A retrospective analysis of the complications associated with miniscrew-assisted rapid palatal expansion

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Introduction: Miniscrew-assisted rapid palatal expansion (MARPE) has recently been advocated as a treatment option for older adolescents and adult patients with maxillary transverse deficiencies. This study aimed to identify the complications associated with MARPE and the frequency of their occurrences. **Methods:** A retrospective analysis was conducted on 256 patients (mean age, 18.8 ± 8.6; 126 females and 130 males) who underwent MARPE at a private practice and a graduate orthodontic clinic. Specific complications and their severity were identified by reviewing clinical notes and photographs. Asymmetric expansion was measured for patients who had cone-beam computed tomography scans taken before MARPE and immediately after expansion. **Results:** The midpalatal suture was separated in 87.8% of patients. The most common complication was gingival inflammation around the appliance, found in 83.9% of patients. 45% of patients reported some form of pain during and after expansion. Appliance breakage occurred in 10% of patients. 47.8% of patients showed >1 mm of asymmetric expansion. Rare complications included tooth discoloration (potentially indicative of tooth vitality loss), temporary hearing loss, numbness, swelling, severe gag reflex, and sinus infection. **Conclusions:** The most common complication was gingival inflammation followed by pain; major and long-term complications were rare with MARPE. Overall, patients should be informed that gingival inflammation and pain are common side effects of MARPE and that rare complications can occur. Although asymmetric expansion was common after the palatal split, most patients were managed with orthodontic treatment. **(Am J Orthod Dentofacial Orthop Clin Companion 2022;2:423–30)**

Maxillary transverse deficiency (MTD) is a common skeletal manifestation encountered by orthodontists.[1] Defining characteristics of MTD can include unilateral or bilateral crossbite, narrow palate, and severe crowding.[2] These dentofacial changes associated with MTD may contribute to further anatomic and physiological consequences, including blocked nasal airways, open mouth posture, and constricted V-shaped maxillary arch.[3,4] In the past, rapid palatal expansion (RPE) was used to treat pediatric patients with MTD. However, higher stress is needed to open the circummaxillary and midpalatal sutures as maturation occurs.[5] Therefore, RPE demonstrates reduced efficacy in late adolescents and adults. To accommodate patients with mature sutures, surgically assisted rapid palatal expansion (SARPE) has traditionally been used.[6] However, with the recent invention of temporary skeletal anchorage devices, tooth-bone-borne expander miniscrew-assisted rapid palatal expansion (MARPE) has emerged as a potential treatment modality for patients with mature sutures.[7-9]

Recent trends show increasing numbers of adults pursuing orthodontic treatment, and the prevalence of MTD in these adults can reach nearly 30%.[8,10-12] Therefore, MARPE is a potential treatment option for patients with mature palates who wish to avoid more invasive procedures such as SARPE. Several studies have shown MARPE to be an effective nonsurgical treatment modality that aims to expand a narrow maxilla by applying forces to microimplants rather than to one's teeth and tissues.[13,14] However, incorporating microimplants into the palatal jackscrew may create an oral environment susceptible to infection if the appliance is improperly positioned or maintained.[15,16]

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Despite the attention this technique has garnered since its development, there exists little data in the literature regarding the complications that arise with the use of MARPE. A few studies have mentioned some potential MARPE complications, such as buccal tipping of anchorage teeth and alveolar bone bending, gingival recession, bony dehiscence, and damage to underlying nerves and vessels.[17,18]

This study aimed to identify the possible oral, dental, and facial complications that may occur with MARPE treatment and their frequencies. With this knowledge, clinicians can better advise their patients regarding the risks and benefits of this treatment modality.

MATERIAL AND METHODS

A retrospective analysis was conducted on 256 patients (mean age, 18.9 ± 8.6 years; 126 females and 130 males) who underwent MARPE, regardless of failure or success of expansion, at a private practice office (n = 159; Bellflower, Calif) and graduate orthodontics clinic at the University of the Pacific Arthur A. Dugoni School of Dentistry (n = 97) between August 2014 and June 2021 (Table I). This study was approved by the University of the Pacific Institutional Review Board (No. 2020-74).

The MARPE patient informed consent was obtained from all patients (Fig 1). The MARPE procedure was performed under local anesthesia. Custom-made maxillary expanders or MSE (BioMaterials Korea, Seoul, South Korea) were bilaterally fitted to the permanent first molars. Four miniscrews were placed along the midpalatal suture. Patients were given specific instructions on activating the expander for 4-6 weeks. After expansion, the expanders were kept in place for an additional 4-6 months to prevent relapse.

One examiner (J.P.) reviewed all patient charts and collected any complication reports to obtain data regarding the velocity of turning, the total amount of expansion, and the presence of a diastema after expansion. Postoperative complications were categorized using patient reports, clinical evaluation, and measurements from cone-beam computed tomography (CBCT) scans.

Table I. Demographics of all patients treated with MARPE

	Sex		
Demographics	*Male*	*Female*	*Total*
Age, y			
<19	73	85	158 (61.7)
19-29	45	29	74 (28.9)
≥30	12	12	24 (9.4)
Total	130 (50.8)	126 (49.2)	256 (100)

Note: Values are n (%).

Inflammation around the appliance was measured using chart notes, and clinical photographs were taken after expansion and before removal. The amount of inflammation is presented in Fig 2. Inflammation of the palate and around the appliance arms was measured on a scale from 0 to 3; 0 indicated no sign of swelling, 1 indicated a sign of swelling, 2 indicated enough swelling to cover parts of the MARPE, and 3 indicated severe swelling that led to appliance removal. Each image was graded by four clinicians. After independent evaluation, the four judges discussed and resolved any grading discrepancies.

Any pain associated with the MARPE area, nasal area, headache, or dentition was categorized as (1) none, (2) mild, and (3) severe.

Other complications include tooth color change (potentially indicative of tooth vitality loss), infraorbital numbness, temporary hearing loss, zygomatic swelling, strong gag reflex resulting in appliance removal, sinus infections, appliance breakage, and broken screw were identified.

Asymmetric expansion was measured on CBCTs for patients with CBCT scans taken before MARPE treatment (T1) and immediately after expansion with the MARPE expander in place (T2). CBCT images were acquired using an i-CAT device (Imaging Sciences International, Hatfield, Pa). CBCTs of a subgroup of 67 patients were collected. Asymmetry was assessed at the ANS level using Invivo software (Anatomage, San Jose, Calif). Three-dimensional superimposition and measurement of asymmetrical expansion at the basal bone level of the maxilla were completed as described by Kim et al.[17] Three judges located 10 landmarks, and the average coordinate values were used for measurements. Expansion at the basal bone level of the maxilla was considered asymmetrical if the difference in the movement for ANS-right and ANS-left was >1 mm (Fig 3; Table II).

Statistical Analyses

Simple descriptive statistics, such as mean, standard deviation, range, and percentage, were performed for 256 patients to report the frequencies of each complication. Data were managed with Microsoft Excel 2013 (Microsoft Corp, Redmond, Wash) and SPSS (version 27; IBM, Armonk, NY).

RESULTS

A total of 256 charts of MARPE patients were reviewed. The average palatal expansion achieved at the jackscrew level was 7.8 ± 2.4 mm. In most patients (248 out of 256), the first molars were used for banding; for the remaining 8 patients, either the second molars or second premolars were used due to missing first molars. Midpalatal sutures were not opened in 31 patients, whereas 87.8% (225 out of 256) of total patients showed diastemas. Even though there was the presence of a diastema, 31% of patients did

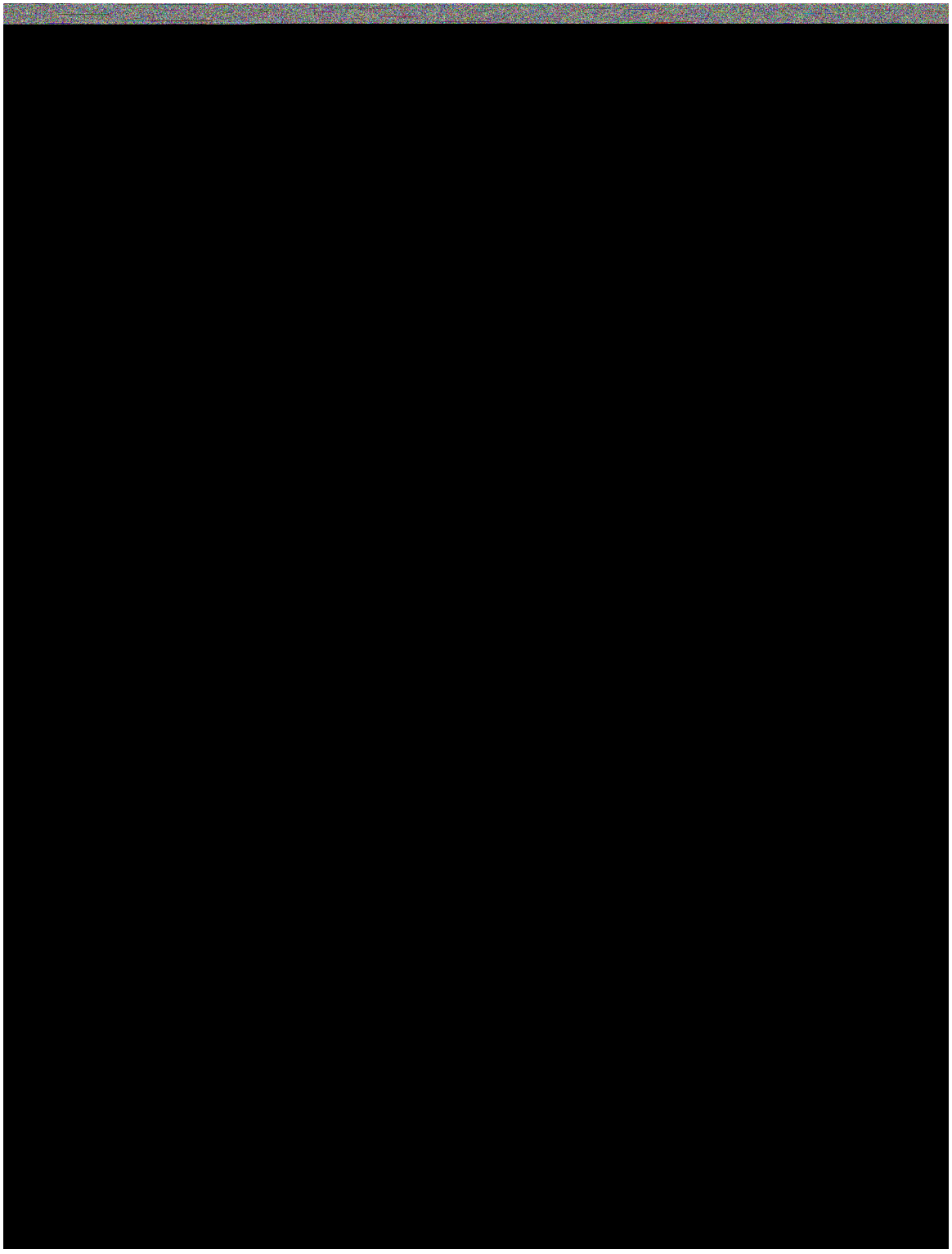

Fig 1. Informed consent for MARPE placement.

not get adequate expansion in the first attempt. For patients who underwent a second MARPE attempt, 38% did not get adequate expansion. Most failures were in patients aged >25 years (mean age, 23.6 ± 6.0 years). Among 31 patients with failures, 32.2% were females and 67.7% were males.

The incidences of different complications are described in Table III. The most frequent complication was

Fig 2. The presence of inflammation defined as (**A**) 0, No inflammation; (**B**) 1, Mild; (**C**) 2, Moderate; and (**D**) 3, Severe.

inflammation (83.9%). Expanders were prematurely removed in 8.5% of patients because of inflammation or infection. Half of the patients (50.7%) showed mild inflammation around the appliance. This inflammation tended to worsen during the retention stages after active expansion.

Furthermore, 45% of patients reported pain or tenderness during expansion. 23.8% of patients reported transient pain in the MARPE area and 2% within the nose, 10.6% reported headaches, and 19.5% reported pain and tenderness of the dentition. Most dental tenderness and pain (42 out of 50) were associated with the banded maxillary first molars attached to the MARPE, but some (9 out of 50) were associated with the central incisors. However, it was rare to have severe pain that required early removal of the appliance (2.0%).

Breakage of the appliance occurred in 27 (10.5%) patients. The most common breakage (10 patients) was related to the bent guide-rod-holding plates, which prevented further expansion. Guide rods also loosened and came out of the expander in 8 patients. Five jackscrews malfunctioned, whereas 6 jackscrews were working but did not maintain the expansion. These malfunctions prevented expansion from progressing and limited stability. In addition, soldering joints were broken in 4 patients. Only 5 patients (2.0%) had broken miniscrews, which were all 1.5 mm in diameter; none of the 1.8 mm miniscrews broke.

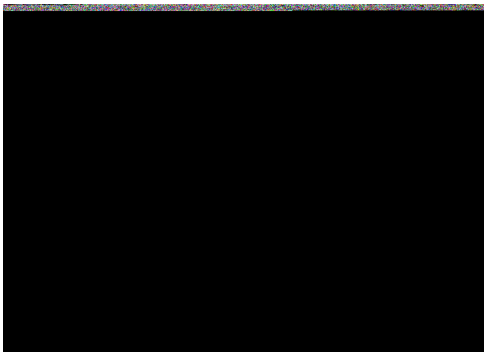

Fig 3. ANS_R vs ANS_L expansion. This measurement was determined by first determining the x-distance of T1 ANS from the midsagittal plane (MSP). Then, the distance from T1 ANS to T2 ANS_R and from T1 ANS to T2 ANS_L could be determined using the following equations: ΔANS_R = distance of ANS_R to MSP + distance of T1 ANS to MSP; ΔANS_ L = distance of ANS_L to MSP − distance of T1 ANS to MSP. *R*, right; *L*, left.

Four out of the 5 broken miniscrew patients were on the palatal tori. All breakage occurred during placement.

Rare complications included tooth discoloration, temporary hearing loss, numbness, swelling, severe gag reflex, and sinus infection. Two out of the 5 teeth observed with tooth discoloration had root canal treatment, whereas the other 3 are under observation.

Finally, 52% of patients exhibited symmetrical expansion of ANS, indicating a difference of ≤1 mm. 47.8% of patients showed >1 mm of asymmetric expansion at ANS, and 27% showed ≥2 mm of asymmetric expansion at ANS (Table IV).

DISCUSSION

Our study investigated complications related to MARPEs (tooth-bone-borne expanders) based on the clinical chart notes and clinical photographs of 256 patients. Although MARPE is considered a relatively simple procedure associated with minimal morbidity compared with SARPE or orthognathic surgery, over 88% of the patients in this study presented with at least one complication. Most complications were minor, resolved spontaneously, or managed with minor treatments.

The midpalatal suture was separated in 87.8% of total patients. The main resistance area to midpalatal separation is debatable. The midpalatal suture, zygomatic buttress, and pterygomaxillary junction are important areas in palatine disjunction. The magnitude of the mechanical stress depends greatly on bone elasticity and the patient's age.[19,20] The high percentage of successful midpalatal suture opening was due to our relatively young patient age group, whose average age was 18.9 ± 8.6 years. Most of the failures were seen in patients aged >25 years, but the youngest failure patient was 21 years old male. When treatment planning for MARPE, we did not consider middle-aged or older patients as ideal candidates for MARPE-only expansion; hence, further studies are needed to evaluate the realistic success rate of midpalatal suture opening in different age groups.

The most common MARPE complication in our study was gingival inflammation around the appliance (83.9% of patients). The MARPE appliance is designed to be adapted very closely to the palate, where the expansion jackscrew typically touches the palatal tissue. Consequently, it is difficult for the patient to maintain proper and adequate oral hygiene

Table II. Definitions of skeletal, dental, and soft tissue landmarks digitized for each patient through Invivo 3D Tracing

Landmark	*Symbol*	*Definition*
Skeletal		
Nasion	N	Midpoint of the frontonasal suture
Basion	Ba	Most inferior and posterior point at the anterior margin of the foramen magnum
Sella	S	Midpoint of the cavity of sella turcica in all 3 planes
Orbitale†	Or	Most inferior point along the inferior margin of the orbital rim
Porion†	Po	Most superior and lateral point of the external auditory meatus
Anterior nasal spine‡	ANS	Most anterior point of the premaxilla along the midline of the maxilla
Posterior nasal spine‡	PNS	Most posterior point of the palatine bone
Point A‡	A	The deepest point on the contour of the maxilla between the anterior nasal spline and the maxillary incisor
Dental		
U1 incisal edge†	U1	Most mesial point along the maxillary central incisor incisal edge
U1 apex†	U1A	Maxillary central incisor root apex

† Bilateral landmarks (right and left).
‡ Landmark becomes bilateral when palatal suture is split by MARPE.

around the appliance, leading to tissue inflammation. Mild inflammation was managed with a 0.12% chlorhexidine gluconate oral mouth rinse and improved oral hygiene. Antibiotics were prescribed to 5% of patients with inflammation of the palatal tissue, and MARPE was prematurely removed in 8% of patients with severe inflammation. Palatal tissue necrosis was not observed in any of the patients in this study. Although there was no measure to identify the causes of inflammation, most of the inflammation patients seemed

Table III. Incidence of each complication after MARPE procedure

Category	*Score*
Diastema	
No	31 (12.2)
Yes	225 (87.8)
Inflammation	
0-None	41 (16.1)
1-Mild	130 (50.7)
2-Moderate	63 (24.6)
3-Severe†	22 (8.5)
Pain	
MARPE area (M)	
None	195 (76.2)
Mild	55 (21.5)
Severe†	6 (2.3)
Nose (N)	
None	251
Mild	5 (2.0)
Severe†	0 (0)
Headache (H)	
None	229 (89.5)
Mild	27 (10.6)
Severe†	0 (0)
Dentition	
None	206 (80.5)
Mild	45 (17.6)
Severe†	5 (1.95)
Tooth discoloration	5 (1.95)
Infraorbital nerve numbness	1 (0.04)
Temporary hearing loss	1 (0.04)
Zygomatic swelling	1 (0.04)
Severe gag reflex resulting in removal	1 (0.04)
Sinus infection resulting in removal	1 (0.04)
Appliance breakage	27 (10.5)
Broken screw	5 (1.95)

Note. Values are n (%).
† Severe enough to remove a MARPE.

Table IV. Asymmetry at ANS[†]

Asymmetry at ANS, T1 − T2 (mm)	*n (%)*
≤1	35 (52)
>1-2	14 (21)
≥2	18 (27)

[†] Difference between the expansion of ANS-right vs ANS-left.

related to poor oral hygiene. However, further studies are necessary to examine the causes of inflammation.

Because expander design is closely linked to the patient's ability to properly clean around the appliance, gingival inflammation was reduced once the MARPE fabrication design was changed. Originally, the expansion jackscrew was adapted flush to the palate; we changed the MARPE design so that the jackscrew was placed 1 mm away from the palate, and the side arms were placed 3 mm away from the palatal shelf. This new design prevented overcompression of the palatal tissue during appliance installation, allowing patients to clean under the appliance.

The MARPE was actively expanded for 4-6 weeks, depending on the amount of maxillary expansion needed, and it was retained in the mouth for 4-6 months after for bone consolidation to prevent relapse. Interestingly, delayed gingival inflammation around the corners of the jackscrew and sidearms was frequently observed during this retention period, especially in patients with extremely narrow palates (Fig 4). We postulate that the palatal vault's relapse tendency is much higher in these patients so that the MARPE device would get embedded in the palatal tissue. Future studies are needed to explore this observation.

When evaluating pain in MARPE patients, we found that 45% of patients reported some level of pain. Most of the pain occurred on the initial day of appliance installation and was controlled with either 800 mg ibuprofen or 1000 mg acetaminophen; the pain resolved within 1-2 days. Only 3% of patients requested analgesics stronger than ibuprofen or acetaminophen. Tenderness around the banded maxillary first molars, where the MARPE was connected during expansion, was also commonly reported; this dull, aching pain was mostly resolved without analgesics. Moreover, 10.6% of patients experienced headaches during MARPE expansion, possibly because of the high force and pressure exerted on the craniofacial structures. It was rare to prematurely remove the MARPE appliance because of pain alone.

Fig 4. Delayed gingival inflammation can be seen with the gingival tissue covering parts of the remaining appliance.

Maxillary central incisor discoloration after MARPE expansion was found in 5 incisors. This incidence of tooth discoloration from MARPE (2.0%) was lower than from SARPE (4.5%). None of the MARPE expansion patients resulted in tooth loss. However, more posttreatment follow-up is needed to evaluate any long-term effects on tooth vitality.

Neurosensory disturbance was extremely rare after MARPE expansion. Only one patient reported hypoesthesia in the infraorbital nerve branch; however, the numbness fully resolved in 2 weeks.

Breakage or distortion of the MARPE appliance was seen in 27 of the 256 patients. These included jackscrew distortion during expansion, malfunctioning jackscrews, loose guide rods, working jackscrews that did not maintain the expansion, and jackscrew breakage (Fig 5). The solder joint where the jackscrew extension arms connected to the molar bands was broken in 5 patients. In addition to breakage or distortion of the main jackscrew, complications were observed in the miniscrews themselves. Five miniscrews broke during MARPE installation; of the 5 broken screws, 4 of them were placed in the palatal tori. All of the fractured miniscrews were 1.5 mm in diameter, whereas none of the 1.8 mm diameter miniscrews fractured. Therefore, special consideration for thicker diameter miniscrews, which are more fracture-resistant, is needed for placement in the palatal tori.

Asymmetric expansion of ≥1 mm was identified in 47.8% of patients (20.9% of patients had 1-2 mm of asymmetric expansion, 26.9% had ≥2 mm of asymmetric expansion); this number is higher than the asymmetric expansion reported in another study (30.3%).[17] In comparison, studies evaluating SARPE expansion found that 3.3% to 13.3% of patients resulted in asymmetric or inadequate expansion, much less than our current findings.[21,22] However, studies in the literature did not have a quantitative definition of asymmetry; thus, it is possible that only patients with more obvious, severe asymmetry were counted, resulting in a lower percentage of asymmetrical expansion from SARPE being reported. An interesting observation was that the frequency of asymmetric maxillary expansion was higher in patients that needed a greater amount of expansion. In most patients in which asymmetric expansion was clinically apparent, the occlusion was successfully managed with subsequent orthodontic treatment. In some instances, temporary skeletal anchorage devices were needed to help facilitate the complete correction of the asymmetry. In our study, asymmetric expansion was defined as the difference between the expansion of ANS-right vs ANS-left because a previous study reported [17] ANS

Fig 5. Clinical example illustrating three types of appliance breakage: **A**, Guide rods have become loose from the expander. Such malfunctions prevented the continuation of expansion or stability; **B**, Guide rods have come out of the expander; **C**, The plate holding the guide rod has been bent. This prevents the patient's ability to turn the expander.

Fig 6. A, Patient presented with posterior crossbite at T1; **B**, 3-Dimensional asymmetry toward the patient's right is demonstrated when the CBCT from T1 (*white*) and T2 (*green*) are superimposed.

as being the most clinically impactful for tissues of the facial complex. However, asymmetric expansion occurs in 3D (Fig 6), so a future study should include more comprehensive 3D asymmetric changes such as yaw and cant.

Previous studies evaluating SARPE expansion found a 10% incidence rate of gingival recession.[21,22] In our study, gingival recession or bone loss from MARPE expansion was not documented. The authors often observed mild gingival recession around the maxillary first molars or between the maxillary central incisors, but the incidence rate could not be calculated because of a lack of documentation. This lack of documentation is the main limitation in our retrospective chart-review design because the incidence rate is possibly underreported or underestimated when evaluating MARPE complications. Future prospective studies are warranted to confirm our findings.

CONCLUSIONS

Common complications with MARPE expansion include inflammation, pain, appliance breakage or distortion, and asymmetrical expansion. Although major and severe long-term complications were rare with MARPE, short-term discomfort with MARPE was prevalent. Our findings provide a better understanding of the complications associated with MARPE, emphasizing the importance of getting a patient's informed consent before appliance delivery.

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