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Skeletal effects of mini-implant assisted rapid palatal expansion (MARPE) on the sagittal dimensions of the maxilla an in-vivo cone-beam computed tomography (CBCT) study

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ABSTRACT

Introduction: Transverse discrepancies of the maxilla is one of the most prevalent skeletal problems. Due to the drawbacks of conventional RPE and invasive surgical expansion, alternative methods were developed, such as Mini Implant-supported rapid maxillary expanders (MARPE). Many studies reported by Haas, Davis and Kronman, Akkaya et al. regarding the maxillary response after MARPE on the sagittal dimensions were inconclusive.

Aim: The aim of this study was to analyze the sagittal effects on the maxilla after Mini Implant assisted rapid palatal expansion (MARPE) in adolescents.

Materials and methods: Pre-treatment CBCT images (T1) were taken as a standard initial record for all patients and post-treatment CBCT (T2) was taken three months in retention after expansion with MARPE. The parameters SNA angle, Frankfort horizontal plane to NA angle, A-N perpendicular in mm, ANS – PNS (in mm) were measured and calculated for evaluation of the sagittal maxillary changes. Comparisons were then made between the two treatment groups at T1, T2 and T2 - T1.

Results: A positive increase was seen from pretreatment to post-treatment in both angular and linear measurements showing the significant sagittal skeletal change.

Conclusion: The study found a statistically significant forward displacement of maxilla after transverse skeletal expansion in adolescent patients with transverse problems achieved through MARPE.

INTRODUCTION

Transverse discrepancies of the maxilla are one of the most prevalent skeletal problems, which could be due to various factors like genetic or environmental, the effect of soft tissue, cleft palate and habits.[1] It may express as crossbite, narrow maxilla which has intermolar width less than 31 mm, accentuated curve of Wilson [1] and/or dark spaces at the corner of the mouth. [2] There are various removable and fixed maxillary expansion appliances that can be used depending on the age of the patients which include conventional Rapid Maxillary Expansion, Surgically Assisted RME (SARME) and the recent Mini-implant supported Rapid Palatal Expansion (MARPE).

In adolescents, conventional RPE effectiveness decreases because of increased fusion of palatal sutures leading to more dentoalveolar changes than skeletal changes [3-6]. Surgical assisted RME (SARME) can overcome the limitations mentioned earlier but has drawbacks like invasive procedures, expensive, and hospitalization requirements for surgery. Due to the drawbacks of conventional RPE and invasive surgical expansion methods, alternative methods were developed such as Mini Implant-

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supported rapid maxillary expanders (MARPE).

Many studies such as Haas [7], Davis and Kronman [8], Akkaya et al [9] have reported the maxillary re-sponse after MARPE on the sagittal dimension, but their results were inconclusive. So, this study's objective was to analyze the sagittal effects on the maxilla after Mini Implant assisted rapid palatal expansion (MARPE) in adolescents.
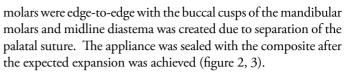
MATERIALS AND METHODS

This study included fifteen healthy patients who were treated with the Mini-Implant Assisted Rapid Palatal Expansion (MARPE).

Inclusion criteria were 1) Patient's age ranged between 16 to 21 years wherein the growth was almost completed 2) Patients with skeletally constricted maxillary arches which required expansion of less than 5 mm. [10] 3) Patient belonging to Indian ancestry.

Exclusion criteria were 1) Patients with general developmental anomaly 2) Patients with congenital anomalies of the palate such as cleft palate 3) Patients with any significant medical history that would affect physical development and growth. Ethical Approval Number Adm/7505.A/2016.

The appliance Mini-Implant Assisted Rapid Palatal Expansion consisted of four 1.8 x 10 mm (6mm threaded portion, 4mm soft tissue contacting area) miniscrew implants (C1846) (ORLUS IMPLANTS, FORESTADENT). Two anterior implants were placed 3–4 mm laterally to the midpalatal suture and 3– 4 mm posterior to the incisive foramen. Two posterior implants were inserted 3–4 mm laterally to the midpalatal suture in the palatal alveolus bilaterally between the projection of the second premolar and first molar roots. [9] Loops of 1mm stainless steel wire were made and soldered to the hyrax screw to incorporate the mini-implants at the desired positions. After the mini-implant stabilized, the implant head and the loop were covered with composite (figure 1). At the delivery time, the expansion screw was activated with 2 turns followed by 1 turn per day until overcorrection was achieved. The palatal cusps of the maxillary

molars were edge-to-edge with the buccal cusps of the mandibular molars and midline diastema was created due to separation of the palatal suture. The appliance was sealed with the composite after the expected expansion was achieved (figure 2, 3).

A standard initial record of pretreatment CBCT image (T1) and post-treatment CBCT (T2) was taken after three months in retention for all patients. The scans were obtained with an iCAT machine (Imaging Sciences International) taken with the voxel size set at 0.25 to 0.4 mm and either at 20 sec. or 26.9 sec. scan. The placement of landmarks was accomplished on 3D Imaging Software. The CBCT scans were oriented and visualized in all three planes of space to obtain a lateral view. Oblique slices of lateral view were made to locate the landmarks used for evaluation. To obtain standardized oblique slices and compare T1 and T2, the point nasion was used as a stable reference.

For angular measurements, an increase in value was considered positive, and a decrease in value was considered negative. For linear measurements, forward displacement of the skeletal structure from T1 to T2 was given a positive value, whereas backward displacement was considered negative.

Figure 2. MARPE Post expansion (sealing)

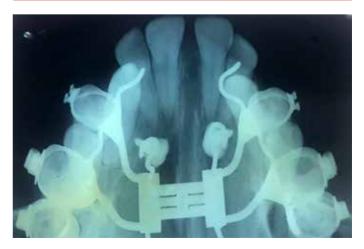*Figure 1. MARPE - Intraorally placed tooth and tissue borne appliance*

Figure 3. Occlusal radiograph of MARPE Post expansion (sealing)

Table 1. Landmarks for sagittal maxillary evaluation

In degrees	In millimeters
SNA angle	A-N perpendicular
Frankfort horizontal plane to NA angle	ANS to PNS

All measurements and data were completed by the same examiner and verified by the second examiner.

The landmarks used for evaluation of the sagittal maxillary changes are defined in Table 1. [6]

Once the landmarks were defined, the parameters listed in Table 1 were measured and calculated. Comparisons was made between the two treatment groups at T1, T2 and T2 - T1.

Statistical analysis

The data on continuous variables are presented as Mean and Standard deviation (SD). The pair-wise statistical comparison (T1 vs. T2) of means of continuous variables was made using paired t-test. The mean difference between T1 and T2, along with 95% confidence interval (CI), was calculated for each parameter included in the study. [11] In the study, the p-values less than 0.05 were considered to be statistically significant. All the hypotheses were formulated using two-tailed alternatives against each null hypothesis (hypothesis of no difference). The entire data was statistically analyzed using Statistical Package for Social Sciences (SPSS ver 21.0, IBM Corpo-ration, USA) for MS Windows.[12, 13]

RESULTS

The distribution of mean ± SD of SNA at T1 and T2 was 79.60 ± 2.99 degrees and 80.87 ± 3.25 degrees, respectively. The mean difference and 95% CI of mean difference between T2 and T1 were 1.27 (0.94 – 1.59). The distribution of mean SNA at T2 is significantly higher compared to mean SNA at T1 (P-value<0.001). (Table 2)

The distribution of mean ± SD of FH-NA at T1 and T2 was 85.53 ± 2.13 deg and 86.67 ± 2.13 deg respectively. The mean difference and 95% CI of mean difference between T2 and T1 were 1.13 (0.94 – 1.33). The distribution of mean FH-NA at T2 was significantly higher compared to mean FH-NA at T1 (P-value<0.001). (Table 2)

Hence a significant difference was seen in angular parameters from T1 to T2, showing an increase in measurements that were considered positive.

The distribution of mean ± SD of A-Nperp at T1 and T2 was 1.38 ± 2.26 mm and 2.67 ± 1.70 mm, respectively. The mean difference and 95% CI of mean difference between T2 and T1 were 1.29 (0.83 – 1.74). The distribution of mean A-Nprep at T2 is significantly higher compared to mean A-Nprep at T1 (P-value<0.001). (Table 3)

The distribution of mean ± SD of ANS-PNS at T1 and T2 was 47.45 ± 3.48 mm and 48.79 ± 3.56 mm, respectively. The mean

difference and 95% CI of mean difference between T2 and T1 were 1.35 (0.66 – 2.03). The distribution of mean ANS-PNS at T2 was significantly higher com-pared to mean ANS-PNS at T1 (P-value<0.001). (Table 3)

Hence a significant difference was seen in linear parameters from T1 to T2 showing increase in measurements that were considered positive.

Statistically significant change was observed in both angular and linear measurements.

Table 2. The distribution of mean angular parameters studied.

	T1		T2		Difference (T2-T1)		P-value
Parameters	Mean	SD	Mean	SD	Mean	95% CI	T1 v T2
SNA (0)	79.60	2.99	80.87	3.25	1.27	0.94 – 1.59	0.001***
FH-NA (0)	85.53	2.13	86.67	2.13	1.13	0.94 – 1.33	0.001***

P-value by paired t-test. P-value<0.05 is considered to be statistically significant.

Table 3. The distribution of mean linear parameters studied.

	T1		T2		Difference (T2-T1)		P-value
Parameters	Mean	SD	Mean	SD	Mean	95% CI	T1 v T2
A-Nperp (mm)	1.38	2.26	2.67	1.70	1.29	0.83 – 1.74	0.001***
ANS-PNS (mm)	47.45	3.48	48.79	3.56	1.35	0.66 – 2.03	0.001***

P-value by paired t-test. P-value<0.05 is considered to be statistically significant. ***P-value<0.001.

DISCUSSION

MARPE is a tooth and tissue-borne expansion appliance in which forces are delivered primarily to the four anchoring mini-implants [14,15] causing more skeletal expansion than dental expansion. This, in turn, decreases the load on the buccal periodontal ligament of teeth reducing chances of root resorption.[16,17] The site of placement of the four palatal mini-implants had thick palatal cortical bone and attached gingiva. All these factors played a major role in the stability of the im-plants ensuring the expansion of maxillary arch without failure of mini-implants.[18]

In this study CBCT was preferred because of its high dimensio-nal accuracy, reliability for quantifying the structural changes in all three planes of space and acquire accurate radiographic images. [11, 19, 20]

Analysis of the results showed a slight forward displacement of maxilla as the mean distribution of SNA angle and FH-NA angle at T2 was significantly higher when compared to T1 (P-value<0.001) (Table 2, Graph 1,2). A significant increase was also observed in the mean distribution A-Nperp(linear) at

T2 when compared to T1 (P-value<0.001). (Table 3, Graph 3) indicating a slight forward displacement of maxilla. Hass et al.[4] was the first to mention forward displacement of maxilla after expansion. Studies by Haas et al.[7], Miriam Habeeb et al.[4] and Chung et al.[21] also showed similar results with a significant change in value from T1 to T2 for SNA angle, FH-NA angle and A-Nperp linear measurements.

The results also showed a slight increase in the length of maxilla as the distribution of mean ANS-PNS (linear) at T2 was significantly higher compared to T1 (P-value<0.001). (Table 3, Graph 4)

It should be noted that the sagittal changes found may not be clinically significant but were statistically significant. Chung et al. reported that one should not anticipate RPE can correct a skeletal Class III malocclusion, but a need for reverse-pull headgear is indicated in children after RPE.[21]

There are additional studies in which miniscrew assisted rapid palatal expansion has been found to be of benefits like the volume and cross-sectional area of the nasal cavity increased, thereby increasing nasal airway in obstructive sleep apnea patients.[7,22,23] There are also studies in which the RPE reduced the percentage of ectopic eruption paths, as after expansion, canine significantly moved further from midline, causing improvement in percentage of an eruption.[24]

Though MARPE has many advantages, there are few drawbacks, such as being very technique sensitive, patient discomfort due to bulky appliances, patient co-operation for regular activation, and difficulty maintaining oral hygiene.[25]

The study had limitations such as small sample size and only short-term effects were considered. A study with larger sample size is needed to understand the complete dynamics of the expansion of MARPE and evaluate the reproducibility of the results and its long-term stability.

CONCLUSIONS

The study found a statistically significant forward displacement and increase in the length of maxilla after transverse skeletal expansion using MARPE in adolescent patients with transverse problems.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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