal maxillary expansion. The method of Cantarella et al[33] was used for diagnosis of the transverse maxillary deficiency and for quantifying the amount of the discrepancy by measuring the difference between the maxillary and mandibular widths. The patients were equally divided into two groups: Slow expansion group (Group I), and Rapid expansion group (Group II).

Patients in both groups were treated using a miniscrew-supported ME (**Figure 1**). Four self-drilling miniscrews (1.6x10 mm, H-screw, Hubit Co Ltd, Ojeon-Dong, Korea) were placed in the palate, 6 to 8 mm from the gingival margin of teeth. Two of the miniscrews were placed bilaterally between the maxillary first and second premolars, and two of the miniscrews were placed between the maxillary second premolars and first molars. An alginate impression was made and poured in stone, and a 9 mm expansion screw (Leone orthodontic products, Sesto Fiorentino, Firenze, Italy) was placed in the middle of the palate, and acrylic resin was added. The finished appliance was then fixed in place using light-cure flowable composite resin (Te-econom flow, Ivoclar Vivadent, Schaan, Liechtenstein).

The patients in group 1 activated the appliance at a slow rate of once every other day, while the patients in group 2 activated the appliance rapidly at a rate of twice per day, once in the morning and once in the evening. Each activation of the expansion screw corresponds to 0.2 mm of expansion. The patients were asked to keep a log of their activations and the log was checked regularly to confirm their compliance. Expansion was continued until the transverse discrepancy was corrected, then the appliance was left in place for retention. The appliance was removed at the end of the retention period, 5 months after the initial activation of the appliance.

A CBCT scan was performed using i-CAT Next Generation device (Imaging Sciences International, Hatfield, Pa) before expansion (T1) and after removal of the expansion appliance at the end of the retention period (T2). All the scans performed during the study were made with the following parameters: 120 Kvp, 5 mA, 640x640x544 field of view and 25 sec scanning time at 0.25 resolution. The data from the CBCT scans was exported in Digital Imaging and Communications in Medicine (DICOM) format and processed using the 3D module in OnDemand3D™ software (Cybermed Inc., Seoul, Korea). The CBCT data was reconstructed with 0.5 mm slice thickness. Linear measurements were made to the nearest 0.01 mm using the software measurement tools. Standardization of the CBCT analysis procedure was done by reorienting the axial plane to be parallel to the palatal plane in both the sagittal and coronal cuts, then the coronal axis was re-oriented in the axial cut to bisect the palatal roots of the first premolars when making measurements at the level of the first premolars, and to bisect the palatal roots of the first molars when making measurements at the level of the first molars.

The landmarks and measurements utilized to evaluate the nasal cavity width changes in both groups are shown in **Figure 2**. RtN-4 and LtN-4 refer to the most lateral point of the nasal cavity on the right side and left side, respectively, as seen on the coronal section at the level of the maxillary first premolars. RtN-6 and LtN-6 refer to the most lateral point of the nasal cavity on the right side and left side, respectively, as seen on the coronal section at the level of the maxillary first molars. NCW-4 describes the widest nasal cavity width measured on the coronal slice at the level of the maxillary first premolar between the points RtN-4 and LtN-4, while NCW-6 describes the widest nasal cavity width measured on the coronal slice at the level of the maxillary first molar between the points RtN-6 and LtN-6.

Statistical analysis

The statistical analysis was performed using IBM SPSS software, version 25 (IBM Corp., Armonk, NY). All the variables were presented using the mean ± standard deviation. The normality of the data was tested using descriptive statistics, plots (histogram and box plot), and Shapiro Wilk test and it was found to be normally distributed. Comparisons between the groups were assessed by independent t-test. Paired t-test was used for comparisons within each group. The significance level was set at p value ≤0.05. To calculate the error of measurement, measurements were repeated after 2 weeks by the same researcher on 12 randomly selected CBCT scans. the intra-examiner reliability was assessed using intraclass correlation coefficient.

RESULTS

The mean age of group I at the start of treatment was 14.30 ±1.37 years old, whereas the mean age in group II was 15.07±1.59 years old. Comparison between the groups did not show a significant difference (p=0.218). The amount of screw expansion was 5.75±0.76 and 5.90±0.68 mm in group I and group II, respectively, which was not significantly different between the groups (p=0.617). Opening of the mid-palatal suture was discernible in all the patients by the appearance of a median diastema between the upper central incisors.

Comparison of NCW-4 and NCW-6 measurements using intraclass correlation coefficient showed high intra-examiner reliability (0.989 and 0.931, respectively). The results of the current study are shown in **table**

1. No significant difference was found between the two groups at T1 or at T2. Slow activation of the miniscrew-supported ME resulted in a significant increase in the nasal cavity width at the level of the maxillary first premolar amounting to 2.95 mm, and in the nasal cavity width at the level of the maxillary first molar amounting to 2.62 mm ($p<0.001$). Rapid activation, on the other hand, resulted in a significant increase in the nasal cavity width at the level of the maxillary first premolar and maxillary first molar amounting to 2.54 mm and 2.57 mm, respectively ($p<0.001$). The increase in nasal cavity width was not significantly different between the two groups. The increase in nasal cavity width at the level of the maxillary first molar in the slow expansion group amounted to 46.6% of the amount of jackscrew expansion, whereas it amounted to 43.6% in the rapid expansion group.

DISCUSSION

Multiple studies have previously investigated the skeletal and dento-alveolar effects of miniscrew-supported ME and have demonstrated their effectiveness in treating transverse maxillary deficiency,[8, 34, 35] in addition to their positive effects on the nasal airway.[18-21] However, there is a lack of consensus across the published studies regarding their optimal rate of activation,[32] and none of the studies compared the effect of the different activation protocols on the nasal cavity width. Hence, the objective of the current study was to compare the nasal cavity width changes following miniscrew-supported ME using slow and rapid activation protocols.

A significant increase in the nasal cavity width at the first premolar and first molar (2.95 mm and 2.62 mm, respectively) was detected with the slow activation rate in group I. A larger increase in the nasal cavity width (4.1 mm) was previously reported by Arman-Özçırpıcı et al,[36] using the same appliance design, but with a mixed activation rate (Rapid activation for one week, followed by slow activation for 3 weeks). The differences in the activation protocols and the analysis methods could be reasons for the different findings in the two studies. CBCT assessment was employed in the current study, in contrast to postero-anterior radiographs employed in their study.[36] The increase in nasal cavity dimensions potentially improves air intake and nasal breathing.[37] However, when Kabalan et al[25] investigated the effect of slow activation of a bone-borne expander on the nasal airway, they did not find a correlation between the functional changes and the dimensional changes that took place in the nasal cavity.

Significant expansion of the nasal cavity was found at the first premolar and at the first molar (2.54 mm and 2.57 mm, respectively) at T2 after rapid expansion. A similar result was reported by Celenk-Koca et al,[27] where they found an increase of 2.8 mm and 2.9 mm at the first premolar and the first molar, respectively, after rapid activation of a bone-borne expander supported by four miniscrews. Conversely, Oh et al[38] reported a significant but smaller increase in the nasal cavity width than reported in the current study, and Akin et al[39] reported a non-significant increase in nasal width. This inconsistency between the studies may have risen from the differences in the utilized landmarks. In addition, both studies employed a bone-borne expander supported solely by two miniscrews,[38, 39] contrary to the expander used in the current study which was supported by four miniscrews. Placing anterior and posterior miniscrews, in contrast to only placing posterior miniscrews, was previously shown to increase stress distribution in the nasal bones, resulting in greater lateral displacement.[40]

When the changes in the nasal cavity width from T1 to T2 were compared between the two groups, comparable outcomes were reported, and no significant differences were found. Consequently, we failed to reject the null hypothesis. Previous research investigating slow and rapid expansion using conventional Hass expander found that rapid expansion resulted in significantly larger increase (2.38 mm) in the nasal cavity width compared to slow expansion (1.45 mm).[41] The difference in appliance designs may have contributed to such difference between the two studies. In addition, the amount of posterior nasal width increase in their rapid expansion group (2.38 mm) was analogous to that reported in the current study (2.57 mm), although the amount of jackscrew expansion was larger (8 mm).[41] The greater relative expansion reported in the current study may be attributed to the incorporation of miniscrews in the expander design.

Rapid maxillary expansion using a conventional hyrax has been previously shown to reduce the symptoms of obstructive sleep apnea in children and to improve nasal breathing in mouth breathers.[42] Correspondingly, widening of the nasal cavity following rapid and slow maxillary expansion using miniscrew-supported ME may provide a viable option for reducing obstructive sleep apnea in adolescents having transverse maxillary deficiency. Future research should be conducted to compare the effect of the two activation protocols of miniscrew-supported ME on the sleep respiratory parameters and respiratory pattern. Moreover, further research should be conducted to compare the effect of the different activation protocols of miniscrew-supported ME on the nasal airflow and nasal resistance and to compare their long-term effects.

CONCLUSION

Based on the results of the current study, it can be concluded that both slow and rapid activation protocols of miniscrew-supported maxillary expanders are equally effective in increasing the nasal cavity width.

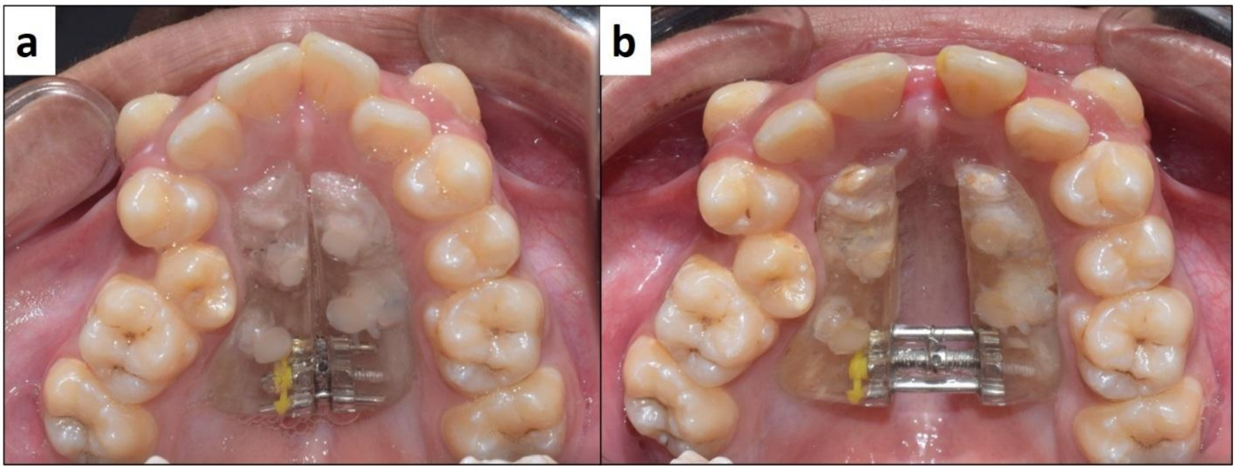

Figure 1. Pre-expansion (a) and post-expansion (b) photographs of miniscrew-supported maxillary expander.

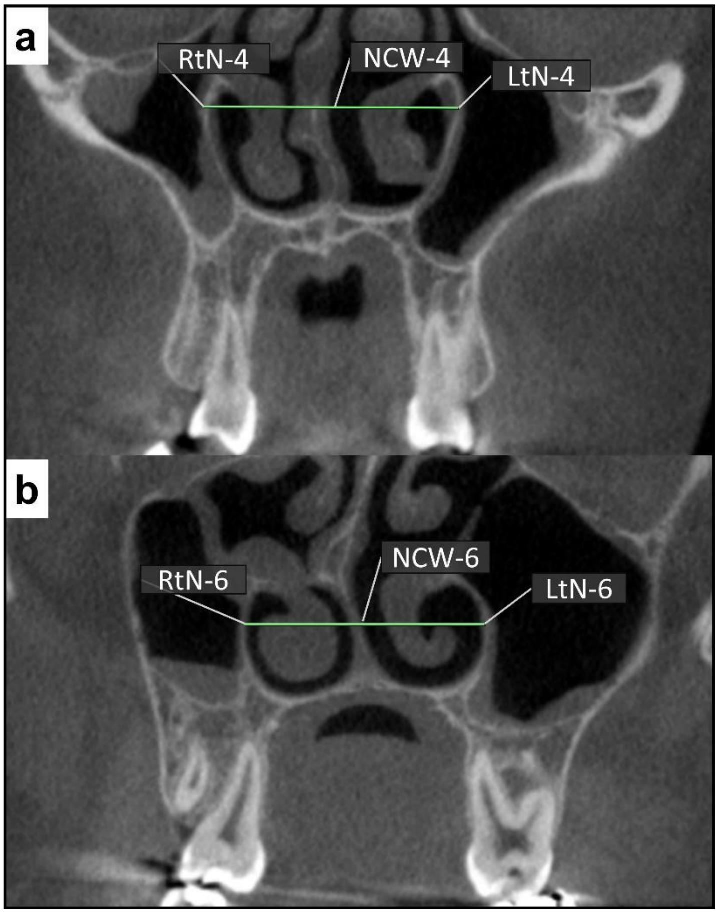

Figure 2. Landmarks and measurements made on coronal CBCT cuts (a) at the level of maxillary first premolar, and (b) at the level of maxillary first molar.

Table 1. Comparison of nasal cavity widths in slow and rapid expansion groups.

Variable	Group	T1, mm (Mean±SD)	T2, mm (Mean±SD)	ΔT1-T2, mm (Mean±SD)	*p* value
NCW-4	Group I	28.78±2.74	31.71±2.43	2.95±0.46	**<0.001***
	Group II	29.49± 3.73	32.04±3.71	2.54±0.83	**<0.001***
	***p* value**	0.599	0.812	0.154	
NCW-6	Group I	29.51±1.68	32.13±2.20	2.62±0.92	**<0.001***
	Group II	29.93±3.48	32.51±2.87	2.57±0.87	**<0.001***
	***p* value**	0.710	0.724	0.893	

*Statistically significant at p value≤0.05

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