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Miniscrew-Assisted Palatal Expansion and Airway Volume Changes; A Systematic Review

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Abstract

Background and Objective: Palatal expansion can be done with tooth-borne and bone-borne appliances; Bone maturity is one of the factors required placing a mini-screw in the palate for expansion. Expansion with bone-based appliance also has two dental and skeletal responses; Part of the skeletal response can be to increase the size of the airway. The present study evaluates the effect of Miniscrew-assisted palatal expansion on airway volume.
Methods: Search was conducted for articles published between January 2010 to January 2021 in PubMed, Embase, Google Scholar, and Cochrane using the following inclusion criteria: 1) patients whose treatment with Miniscrew-assisted palatal expansion and who with transverse discrepancy 2) all languages, 3) Randomized clinical trials (RCTs) or non-randomized clinical trials (Non-RCTs) and retrospective studies were considered.
Results: Of the 123 studies on miniscrew-assisted palatal expansion, only 7 studies clinically evaluated the effect of miniscrew-assisted palatal expansion on airway dimensions. The results of studies show that the miniscrew-assisted palatal expansion increasing airway dimensions; so that, increased nasal cavity volume and nasopharyngeal volume have been observed following this treatment. However, studies have shown that this approch does not effect on oropharyngeal, palatopharyngeal, glossopharyngeal and posterior areas.
Conclusion: The results of the study demonstrated that Miniscrew-assisted palatal expansion is an effective and efficient treatment in increasing airway dimensions via its increasing nasal cavity and nasopharynx volume.

Keywords: Maxillary expansion, Palatal expansion, Miniscrew-assisted palatal expansion, Airway dimension

1. Introduction

Maxillary expansion treatments are used to correct transverse discrepancy of the maxilla that is applicable based on factors such as patient's age, speed rate of expansion, the rate of force applied, appliance design, and retention protocol using various appliances. Maxillary expansion has skeletal and dental effects on the maxilla and mandible [3-1]. Maxillary expansion opens midpalatal suture, and the rate of the opening is more frequent in the anterior region causing space creation among the central incisor teeth. Albeit, from the frontal view, the midpalatal suture opens up like a pyramid the vertex of which is situated in the nasal cavity [4, 5]. Anatomically, the nasal cavity volume increases immediately after expansion improving respiration [6]. Expansion is performed via tooth- and bone-borne appliances. With age, heavy forces are required due to the need for creating microfractures in the midpalatal suture increasing the probability of unwanted tooth movements in the case of utilizing tooth-borne appliances [7]. In posterior teeth, the expansion is accompanied by buccal tipping of the crowns of posterior teeth that in turn can cause downward and backward rotation of the mandible leading to increased anterior facial height [8]. With the advent of screws in the world of orthodontics, bone-borne expansions for applying direct forces to the bone and the least tooth movement are readily feasible [9]. Changes in airway dimensions following expansion is a significant feature requiring further examination and evaluation since such changes can improve respiration. Obstructive sleep apnea is a common disorder that

has recently received noticeable attention, and palatal expansion with its improving effect on the airway dimensions has been proposed as a treatment method for this disorder [10, 11]. Respiratory disorders are usually more evident in the elderly, which as previously stated, expansion at this age requires applying a direct force to the bone to achieve a favorable skeletal effect [12-14]. The present study evaluates the effect of Miniscrew-assisted palatal expansion on airway volume.

2. Methods

1. Guidelines

The reporting of this study is in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and followed the guidelines in the Cochrane Handbook for Systematic Reviews of Interventions.

2. Eligibility criteria

Does maxillary expansion with bone- borne appliances effect on airway volume?

The search strategy was done due to PICO.

- *Patients (P).* Individuals of both sexes, no age limit, without restriction on ethnic or socioeconomic group, whose treatment with Miniscrew-assisted palatal expansion, who with transverse discrepancy
- *Intervention (I).* Application of Miniscrew for palatal expansion
- *Control (C).* Patients who received placebo or no treatment on Miniscrew-assisted palatal expansion
- *Outcome (O).* Airway volume change.
- *Study design (S).* Randomized clinical trials (RCTs) or non-randomized clinical trials (Non-RCTs).

Animal and laboratory studies, technical and case reports, and opinion and review articles were excluded.

3. Information Sources

PubMed, Embase, Google Scholar, and Cochrane.

4. Search

Searches were tailored to the specific databases from January 2010 to January 2021. An example of a search on PubMed is: ((("maxilla") OR ("maxillary") OR ("palatal") OR ("Palatal Expansion Technique"[Mesh]") OR ("Palate")) AND (("airway") OR ("airway dimension") OR ("airway volume") OR ("Orthodontic")) AND (("mini-screw") OR ("bone-borne") OR ("Skeletal anchorage") OR ("mini-implant")) AND (("Distraction") OR ("Widening") OR ("Expansion"))).

5. Study Selection

Two independent reviewers performed the study selection that comprised assessment of title, abstract, and full text of the retrieved references. No language or publication date restriction was imposed. After exclusion of duplicate and non-eligible studies, the full text of references considered eligible for inclusion were assessed by the two reviewers independently.

Inclusion criteria for this review were: 1) patients whose treatment with Miniscrew-assisted palatal expansion and who with transverse discrepancy 2) all languages, 3) Randomized clinical trials (RCTs) or non-randomized clinical trials (Non-RCTs) and retrospective studies were considered, 4) from January 2010 to January 2021, and 5) both published and unpublished data were sought out.

Exclusion criteria were: 1) studies that are not about maxillary expansion with bone- borne appliances, 2) studies that do not provide quantitative data, and 3) review or case-report study. Authors were contacted to obtain additional data as needed. The details of inclusion criteria are shown in Figure 1.

6. Data collection process

The two review authors extracted the relevant data of the included studies independently. Information from the included studies was synthesized by tabulating the general characteristics, including author, year of publication, study design, number of participants along with information on their age and sex, evaluation methods, and follow-up.

7. Duplicate data

The data published several times, was considered a duplicate. In the case of any doubts or ambiguity, the original article (the first study done) was always considered the final solution. This reduces any overestimation of the effect of the intervention since there are no duplicate data exceptions.

8. Investigating the missing or defective data

The strategies for missing/defective data in the present study are as follows:

1. Contact the author if possible.
2. Analyze only the current data (overlooking the missing data).
3. Finally, we discussed the possible effects of the missing data on the understudy findings in the discussion.

9. Evaluating the quality of studies

Evaluating the quality of studies was conducted independently by two authors. The National Institute for Health and Clinical

Excellence (NICE) tool for quality assessment was used (15). We graded studies as having high quality if 6 ≥NICE criteria were met (table 1).

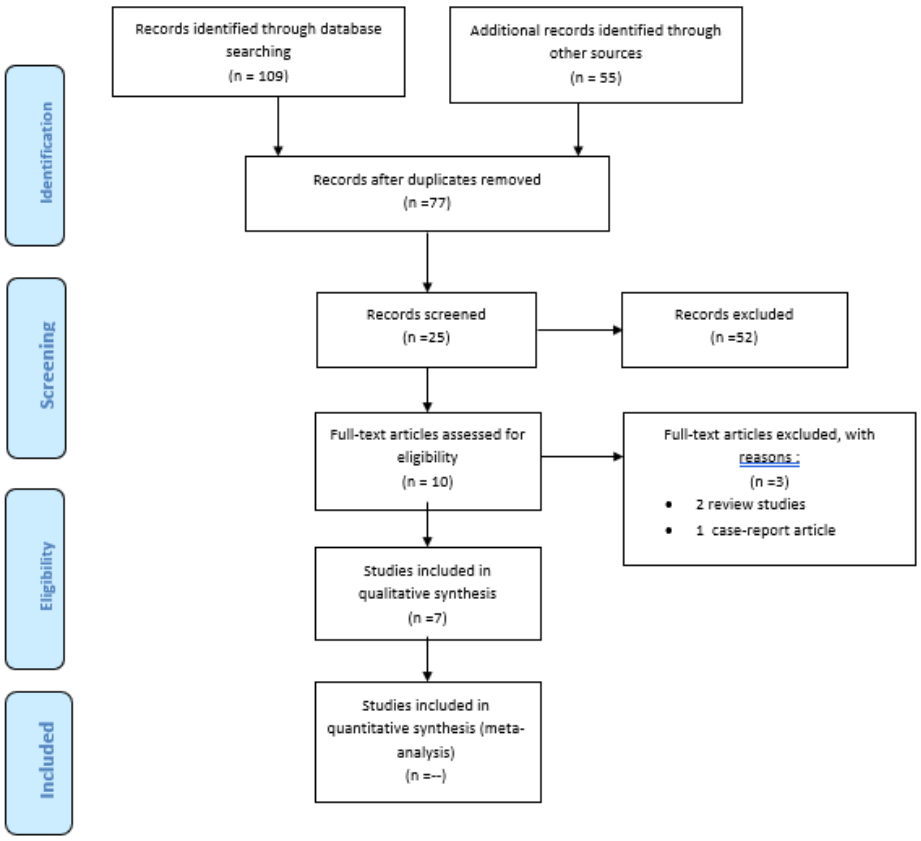

Figure 1. PRISMA flow-chart of selected criteria for the included article reports

3. Results

1. Study Selection

After searching through the databases, 143 study titles and abstracts were screened and 110 potentially relevant studies were downloaded for detailed review. After review of the downloaded studies, 10 had duplicate and/or cumulative data, 2 review studies and one case-report article, whereas 7 studies met criteria and had unique data. Table 2 summarizes these articles. Full texts of the remaining 7 articles were obtained.

2. Study Characteristics

The NICE quality assessment tool identified all studies of high quality (see Table 1).

Table 1. General Characteristics and Quality Criteria of Included Studies

Study	Quality Assessment*																								
	Population			Method of allocation to intervention									Outcomes						Analyses					Overall assessment	
	1	2	3	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	1	2	3	4	5	1	2
Kim& et al. 2018[16]	++	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	++	+	++	NA	NR	+	NR	++	+	+
Li & et al. 2020[17]	++	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	+	+	-	NA	NR	+	NR	++	+	+
KabalaN & et al. 2010[18]	+	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	+	+	-	NA	NR	+	NR	++	+	+
Jesus & et al. 2021[19]	-	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	+	+	-	NA	NR	+	NR	+	+	-
Calil & et al. 2020[20]	+	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	+	+	-	NA	NR	+	NR	++	+	+
Park & et al. 2016[21]	+	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	+	+	-	NA	NR	+	NR	++	+	+
Yi & et al. 2020[22]	+	+	+	+	+	NA	+	NA	+	+	+	+	+	+	+	+	+	-	NA	NR	+	NR	++	+	+

*Quality assessment of cases series studies checklist from National Institute for Health and Clinical Excellence: 1-Population: 1.Is the source population or source area well described? 2. Is the eligible population or area representative of the source population or area? 3. Do the selected participants or areas represent the eligible population or area? / 2- Method of allocation to intervention: 1. How was selection bias minimized? 2. Were interventions (and comparisons) well described and appropriate? 3. Were participants or investigators blind to exposure and comparison? 4. was the exposure to the intervention and comparison adequate? 5. Are the groups matched? 6. Were other interventions similar in both groups? 7. Were all participants accounted for at study conclusion? 8. Are the conditions provided in the study similar to the usual conditions of population? 9. Did the intervention or comparison differ significantly from usual practice in the population? / 3- Outcomes: 1. were outcome measures reliable? 2. Were all outcome measurements complete? 3. Were all important outcomes assessed? 4. Were outcomes relevant? 5. Were there similar follow-up times in exposure and comparison groups? 6. Was follow-up time meaningful? / 4- Analyses: 1. was exposure and comparison groups similar at baseline? If not, were these adjusted? 2. Was intention to treat (ITT) analysis conducted? 3. Was the study sufficiently powered to detect an intervention effect (if one exists)? 4. Were the estimates of effect size given or calculable? 5. Were the analytical methods appropriate? / 5- Overall assessment: 1. Are the study results internally valid (i.e. unbiased)? 2. Are the findings generalizable to the source population (i.e. externally valid)?
++: Indicates that for that particular aspect of study design, the study has been designed or conducted in such a way as to minimize the risk of bias/ +: Indicates that either the answer to the checklist question is not clear from the way the study is reported, or that the study may not have addressed all potential sources of bias for that particular aspect of study design/ -: Should be reserved for those aspects of the study design in which significant sources of bias may persist/ NR: Not reported/ NA: Not applicable
In overall assessment: ++: All or most of the checklist criteria have been fulfilled; where they have not been fulfilled the conclusions are very unlikely to alter. / +: Some of the checklist criteria have been fulfilled, where they have not been fulfilled, or not adequately described, the conclusions are unlikely to alter. /−: Few or no checklist criteria have been fulfilled and the conclusions are likely or very likely to alter.

Table 2. Summary of articles

Author	Type of Study	Control group	Intervention group	Gender	Mean Age (Year)	Evaluation Methods	Follow-up Periods (year/month/day)	Results
Kim et al.2018	Retrospective	____	-14 patients -Treatment with MARPE	10 women 4 men	22.7± 3.37	CBCT	One year	Significant increase in the nasal cavity volume immediately after the intervention and after one year- increased anterior and middle cross-sectional planes immediately following intervention and after one year; and no change in the posterior cross-sectional plane after one year
Li et al.2020	Retrospective	____	-22 patients -Treatment with MARPE	4 men 18 women	22.6± 4.5	CBCT	3 months	Increased nasal cavity volume and nasopharyngeal cavity volume
Kabalan et al.2010	Clinical trial	-30 patients - Treatment with hyrax	-30 patients -Treatment with MARPE	---	11-17	CBCT	6 months	No noticeable and significant increase in respiratory tract volumes
Jesus et al. 2021	Retrospective	____	-36 patients -Treatment with MARPE	---	---	CBCT	-	Tract expansion in the maxilla and the nose
Calil et al. 2020	Clinical trial	- 21 patients - Treatment with Damon self-ligating appliance	-16 patients -Treatment with MARPE	---	7.60 ± 24.92	CBCT	6 months	Increased intercanine and intermola distances and nasal base and jugular widths
Park et al. 2016	Retrospective	____	-14 patients -Treatment with MARPE	9 men 5 women	20.1	CBCT	38 days (24-66 days)	Increase in respiratory tract volumes
Yi & et al. 2020	Retrospective	____	-19 patients -Treatment with MARPE	15 men 4 women	4.39 ± 19.95	CBCT	3 months	The MARPE technique had increased nasopharyngeal volume and caused maxillary expansion, but did not produce any changes in glossopharyngeal, palatopharyngeal, and oropharyngeal volumes.

4. Discussion

Because of interdigitation of the midpalatal suture and adjacent articulations in late adolescence and in adults' patient, boDne-borne expansion such as mini-implant assisted rapid maxillary expansion (MARPE) is a good choice for maxillary expansion. Increased volume and crosssectional area of the nasal cavity have been reported after MARPE; because the nasomaxillary complex provides anterior bony support for the upper airway and expansion can effect on these structures [16]. The present study reviews the effect of Miniscrew-assisted palatal expansion on airway volume. In the current study, 7 research articles were reviewed. The age group of the participants in the studies reviewed was mainly the adolescence and young adult with the age range of 14 to 24.9 years. The follow-up interval was chiefly less than one year and ranged from one year to immediately following treatment. The literature reviews were dominantly retrospective and had made use of current evidence. The methodology with respect to changes in the

airway dimensions and the upper respiratory tract was conducted via using parameters obtained from CBCT in most studies. However, the studies used different metrics and measurements for evaluation; different parts of the airway tract were assessed in the included studies so a pooled outcome measurement was not possible.

Li et al.[2020] treated young individuals with transverse discrepancy via the MARPE method and studied the airway dimensions using CBCT three months after treatment. Their results show that after MARPE the bone effect accounted for 39.1%; the volumes of the nasal cavity and nasopharyngeal volume noticeably increased 2925.9 ± 4974.6 mm^3 and 734.9 ± 1045.1 mm^3, respectively. They stated that increased nasopharyngeal volume was associated with increased nasal floor width (2.3± 1.2 mm), and increased maxillary width (2.0 ± 1.0 mm) was not correlated to increased airway volumes directly [17]. The results of the study conducted by Park et al.[2016] demonstrated the effectiveness of the MARPE procedure in the increase of the airway volumes of young individuals with maxillary transverse discrepancy [21]. They examined the CBCT image after 2 to 3 months of treatment. Analyses showed that the palatal suture was opened following maxillary expansion using miniscrews placed in the palate which has subsequently been accompanied by increased intermolar width (5.4 ± 1.7mm) and Interpremolar width (5.5 ± 1.4mm) as well widening of the zygomatic arch and nasal cavity with rates of 0.8 ± 0.5 and 1.4 ± 1.0 mm, respectively. Calil et al. [2020] also demonstrated increased intermolar and intercanine width (56.68± 3.85 mm and 38.53±3.3 mm, respectively) as well as increased jugular and nasal base widths (59.96± 3.36 mm and 30.96±3.96 mm, respectively) after 6 months of treatment using the MARPE technique [20].

Also, Yi et al. [2020] showed the 8.84% increase in the size of the nasopharyngeal volume (502.00 ± 974.73 mm^3) three months after the patients underwent treatment with the MARPE technique [22]; and Park et al. similarly reported it accounted for 37.0% [21]. Examinations of Yi et al. study showed no significant changes in the palatopharyngeal, oropharyngeal, glossopharyngeal and airway total volume [22]. It should be mentioned that according to the study conducted by Kabalan et al., [2015] the results similar and they also stated that the MARPE procedure was not associated with effective treatment outcomes with respect to increased airway volumes [18].Albeit, Jesus et al. [2021] claimed that the MARPE procedure with the least dental effect and the greatest skeletal effect during expansion led to the integrated widening of the anterior region and posterior nasal cavity (23.21± 2.26 mm) [19].

Kim et al. evaluated the long-term effect of the MARPE procedure on the airway dimensions [16]; they demonstrated that the MARPE technique was associated with a significant increase in the nasal cavity volume immediately after treatment (1061.6 ± 613.9 mm^3), with an additional increase of 648.6± 827.2mm^3 during the 1 year after expansion ($P < 0.05$). Consequently, the nasal cavity volume increased by 1710.2 mm3 from before treatment to 1 year after treatment; and one year later and also significant increase in the nasopharyngeal volume after one year (942.4 ± 821.0 mm^3). Briefly, 9.9%, 5.5%, and 15.4% increase in the nasal cavity volume from before treatment to immediately after treatment, immediately after treatment to 1 year after treatment, and before treatment to 1 year after treatment, respectively; and the nasopharyngeal volume increased by 6.4%, 4.1%, and 10.5% respectively. They attributed the further increase in the volume of the nasal cavity to the following two reasons: 1- The location of the mini-screws 2- The resistance caused by zygomatic buttress and pterygomaxillary junction.

MARME could be a therapeutic option for nasal obstruction; because, it can improve nasal airflow, leading to better ventilator function through increased upper airway volume, though the initial purpose of the procedure was to correct a narrow maxilla. Although there are certain ambiguities such as its long-term effect on the airway dimensions (conducting studies with long-term follow-up), its impact on the respiratory indexes including apnea–hypopnea index, and improving effect on patients with obstructive sleep apnea; It is suggested that these factors (long-term follow-up and respiratory indexes) be considered in future studies.

Conclusion

The results of the present review study are as follows:

1. The nasal cavity, nasopharyngeal and total airway volume increased after MARME.
2. Retropalatal, retroglossal, and hypopharyngeal airway volume were not found to be changed significantly in these studies after MARPE.
3. The studies suggested that MARPE can be a helpful modality to improve breathing in young adults with maxillary constriction; because of this effect on airway volumes.

References

1. Bell RA. A review of maxillary expansion in relation to rate of expansion and patient's age. American journal of orthodontics. 1982 Jan 1;81(1):32-7.
2. Topal R, Arslan SG. The maxillary expansion procedures, the types, and the root resorption analysis methods. International Dental Research. 2019 Dec 31;9(3):145-51.
3. Krüsi M, Eliades T, Papageorgiou SN. Are there benefits from using bone-borne maxillary expansion instead of tooth-borne maxillary expansion? A systematic review with meta-analysis. Progress in orthodontics. 2019 Dec;20(1):1-2.
4. Agarwal A, Mathur R. Maxillary expansion. International journal of clinical pediatric dentistry. 2010 Sep;3(3):139.
5. Huang WJ, Creath CJ. The midline diastema: a review of its etiology and treatment. Pediatric dentistry. 1995 Jun;17:171-.
6. Gray LP. Results of 310 cases of rapid maxillary expansion selected for medical reasons. J Laryngol Otol. 1975 Jun;89(6):601–614.
7. Lee KJ, Choi SH, Choi TH, Shi KK, Keum BT. Maxillary transverse expansion in adults: Rationale, appliance design, and treatment outcomes. InSeminars in Orthodontics 2018 Mar 1 (Vol. 24, No. 1, pp. 52-65). WB Saunders. M
8. de Silva Fo OG, Boas CV, Capelozza LF. Rapid maxillary expansion in the primary and mixed dentitions: a cephalometric evaluation. American Journal of Orthodontics and Dentofacial Orthopedics. 1991 Aug 1;100(2):171-9.
9. Moon W. Maxillary Expansion in Skeletally Mature Patients with TADs. Temporary Anchorage Devices in Clinical Orthodontics. 2020 Apr 6:223-32.
10. Vale F, Albergaria M, Carrilho E, Francisco I, Guimarães A, Caramelo F, Maló L. Efficacy of rapid maxillary expansion in the treatment of obstructive sleep apnea syndrome: a systematic review with meta-analysis. Journal of Evidence Based Dental Practice. 2017 Sep 1;17(3):159-68.
11. Mirhashemi AH, Arab S, Bahrami R. Orthodontics as a therapeutic tool for managing sleep apnea: A review. Journal of Craniomaxillofacial Research. 2020 Oct 3:50-61.
12. Capalbo LC, Dal-Fabbro R, de Albuquerque Donine AL, Saraiva JS, Bigliazzi R, Weber SA, Bertoz AP. Rapid maxillary expansion as a treatment for obstructive sleep apnea syndrome in children and adolescents: an evaluation by polysomnography and quality of life. Research, Society and Development. 2021 Feb 27;10(2):e52710212825-.
13. Amaddeo A, Griffon L, Thierry B, Couloigner V, Joly A, Galliani E, Arnaud E, Khirani S, Fauroux B. Obstructive sleep apnea syndrome (OSA) in adolescents: therapeutic management. Journal of Dentofacial Anomalies and Orthodontics. 2018 Jan 1;21(1):107.
14. Cunha AC, Lee H, Nojima LI, Nojima MD, Lee KJ. Miniscrew-assisted rapid palatal expansion for managing arch perimeter in an adult patient. Dental press journal of orthodontics. 2017 Jun;22(3):97-108.
15. National Institute for Health and Care Excellence (Great Britain). Methods for the development of NICE public health guidance. National Institute for Health and Care Excellence; 2012.
16. Kim S-Y, Park Y-C, Lee K-J, Lintermann A, Han S-S, Yu H-S, et al. Assessment of changes in the nasal airway after nonsurgical miniscrew-assisted rapid maxillary expansion in young adults. The Angle Orthodontist. 2018;88(4):435-41.
17. Li Q, Tang H, Liu X, Luo Q, Jiang Z, Martin D, et al. Comparison of dimensions and volume of upper airway before and after mini-implant assisted rapid maxillary expansion. The Angle Orthodontist. 2020;90(3):432-41.
18. Kabalan O, Gordon J, Heo G, Lagravère MO. Nasal airway changes in bone-borne and tooth-borne rapid maxillary expansion treatments. International orthodontics. 2015;13(1):1-15.
19. Jesus A, Oliveira C, Murata W, Gonçales E, Pereira-Filho V, Santos-Pinto A. Nasomaxillary effects of miniscrew-assisted rapid palatal expansion and two surgically assisted rapid palatal expansion approaches. International journal of oral and maxillofacial surgery. 2021.
20. Calil RC, Ramirez CMM, Otazu A, Torres DM, de Araújo Gurgel J, Oliveira RC, et al. Maxillary dental and skeletal effects after treatment with self-ligating appliance and miniscrew-assisted rapid maxillary expansion. American Journal of Orthodontics and Dentofacial Orthopedics. 2020.
21. Park JJ, Park Y-C, Lee K-J, Cha J-Y, Tahk JH, Choi YJ. Skeletal and dentoalveolar changes after miniscrew-assisted rapid palatal expansion in young adults: a cone-beam computed tomography study. Korean J Orthod. 2017;47(2):77-86.
22. Yi F, Liu S, Lei L, Liu O, Zhang L, Peng Q, et al. Changes of the upper airway and bone in microimplant-assisted rapid palatal expansion: A cone-beam computed tomography (CBCT) study. Journal of X-ray science and technology. 2020(Preprint):1-13.