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Huei-Rou Tsai

Kwok-Hing Ho

Chih-Wei Wang

Kai-Long Wang

Shun-Chu Hsieh

See next page for additional authors

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Abstract

Purpose: Various microimplant- assisted rapid palatal expansion (MARPE) appliances were developed in these years. By applying this procedure, maxillary transverse deficiencies can be corrected in adults with limited dental tipping. However, some undesirable effects could happen during treatment. In this study, we aimed to record the incidence of any adverse effect or complication. Pain score was also measured during treatment. **Patients and Methods:** Twenty-nine patients (22.8 ± 8.6 years old) with 13 males and 16 females were enrolled. Clinical photographs, radiographs and cone-beam computed tomography were taken before insertion of MARPE and after expansion. Interview was conducted by one orthodontist with a questionnaire recording the experiences throughout the MARPE procedure. **Results:** The mean pain score during activation was 4.38 ± 2.4 , moderate in pain category. Inflammation of palatal mucosa was reported by 48.3% of subjects. There were 41.4% of subjects complained difficulty in cleaning and 37.9% experienced soft tissue impingement. Distortion of expander components presented in four subjects, and only one microimplant was loosened during expansion. Two subjects reported tinnitus on and off during MARPE activation. Sutures failed to open on three subjects, and the overall success rate was 89.7% in terms of suture opening. Self-perceived asymmetrical expansion was reported by four subjects. **Conclusions:** Although some adverse effects and complications were reported in this study, MARPE can still provide good outcomes on correcting maxillary transverse discrepancies in skeletally matured patients. The overall success rate is high with moderate patient's pain level. Oral hygiene should be emphasized since the inflammation of palatal mucosa is the most frequent complication during treatment. With all the possible adverse effects in mind, clinician may be more confident in providing MARPE treatment.

Keywords

Microimplant-assisted rapid palatal expansion (MARPE); Maxillary transverse deficiency; Complications; Success rate

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Authors

Huei-Rou Tsai, Kwok-Hing Ho, Chih-Wei Wang, Kai-Long Wang, Shun-Chu Hsieh, and Heng-Ming Chang

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Huei-Rou Tsai, Kwok-Hing Ho, Chih-Wei Wang, Kai-Long Wang, Shun-Chu Hsieh, Heng-Ming Mark Chang*

Orthodontic Department, Chang Bing Show Chwan Memorial Hospital, Changhua, Taiwan

ABSTRACT

Purpose: Various microimplant-assisted rapid palatal expansion (MARPE) appliances were developed in these years. By applying this procedure, maxillary transverse deficiencies can be corrected in adults with limited dental tipping. However, some undesirable effects could happen during treatment. In this study, we aimed to record the incidence of any adverse effect or complication. Pain score was also measured during treatment.

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Results: The mean pain score during activation was 4.38 ± 2.4 , moderate in pain category. Inflammation of palatal mucosa was reported by 48.3% of subjects. There were 41.4% of subjects complained difficulty in cleaning and 37.9% experienced soft tissue impingement. Distortion of expander components presented in four subjects, and only one microimplant was loosened during expansion. Two subjects reported tinnitus on and off during MARPE activation. Sutures failed to open on three subjects, and the overall success rate was 89.7% in terms of suture opening. Self-perceived asymmetrical expansion was reported by four subjects.

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INTRODUCTION

Transverse maxillary deficiency has been reported to affect 8%–23% of adolescent and nearly 10% of adult populations.^{1–5} Proffit and White⁶ investigated the US population and found 30% of the adult patients had transverse discrepancies, which may need surgical-orthodontic correction.

McNamara⁷ introduced a method to evaluate the maxillary transverse dimension. He measured the distance between the closest points of the upper first molars as transpalatal width and a width of 36–39 mm can accommodate an average-sized maxillary dentition with no crowding or spacing. Transpalatal width less than 31 mm was considered as constriction and could result in dental arch crowding. Betts et al.⁸ advised that transverse discrepancy of 5 mm was the limit of camouflage

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* Corresponding author at: Orthodontic and Dental Department, Chang Bing Show Chwan Memorial Hospital, No.6, Lugong Rd., Lugang Township, Changhua County 505, Taiwan. Fax: +886 4 7812869.
E-mail address: markortho@gmail.com (H.-M. Mark Chang).

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treatment, and they advocated orthopedic or surgical expansion if the discrepancy was beyond the limit.

Narrowing of maxilla in growing patient was conventionally treated with rapid palatal expansion (RPE). However, tooth-borne RPE may produce some unwanted effects, e.g. lateral tipping of posterior teeth, buccal root resorption, buccal bone dehiscence, instability of the expansion.^{9–16} When RPE is applied in skeletally matured patient, it is considered to be less effective because the mid-palatal suture has been fused and ossified.^{17,18} The increased interdigitation of the craniofacial sutures are the main reason making maxilla difficult to split.^{19,20} Surgical-assisted rapid palatal expansion (SARPE) is a common option recommended for adult patients with transverse discrepancies. However, some limitations or complications should be noted such as complex treatment process, significant hemorrhage, gingival recession, root resorption, injury to the branches of the maxillary nerve, devitalization of teeth, infection, pain, periodontal breakdown, and sinus infection.²¹

In these years, various microimplant-assisted rapid palatal expansion (MARPE) appliances were developed to expand the scope of maxillary expansion in skeletally matured patients. The expander, which was secured on the palate with microimplants, may exert the expansion force to the circum-maxillary sutures while activation and this may avoid the unnecessary osteotomies.²² MARPE has been demonstrated to be successful on many clinical aspects including constricted maxilla, mild class III skeletal pattern, obstructive sleep apnea (OSA) and compromised periodontium/dentition with maxillary width deficiency.^{22,23} However, some undesirable effects may happen during MARPE procedure, but these were less discussed in the literatures. In this study, we aim to record any possible complication or adverse effect related to MARPE during the whole treatment procedure. Patient's pain score was also recorded.

MATERIALS AND METHODS

This was a prospective study to record patients' experiences of using MARPE during orthodontic treatment from 2018 to 2020. The inclusion criteria were:

1. Patient who sought orthodontic treatment and had maxillary transverse discrepancy problem.
2. Patient who were prescribed MARPE and agreed to join the survey.

3. Patient who had complete orthodontic records and cone-beam computed tomography (CBCT) images before and immediately after expansion.

The exclusion criteria were:

1. Patient who had previous comprehensive orthodontic treatment.
2. Patient who had any surgical procedure over the maxillary region.
3. Patient who had any systemic disease.

Twenty-nine patients (13 males; 16 females) who met the inclusion criteria were enrolled. Full orthodontic records, including photographs (intra-oral and extra-oral), cephalograms (lateral and postero-anterior), panorex and CBCT, were taken before microimplant insertions.

Maxillary Skeletal Expander (MSE) Type-2 (Great Lakes Dental Technologies, Tonawanda, New York, USA) was used as MARPE device in this study to expand skeletally constricted maxilla. The MSE was introduced by Moon with 4 slots around the appliance.²⁴ The MSE device was advised to position at the maxillary first molar level, and the length of microimplant (1.8 mm in diameter) was determined by the palatal bone thickness at this region from CBCT images. Three screw lengths are available (9 mm, 11 mm, and 13 mm) in order to achieve bicortical engagement. All surgical procedures were performed by one operator, and patients were advised to activate the screws three weeks after surgery. The expansion protocol was three turns per day initially followed by one to two turns per day when a diastema appeared. The expansion was ceased until posterior dental crossbite has fully corrected.

Patient interview was conducted by one investigator at the appointment when patient was instructed to stop expansion. Fixed appliance orthodontic treatment was not commenced at this stage. A questionnaire was designed to understand patient's MARPE experiences with eight yes/no questions and one open-ended question if patient had any other problem(s) not mentioned above (Table 1). The patients were also asked to mark a maximum pain score during the whole procedure from 0 to 10 on a 10-cm scale.

This study is compliance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Show Chwan Memorial Hospital (No. 107040). Informed consent was obtained from all the participants.

Table 1. Questionnaire used in the interview.

Questionnaire related to patient's experiences during microimplant-assisted rapid palatal expansion (MARPE) treatment		
■ Yes/No questions:	Yes	No
1. Swelling or inflammation of palatal gingiva		
2. Soft tissue impingement while expansion		
3. Difficulty in cleaning around device		
4. Distortions of the device		
5. Microimplant loosening		
6. Epistaxis		
7. Sinusitis		
8. Failure of mid-palatal suture opening		
■ Open-ended question:		
Any other problem encountered during treatment		
■ Maximum pain score:		
		

Statistical analysis

Continuous data were presented as mean $\pm$ standard deviation. Discrete data were presented as number and percentage. Relationship between age and pain score was analyzed by Pearson's Correlation analysis. Comparison of pain scores between male and female patients was carried out by Mann–Whitney U test. All statistical analyses were performed by IBM SPSS Statistics for Windows, version 24.0 (IBM Corp., Armonk, NY, USA). A p-value of <0.05 was considered to be statistically significant.

RESULTS

Twenty-nine questionnaires and interview results were collected. Patients' average age was 22.8 ± 8.6 years (range, 12.7–43.5 years) with 13 males and 16 females.

The average pain score during MARPE was 4.38 ± 2.4 , which referred to “moderate pain” in pain category. Age and pain score revealed no significant correlation ($r = 0.327$, $p = 0.083$). Pain scores between males and females also revealed no significant difference (male, 3.54 ± 1.85 ; female, 5.06 ± 2.62 ; $Z = -1.596$, $p = 0.111$).

The pain score reported by each subject was shown in Figure 1 individually.

With regard to adverse effect during operation, epistaxis occurred in one subject during microimplant insertion. Unexpected perforation of a supernumerary tooth was accidentally found in another subject (Figure 2).

Some complications happened during expansion procedure and the incidence rates were presented in Table 2. 48.3% of the subjects reported swelling or

inflammation over the palatal mucosa, 41.4% of the subjects complained of difficulty in cleaning around the device, and 37.9% experienced soft tissue impingement while expansion. Soft tissue impingement was recorded if MSE main body or surrounding holding arms were covered by the overgrowth palatal mucosa. Distortion of MSE devices were presented in four subjects, including worn-outs of the spanner keys in three cases and expansion screw bending in one case. Tinnitus was reported by two subjects during expansion period. The symptom still presented on and off after active expansion. But it subsided when the MSE devices and microimplants were removed. One microimplant loosened was noted in one subject before expansion and this was therefore removed. One subject reported acute sinusitis one week during expansion. However, dental origin was diagnosed with periapical abscess over patient's upper left first molar.

Failure of mid-palatal suture opening was shown in three subjects (two males and one female individually). Asymmetrical expansion was reported by four subjects (all females). Patients perceived their interincisal gaps were not opened symmetrically. Initial and post-expansion frontal portraits and intra-oral photos were assessed to determine if the patient had asymmetrical expansion (Figure 3). The axial sections of the CBCT images of these patients were also used to confirm this phenomenon (Figure 4).

DISCUSSION

Pain scale in the MARPE treatment

Patients' average pain score was 4.38, which indicated moderate pain in category, but the scores were quite divergent with the standard deviation of 2.40. Nearly half of the subjects rated the pain score lower than 3. However, still five subjects rated the score greater than 7. Among the patients who reported very severe pain or above, we found the majority were females (four females and one male respectively). Women tend to exhibit greater pain sensitivity, enhanced pain facilitation and reduced pain inhibition compared with men, though the magnitude of these sex differences varies across studies.^{25,26} However, if we further assessed the correlation between pain score and sex, no statistical significance could be found (male, 3.54 ± 1.85 ; female, 5.06 ± 2.62 ; $Z = -1.596$, $p = 0.111$) though female tended to rate score higher. No correlation can be established between pain score and age ($r = 0.327$, $p = 0.083$), either. Pain perception is a

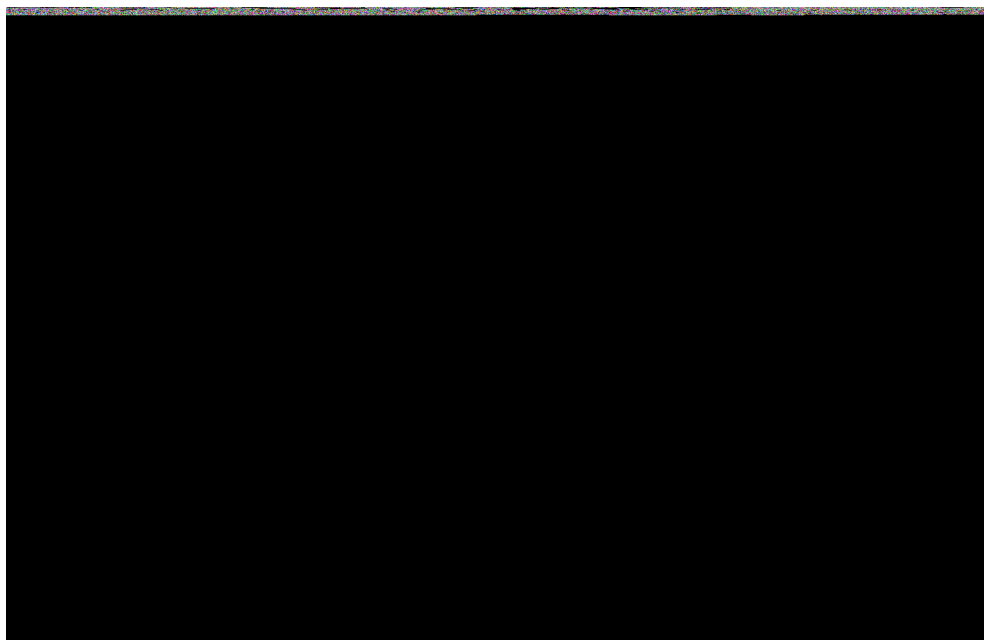


Figure 1. The pain score during activation of MARPE.

very patient-orientated issue, and multiple biological and psychosocial variables could contribute to these individual differences, including demographic variables (e.g. sex, age and ethnic group), genetic factors, and psychosocial processes.²⁷ Explaining the possibility of pain and discomfort before MARPE should be emphasized.

Adverse effects during operation

Placement of microimplants along the mid palatal suture was relatively safe in clinical procedure. The insertion sites of MSE was recommended at the first molar level of the paramedian area, which is far away from any adjacent anatomic structure, e.g. incisive foramen, major palatine foramen, greater palatine artery. Besides, Winsauer et al.²⁸ found good palatal bone quality and thickness can be obtained at the area of 3–4 mm behind the incisive

foramen and 3–9 mm lateral to the midpalatal suture. This area is recommended for microimplant insertion in order to achieve better primary stability.

Very few iatrogenic injuries were reported during the insertion of microimplant. However, one subject in this study presented epistaxis because of perforation of the nasal mucosa during pilot drilling. Bicortical engagement of microimplants was encouraged by most MSE studies to reduce the risk of screw distortion and bending while device activation.^{29,30} However, the depth of initial drill should be carefully measured before operation. The use of CBCT image is strongly advised to evaluate patient's palatal bone thickness over the implant sites to reduce the risk of nasal mucosal perforation. Luckily, microimplant perforation of the nasal cavity seldom cause any major clinical complication.³¹ Crismani et al.²⁵ investigated 20 palatal implants (3.3 mm in diameter; 4–6 mm in length) and



Figure 2. Perforation of a supernumerary tooth by a microimplant.

Table 2. Adverse effects or complications recorded during MARPE procedure.

	Numbers	Incidence rate
Adverse effect during operation		
Epistaxis	1	3.45%
Perforation of supernumerary tooth	1	3.45%
Complications reported during expansion		
Swelling or inflammation of the palatal mucosa	14	48.28%
Difficulty in cleaning around the device	12	41.38%
Soft tissue impingement	11	37.93%
Distortion of the device	4	13.79%
Tinnitus	2	6.90%
Microimplant loosening	1	3.45%
Sinusitis	1	3.45%
Failure or adverse effect of suture opening		
Failure of suture opening	3	10.34%
Asymmetrical expansion	4	13.79%
Total patient numbers = 29		

reported a perforation depth of less than 1.3 mm did not necessarily lead to mucosal perforation. Although this finding may not be directly applied to microimplant, which is much smaller in diameter, the pilot drilling procedure was similar. Pilot drilling with light pecking motion and using rubber stopper as depth indicator are strongly recommended (Figure 5).

An unexpected perforation of a supernumerary tooth happened in one subject. Supernumerary tooth may present in any region of mandible or maxilla, and the premaxilla is the most often-seen location. The perforated supernumerary tooth was located in hard palate and was difficult to be found on the radiographic examinations. Some diseases or syndromes are associated with high prevalence of supernumerary tooth, including cleft lip and palate. The prevalence was reported to be 22.2% in the unilateral cleft lip and/or palate patients.³² The fragmentation of the dental lamina may be related to the supernumerary tooth formation while cleft formation.³³ In this case, we assumed a small fragment of dental lamina was embedded while palatine shelves fusion in the embryo development. This was the only reason we can think of about the presence of supernumerary tooth in the hard palate.

Complications after operation/during expansion

Microimplants are widely used as temporary anchorage device in orthodontics. There are numerous advantages of using microimplants including low cost, small dimension, simple insertion/removal procedure, and the possibility of immediate loading.³⁴ However, there were still some complications, such as inflammation around the microimplant, injury to the adjacent structure and failure of the microimplants, reported in the literature.³⁵

In our study, almost half of the subjects have experienced inflammation or swelling of palatal mucosa during expansion stage. Low dose of Amoxicillin (250 mg every 8 h for 3 days) was routinely prescribed to patient right after MSE operation, and very few inflammation or discomfort happened at this stage. However, difficult cleaning of MSE device and inflammation around was frequently encountered during expansion. Higher dose of Amoxicillin (500 mg every 8 h for 5 days) was prescribed if purulence was noted over the palatal mucosa and the use of chlorhexidine mouth rinsing was suggested.

Distortion of MSE device was noted in four subjects during expansion, including three spanner key worn-outs and one expander distortion. The worn-outs of the spanner keys were probably resulted from inaccurate positioning of the keys to activate the nuts. We also noted the metal material of the spanner key is softer than that of the nut, which may explain the worn-out of the inner surface of key. The distortion of the expander happened in a case that suture failed to open. We therefore inferred the distortion from the excessive resistance around mid-palatal and surrounding sutures during activation.

Tinnitus has occurred in two subjects during MSE activation, and the symptom still present on and off in the retention stage after expansion. We therefore decided to early remove the MSE devices and microimplants, and luckily symptom subsided immediately and no more tinnitus was reported from both cases. Tinnitus could be related to Eustachian tube dysfunction (ETD), which may be caused by local swelling over the tube after zygomaticomaxillary complex expansion. Cantarella et al.³⁶ found both maxilla and zygoma could be displaced significantly in the horizontal plane accompanied with bone bending over zygomatic

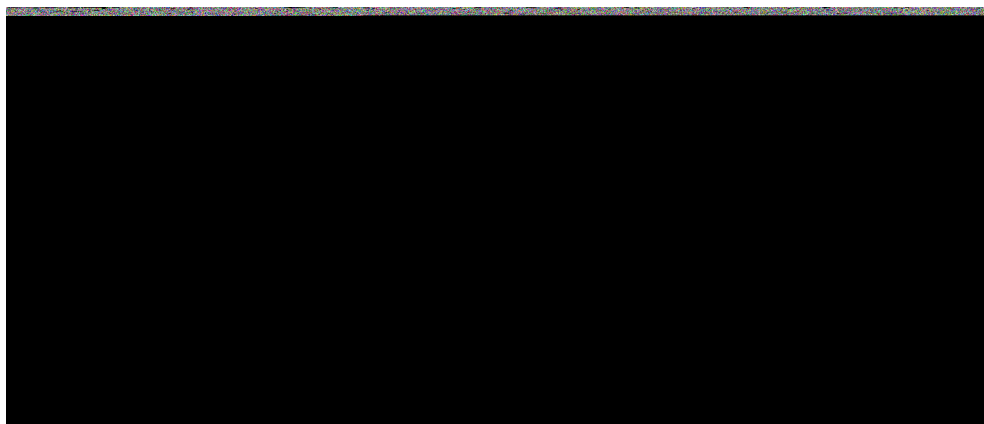


Figure 3. Patient-perceived asymmetrical expansion after MARPE. Pre-and post-expansion frontal portraits and intra-oral photos were used for assessment. Lines passing through labiale superius (LS, the center of Cupid's bow) and the base of labial frenum were used as vertical references to evaluation the degree of differential expansion in two sets of photos.

arch and zygomatic process of the temporal bone after MSE treatment. These zygomaticomaxillary changes may alter the mucosal lining of Eustachian tube, which is located just above soft palate. When the mucosal lining of the tube was swollen, the tube opening/closing function is disturbed. The signs of ETD comprise tinnitus, pain, reduced hearing, full filling in the ear, and problem with balance.³⁷ Fortunately, only mild symptom was presented in our cases and relieved after removal of the devices.

Regarding the failure rate of microimplant, most of the analyzed reviews reported a high success rate

of 90% or more except one systematic review.³⁸ This review reported a lower success rate of less than 56%.³⁹ The reason of the lower success rate was due to early loading (within 4 weeks) of the orthodontic force in adolescent patients (15.9 ± 1.2 years). A latent period of 3 months was recommended by the authors for the success rate improvement in adolescents. In our study, only one microimplant loosened in one 24-year-old female three weeks after operation. The microimplant was removed and reinsertion of a new one three weeks later. The microimplant loosening could be explained by

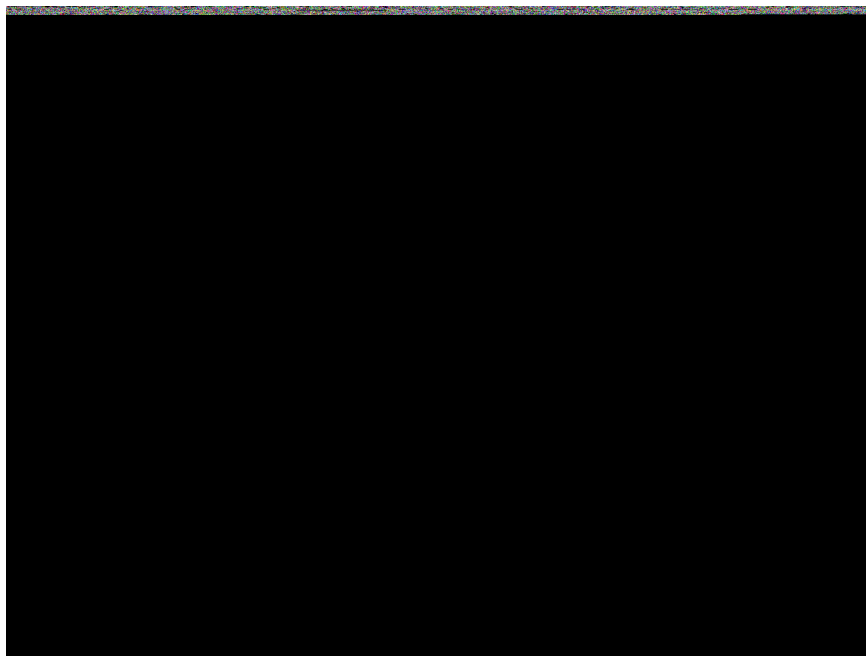


Figure 4. The CBCT image series of the same patient who perceived asymmetrical expansion in Figure 3. A: Axial section of pre-expansion CBCT. B: Axial section of post-expansion CBCT. C, Coronal section of pre-expansion CBCT. D, Coronal section of post-expansion CBCT. Mid-sagittal plane was determined by linking ANS and PNS points. Asymmetrical expansion was confirmed in both axial and coronal sections.

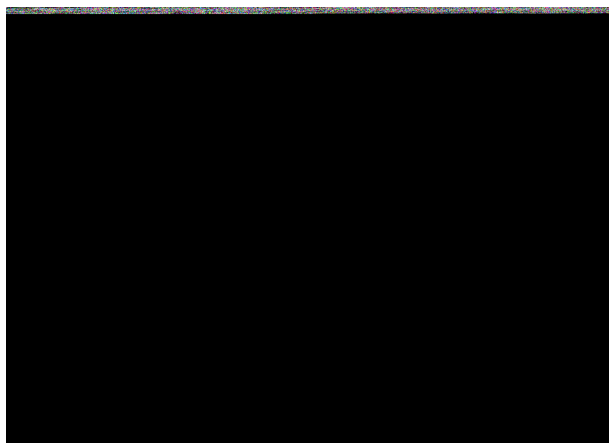


Figure 5. The use of rubber stopper as depth indicator to prevent nasal mucosa damage during pilot drilling.

insufficient cortical bone thickness at the implant site, which resulted in inadequate primary stability.

One subject reported acute sinusitis one week after MARPE activation. However, dental origin infection with periapical abscess was diagnosed on patient's upper left first molar. This tooth had endodontic treatment before and presented no sign or symptom initially. Compression of the periodontal ligament (PDL) space during expansion can alter the blood flow around the affected tooth, which may revitalize the anerobic bacteria flora and cause abscess flare-up. Thorough examinations of all endodontically treated or largely restored tooth/teeth should be done before all types of rapid palatal expansions.

Failure or adverse effect of suture opening

Only three subjects failed to have suture opening after MSE expansion. The remaining subjects contributed to an 89.7% success rate on suture opening, which was competitive to other MARPE studies in the literature (84.2%–86.98%).^{17,40,41} Among these three failure cases, patients' age and gender were different with one young female (13 years 8 months) and two adult males (28 years 9 months and 33 years 11 months). Angelieri et al.⁴² introduced a staging system to evaluate the maturational status of patients' midpalatal sutures. They took CBCTs on 140 subjects (age from 5.6 to 58.4 years) and divided them into four groups according to their chronological ages (5–11 years, 11–14 years, 14–18 years, and >18 years, respectively). They found the chronologic age was unreliable for determining the developmental status of mid palatal sutures and suggested using CBCT to evaluate patient's maturational stage before providing rapid

palatal expansion treatment. The maturation stages of these three subjects from the initial CBCTs were stage B, D and E respectively (Figure 6). Higher maturational staging indicates higher degree of suture integration and may have more resistance against suture opening. The 13-year 8-month-old female who presented mid-palatal suture in stage B, which should be easy to open. However, when we exam different levels of the axial views in vertical dimension, we found higher degree of suture integration at the higher level around the subnasal area (Figure 6, patient A, post-expansion). This could explain why this young female failed on suture opening. On the other hand, the pain scores of these three subjects were 6 (13-year and 8-month old female), 4 (28-year and 9-month old male), and 0 (33-year and 11-month old male) individually. Failure of suture opening seems not to generate more pain during expansion.

Asymmetric expansion was reported by four subjects who perceived their interincisal gaps opened asymmetrically. These cases all presented incisor separation more on one side than the other. Some even had nearly scissors bite on the greater expansion side and edge-to-edge bite on the lesser side with mild occlusal plane canting. Cantarella et al.⁴³ also found this phenomenon in their study and reported on average one half of the ANS moved more than the contralateral half by 1.1 ± 1.0 mm. Elkenawy et al.⁴⁴ further divided patients into symmetric and asymmetric expansion groups by using 1.1 mm of ANS deviation as a reference. In the asymmetric group, the expansion amounts were significantly larger on the greater sides at the anterior nasal spine (ANS), posterior nasal spine (PNS) and zygomaticomaxillary point (ZMA). The deviation amounts of these three landmarks were 2.22 ± 0.89 mm, 1.77 ± 1.1 mm and 1.30 ± 1.18 mm respectively. The deviation of the ANS could affect the soft tissue expression over the premaxilla and resulted in esthetic problem. This potential adverse effect should be warned in advance, especially on patients who already had facial asymmetry.

In the past, SARPE is a widely-used procedure for the correction of transverse maxillary deficiency in skeletally matured patients. However some limitations and complications were reported including high cost, complex treatment process, significant hemorrhage, gingival recession, root resorption, injury to the branches of the maxillary nerve, devitalization of teeth and altered pulpal blood flow, infection, pain, periodontal breakdown, sinus infection, etc.²¹ MARPE is considered as an alternative when treating this particular group of patients in contemporary orthodontics. Our study



Figure 6. Axial sections of CBCTs of the patients who failed on suture opening. Patient A: 13-year and 8-month old female; Patient B: 28-year and 9-month old male; Patient C: 33-year and 11-month old male.

recorded the relevant adverse effects and complications including epistaxis, inflammation and swelling of palatal mucosa, difficulty in cleaning, soft tissue impingement, micro-implants loosening, tinnitus, distortion of expander, failure of suture-opening and asymmetric expansion. With all the possible adverse effects in mind, clinician may be more confident in providing MARPE treatment.

CONCLUSION

Although some undesirable adverse effects and complications were reported in this study, MARPE can still provide good outcomes on correcting maxillary transverse discrepancies in young adolescents and adults. The overall success rate is 89.7% with moderate pain level. Palatal mucosa swelling or inflammation is the most frequent complication happened during MARPE procedure, and oral hygiene should be emphasized before treatment. More patients' data would be necessary in the future study.

Conflict of interest statement

The authors declare no conflicts of interest.

ETHICAL APPROVAL

This study was approved by the Institutional Review Board of Show Chwan Memorial Hospital.

REFERENCES

1. da Silva Filho OG, Santamaria Jr M, Capellozza Filho L. Epidemiology of posterior crossbite in the primary dentition. *J Clin Pediatr Dent* 2007;32(1):73–8.
2. Egermark-Eriksson I, Carlsson GE, Magnusson T, Thilander B. A longitudinal study on malocclusion in relation to signs and symptoms of cranio-mandibular disorders in children and adolescents. *Eur J Orthod* 1990;12(4):399–407.
3. Heikinheimo K, Salmi K. Need for orthodontic intervention in five-year-old Finnish children. *Proc Finn Dent Soc* 1987;83(4): 165–9.
4. Kutin G, Hawes RR. Posterior cross-bites in the deciduous and mixed dentitions. *Am J Orthod* 1969;56(5):491–504.
5. Brunelle JA, Bhat M, Lipton JA. Prevalence and distribution of selected occlusal characteristics in the US population, 1988–1991. *J Dent Res* 1996;75 Spec No:706–13.
6. Proffit WR, White Jr RP. Who needs surgical-orthodontic treatment? *Int J Adult Orthod Orthognath Surg* 1990;5(2):81–9.
7. McNamara JA. Maxillary transverse deficiency. *Am J Orthod Dentofacial Orthop* 2000;117(5):567–70.
8. Betts NJ, Vanarsdall RL, Barber HD, Higgins-Barber K, Fonseca RJ. Diagnosis and treatment of transverse maxillary deficiency. *Int J Adult Orthod Orthognath Surg* 1995;10(2):75–96.
9. Timms DJ. A study of basal movement with rapid maxillary expansion. *Am J Orthod* 1980;77(5):500–7.
10. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. *Am J Orthod* 1970;58(1):41–66.
11. Isaacson RJ, Murphy TD. Some effects of rapid maxillary expansion in cleft lip and palate patients. *Angle Orthod* 1964; 34(3):143–54.
12. Mommaerts MY. Transpalatal distraction as a method of maxillary expansion. *Br J Oral Maxillofac Surg* 1999;37(4): 268–72.
13. Zimring JF, Isaacson RJ. Forces produced by rapid maxillary expansion: III. forces present during retention. *Angle Orthod* 1965;35:178–86.
14. Barber AF, Sims MR. Rapid maxillary expansion and external root resorption in man: a scanning electron microscope study. *Am J Orthod* 1981;79(6):630–52.

15. Langford SR, Sims MR. Root surface resorption, repair, and periodontal attachment following rapid maxillary expansion in man. *Am J Orthod* 1982;81(2):108–15.
16. Timms DJ, Moss JP. An histological investigation into the effects of rapid maxillary expansion on the teeth and their supporting tissues. *Trans Eur Orthod Soc* 1971:263–71.
17. Choi SH, Shi KK, Cha JY, Park YC, Lee KJ. Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. *Angle Orthod* 2016;86(5): 713–20.
18. Suzuki SS, Braga LF, Fujii DN, Moon W, Suzuki H. Corticopuncture facilitated microimplant-assisted rapid palatal expansion. *Case Rep Dent* 2018;2018:1392895.
19. Persson M, Thilander B. Palatal suture closure in man from 15 to 35 years of age. *Am J Orthod* 1977;72(1):42–52.
20. Melsen B, Melsen F. The postnatal development of the palatomaxillary region studied on human autopsy material. *Am J Orthod* 1982;82(4):329–42.
21. Suri L, Taneja P. Surgically assisted rapid palatal expansion: a literature review. *Am J Orthod Dentofacial Orthop* 2008;133(2): 290–302.
22. Brunetto DP, Sant'Anna EF, Machado AW, Moon W. Nonsurgical treatment of transverse deficiency in adults using Microimplant-assisted Rapid Palatal Expansion (MARPE). *Dental Press J Orthod* 2017;22(1):110–25.
23. Chuang YH, Chen JH, Ho KH, Wang KL, Hsieh SC, Chang HM. The role of micro-implant assisted rapid palatal expansion (MARPE) in clinical orthodontics- a literature review. *Aust Orthod J* 2021. in press.
24. Carlson C, Sung J, McComb RW, Machado AW, Moon W. Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult. *Am J Orthod Dentofacial Orthop* 2016;149(5): 716–28.
25. Crismani AG, Bernhart T, Tangl S, Bantleon HP, Watzek G. Nasal cavity perforation by palatal implants: false-positive records on the lateral cephalogram. *Int J Oral Maxillofac Implants* 2005;20(2):267–73.
26. Bartley EJ, Fillingim RB. Sex differences in pain: a brief review of clinical and experimental findings. *Br J Anaesth* 2013;111(1): 52–8.
27. Fillingim RB. Individual differences in pain: understanding the mosaic that makes pain personal. *Pain* 2017;158(Suppl 1): S11–8.
28. Winsauer H, Vlachoianis C, Bumann A, Vlachoianis J, Chrubasik S. Paramedian vertical palatal bone height for mini-implant insertion: a systematic review. *Eur J Orthod* 2014; 36(5):541–9.
29. Nojima LI, da Cunha Gonçalves Nojima M, da Cunha AC, Guss NO, Sant'Anna EF. Mini-implant selection protocol applied to MARPE. *Dental Press J Orthod* 2018;23(5): 93–101.
30. Lee RJ, Moon W, Hong C. Effects of monocortical and bicortical mini-implant anchorage on bone-borne palatal expansion using finite element analysis. *Am J Orthod Dentofacial Orthop* 2017;151(5):887–97.
31. Bourassa C, Hosein YK, Pollmann SI, Galil K, Bohay RN, Holdsworth DW, et al. In-vitro comparison of different palatal sites for orthodontic miniscrew insertion: effect of bone quality and quantity on primary stability. *Am J Orthod Dentofacial Orthop* 2018;154(6):809–19.
32. Vichi M, Franchi L. Abnormalities of the maxillary incisors in children with cleft lip and palate. *ASDC J Dent Child* 1995; 62(6):412–7.
33. Garvey MT, Barry HJ, Blake M. Supernumerary teeth—an overview of classification, diagnosis and management. *J Can Dent Assoc* 1999;65(11):612–6.
34. Yu JH, Lin YS, Chang WJ, Chang YZ, Lin CL. Mechanical effects of micro-thread orthodontic mini-screw design on artificial cortical bone. *J Med Biol Eng* 2014;34(1):49–55.
35. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: a comprehensive review. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007;103(5):6–15.
36. Cantarella D, Dominguez-Mompell R, Moschik C, Sfogliano L, Elkenawy I, Pan HC, et al. Zygomaticomaxillary modifications in the horizontal plane induced by micro-implant-supported skeletal expander, analyzed with CBCT images. *Prog Orthod* 2018;19(1):41.
37. Llewellyn A, Norman G, Harden M, Coatesworth A, Kimberling D, Schilder A, et al. Interventions for adult Eustachian tube dysfunction: a systematic review. *Health Technol Assess* 2014;18(46):1–180.
38. Ramírez-Ossa DM, Escobar-Correa N, Ramírez-Bustamante MA, Agudelo-Suárez AA. An umbrella review of the effectiveness of temporary anchorage devices and the factors that contribute to their success or failure. *J Evid Base Dent Pract* 2020;20(2):101402.
39. Motoyoshi M, Matsuoka M, Shimizu N. Application of orthodontic mini-implants in adolescents. *Int J Oral Maxillofac Surg* 2007;36(8):695–9.
40. Park JJ, Park YC, Lee KJ, Cha JY, Tahk JH, Choi YJ. Skeletal and dentoalveolar changes after miniscrew-assisted rapid palatal expansion in young adults: a cone-beam computed tomography study. *Kor J Orthod* 2017;47(2):77–86.
41. Lim HM, Park YC, Lee KJ, Kim KH, Choi YJ. Stability of dental, alveolar, and skeletal changes after miniscrew-assisted rapid palatal expansion. *Kor J Orthod* 2017;47(5):313–22.
42. Angelieri F, Cevidanes LH, Franchi L, Gonçalves JR, Benavides E, McNamara Jr JA. Midpalatal suture maturation: classification method for individual assessment before rapid maxillary expansion. *Am J Orthod Dentofacial Orthop* 2013; 144(5):759–69.
43. Cantarella D, Dominguez-Mompell R, Mallya SM, Moschik C, Pan HC, Miller J, et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. *Prog Orthod* 2017;18(1):34.
44. Elkenawy I, Fijany L, Colak O, Paredes NA, Gargoum A, Abedini S, et al. An assessment of the magnitude, parallelism, and asymmetry of micro-implant-assisted rapid maxillary expansion in non-growing patients. *Prog Orthod* 2020;21(1):42.