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Original article

Surgical and non-surgical maxillary expansion: expansion patterns, complications and failures

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ABSTRACT – Objective: *The focus of this report was to analyze the pattern of maxillary expansion and complications in patients following surgical and non-surgical maxillary expansion presented for evaluation and second opinion.* **Materials and Methods:** *During a 30-months period, 28 patients presented for second opinion following maxillary expansion performed elsewhere. The indication for treatment was obstructive sleep apnea (OSA). All patients reported a lack of symptomatic improvements and problems associated with the treatment. Clinical examination with pre- and post-expansion cone beam computed tomography (CBCT), and treatment photographs were analyzed.* **Results:** *Complete clinical records and CBCT were available in 22 patients for analysis. Six patients had undergone surgical expansion with distraction osteogenesis maxillary expansion (DOME), and 16 patients had undergone a variety of non-surgical expansion with different appliances. All the DOME patients had anterior nasal spine (ANS) separation without posterior nasal spine (PNS) separation. Diastema ranging between 10-16 mm was noted in the DOME patients, and the ratio of anterior diastema to ANS separation was between 2:1 to 3:1. Bone defects existed between the central incisors at 18 months or beyond following DOME in all the patients despite bone grafting attempts in four patients. Anterior gingival recession occurred in two patients and four incisor teeth required endodontic therapy with long-term guarded prognosis. Sixteen patients underwent non-surgical maxillary expansion with four different appliances, including anterior growth guidance appliance (AGGA), daytime-nighttime appliance (DNA), advanced lightwire functionals appliance (ALF), and mini-screw assisted rapid palatal expansion (MARPE). The midpalatal suture did not separate in any of the 16 patients, and the expansion pattern was purely dental and dentoalveolar in nature. Lateral dental tipping, thinning of the labial/buccal alveolar bone with gingival recession were noted in 10 patients. Significant mobility of the maxillary anterior teeth due to vertical and horizontal bone loss was noted in the five patients that underwent AGGA treatment.* **Conclusions:** *Different maxillary expansion methods are currently being performed with varying outcomes. Critical analyses of these methods are needed to determine their impact and whether the desired outcomes are achieved.*

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1. Introduction

Since the report of improved Obstructive Sleep Apnea (OSA) following maxillary expansion in 1998[5], the use of surgical and non-surgical maxillary expansion for the treatment of OSA has become increasingly popular. However, the results of different maxillary expansion methods seem to vary greatly, and some expansion methods have little or no published outcomes data. The authors aimed to analyze the pattern of maxillary expansion and complication in patients who sought a second opinion following surgical and non-surgical maxillary expansion performed elsewhere.

2. Materials and Methods

Twenty-eight patients requested evaluation following maxillary expansion performed elsewhere during a 30-months period. Complete clinical records with pre- and post-expansion cone beam computed tomography (CBCT) and treatment photographs were collected for analysis.

3. Results

Complete clinical records and CBCT were available in 22 patients. The treatment indication was for OSA in all 22 patients. Six patients underwent distraction osteogenesis maxillary expansion (DOME), five patients were treated by anterior growth guidance appliance (AGGA), two patients were treated by daytime-nighttime appliance (DNA), four patients were treated by advanced lightwire functionals appliance (ALF), and five patients were treated by mini-screw assisted rapid palatal expansion (MARPE).

3.1. Distraction Osteogenesis Maxillary Expansion (DOME)

DOME was described by Liu*, et al.*[16]. It is a modification of the traditional surgically-assisted rapid palatal expansion (SARPE) with several mini-screws added to a tooth-borne expander for improved skeletal anchorage. The use of piezoelectric saw for osteotomies was also advocated. The goal of the modifications was to improve the anchorage and improve skeletal expansion. Six patients with a mean age of 25.2 years (range 26-36 years) underwent DOME. The evaluation found that the expansion pattern was the same as traditional SARPE. The diastema creation was between 10-16 mm in the patients evaluated. The ANS separated in all patients, but PNS separation did not occur in any of the patients. The ratio of diastema: ANS separation was between 2:1 and 3:1.

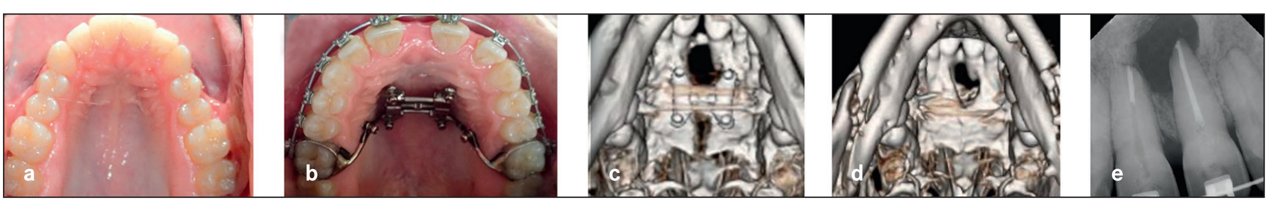

Figure 1

31-year-old man underwent DOME. (a) Preoperative palatal view. (b) Postoperative palatal view after expansion. (c) CBCT axial view showing a large anterior expansion 8 months postoperatively. (d) CBCT axial view showing a large bony defect at anterior maxilla involving the incisor roots two years postoperatively. (e) Periapical dental imaging after apicoectomy and endodontic therapy of maxillary central incisors. The prognosis of the teeth is guarded.

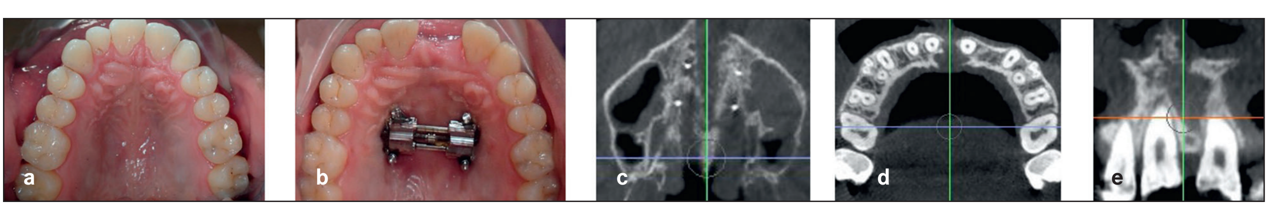

Figure 2

26-year-old man underwent DOME. (a) Preoperative palatal view. (b) Postoperative palatal view after expansion with a 12 mm diastema. (c) CBCT axial view showing large anterior expansion at the completion of the expansion. (d) CBCT axial view showing minimal bone fill two years postoperatively. (e) CBCT coronal view showing a large defect at the distraction site extending to the nasal floor with 3 millimeters of bone at the alveolar crest.

Significant asymmetric expansion was found in four patients with hemimaxilla lateralization on one side only. Large bone defects existed between the central incisors at 18 months or beyond in all six patients despite bone grafting attempts in four patients.

Anterior gingival recession occurred in two patients and four incisor teeth required endodontic therapy with long-term guarded prognosis. None of the patients reported improvement in OSA and three patients proceeded with maxillomandibular advancement (Figs. 1 to 4).

Figure 3

31-year-old man underwent DOME. (a) Preoperative palatal view. (b) Postoperative palatal view after expansion with a 12 mm diastema. (c) Palatal view after diastema closure. (d) Preoperative frontal view. (e) Postoperative frontal view after expansion with a 12 mm diastema. (f) Frontal view after diastema closure. Note the gingival recession and dark triangle at proximal regions. (g) Preoperative CBCT coronal view. (h) Postoperative CBCT coronal view after expansion. Note the significant dentoalveolar displacement contributing to the expansion, the absence of right hemimaxilla movement (black arrow) and slight left hemimaxilla movement (white arrow). (i) Postoperative CBCT after maxillomandibular advancement. (j) Preoperative CBCT showing the nasal floor. (k) Postoperative CBCT after expansion showing the diastema (black arrows) with nasal floor opening (white arrows) from ANS to the premolar region only. (l) Postoperative CBCT after maxillomandibular advancement two years following DOME. Note the bone deficiency between the roots of the maxillary central incisors.

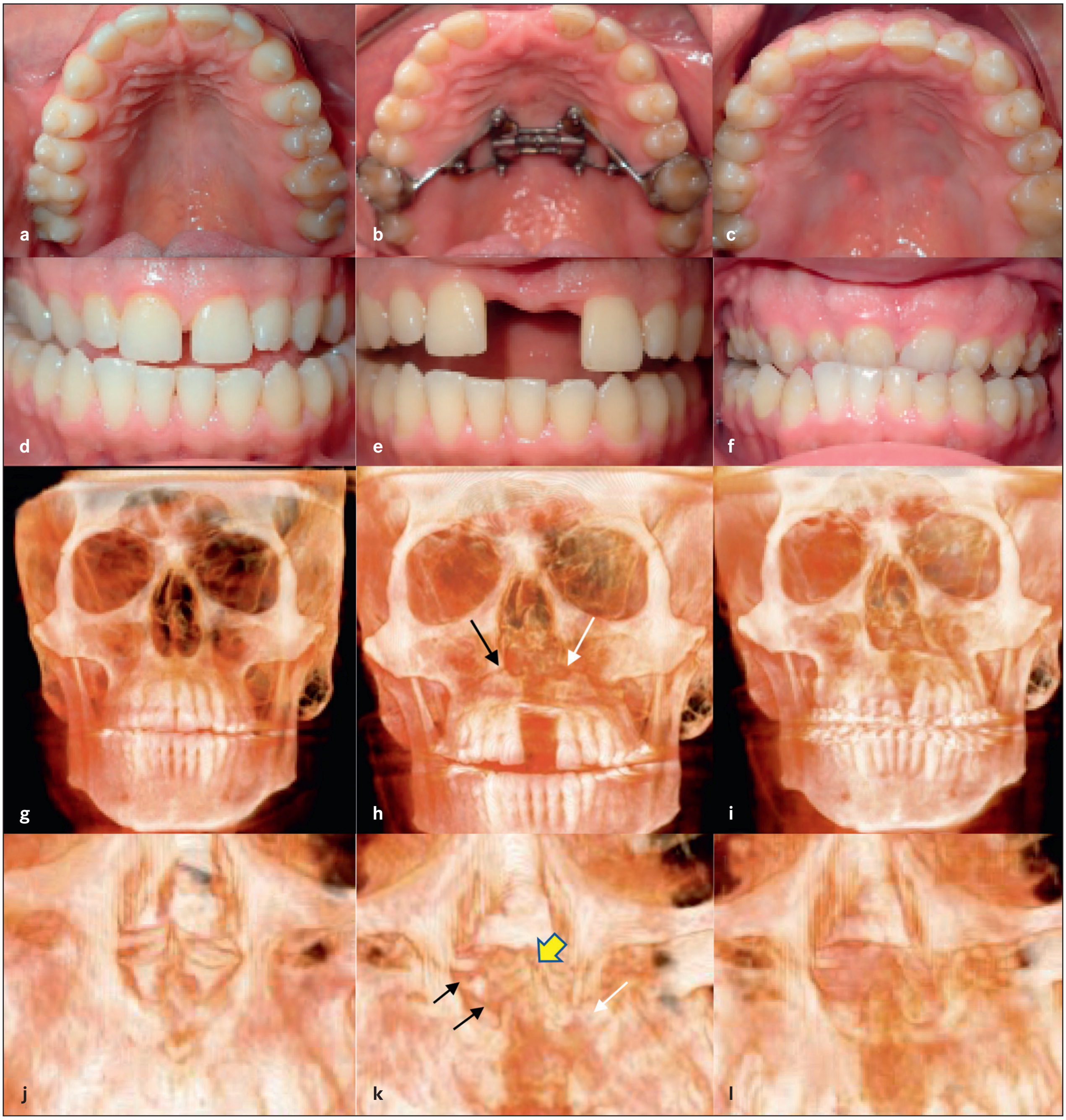

Figure 4

36-year-old man underwent DOME. (a) Preoperative palatal view. (b) Postoperative palatal view after expansion with a 16 mm diastema. (c) Palatal view after diastema closure. (d) Preoperative frontal view. (e) Postoperative frontal view after expansion with a 16 mm diastema. (f) Frontal view after diastema closure. (g) Preoperative CBCT coronal view. (h) Postoperative CBCT coronal view after expansion. Note the significant dentoalveolar displacement contributing to the expansion, the absence of right hemimaxilla movement (black arrow) and the left hemimaxilla movement (white arrow) contributing to asymmetry. (i) Postoperative CBCT after diastema closure. Note the maxillary asymmetry. (j) Preoperative CBCT showing the nasal floor. (k) Postoperative CBCT after expansion showing the intact midpalatal suture (yellow arrow), separation at the right nasal floor with protruding microscrews (black arrow) and the lateralized left hemimaxilla (white arrow). (l) Postoperative CBCT after diastema closure.

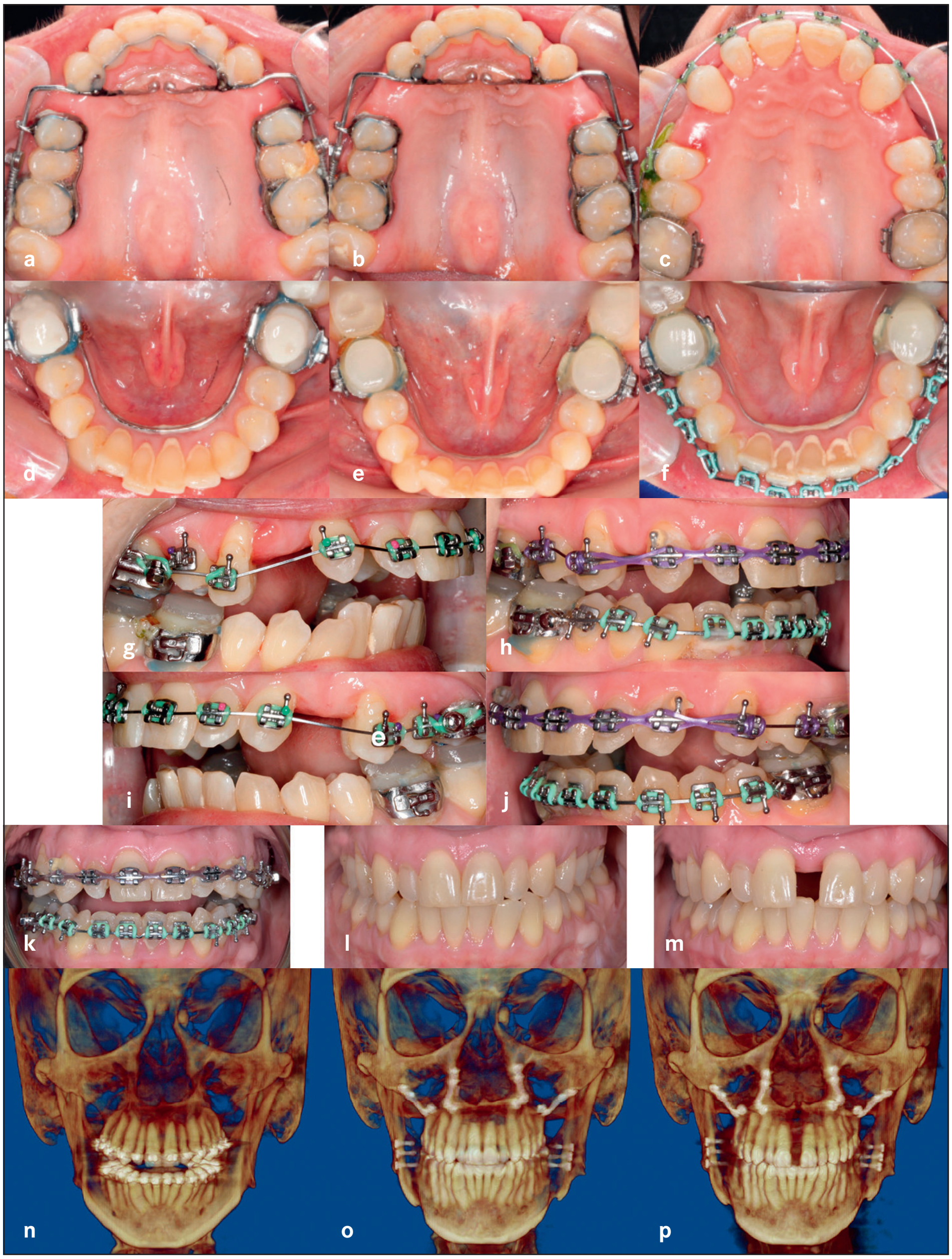

Figure 5

49-year-old woman underwent AGGA. (a) Palatal view during AGGA treatment. (b) Palatal view prior to appliance removal. (c) Palatal view during orthodontic closure of the edentulous space. (d) Mandibular occlusal view during AGGA treatment. (e) Mandibular occlusal view prior to appliance removal. (f) Mandibular occlusal view during orthodontic closure of the edentulous space. (g) Right lateral view in the beginning of the orthodontic closure of the edentulous space. (h) Right lateral view showing closure of the edentulous space. (i) Left lateral view in the beginning of the orthodontic closure of the edentulous space. (j) Left lateral view showing closure of the edentulous space. (k) Frontal view near the completion of the AGGA treatment. Note the lateral displacement of the dentoalveolus. (l) Frontal view after removal of the orthodontic appliance and following maxillomandibular advancement. Note the normalization of the dentoalveolus. (m) Frontal view after nasomaxillary expansion by endoscopically assisted surgical expansion (EASE). Note the absence of dentoalveolar displacement. (n) Postero-anterior (PA) skull view at the completion of the AGGA treatment. Note the lateral displacement of the dentoalveolus. (o) PA skull view with removal of the orthodontic appliance and following maxillomandibular advancement. Note the normalization of the dentoalveolus. (p) PA skull view post nasomaxillary expansion by EASE. Note the nasomaxillary widening without dentoalveolar displacement.

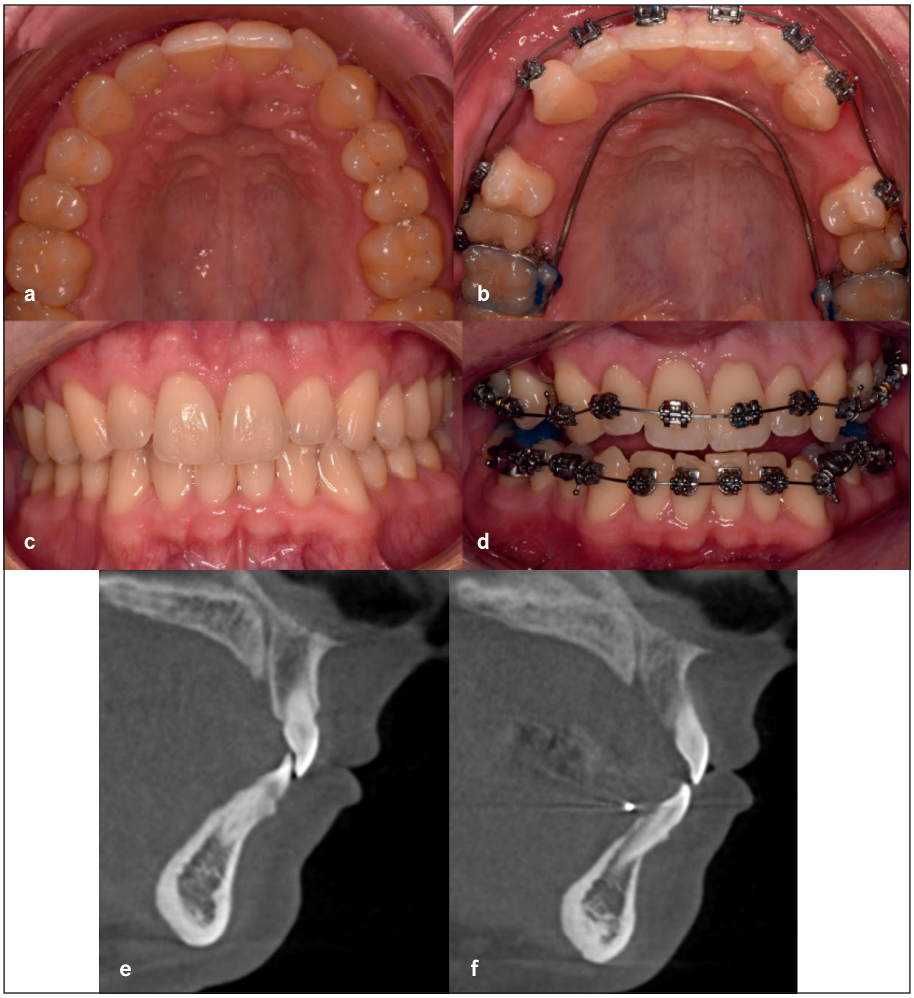

Figure 6
28-year-old man underwent AGGA treatment. (a) Pretreatment maxillary occlusal view. (b) Maxillary occlusal view after AGGA expansion. (c) Pretreatment frontal view. (d) Frontal view after AGGA expansion. (e) CBCT sagittal view showing the alveolar bone at central incisor. (f) CBCT sagittal view showing the reduction of the central incisor labial bone.

3.2. Anterior Growth Guidance Appliance (AGGA)

AGGA has been advocated to promote facial growth due to the physiologic stimulation by the appliance[8,9]. Although the treatment indication was for OSA, no peer-review studies are currently available on the impact of this treatment in OSA. Five patients with a mean age of 32.6 years (range 28-49 years) that underwent AGGA reported no improvement in their symptoms. All five patients reported significant teeth mobility. The CBCT showed dental and dentoalveolar displacement in the maxillary dentition. Thinning and destruction of the labial/buccal alveolar bone with horizontal and vertical bone loss occurred in the anterior dentition in all five patients, and the midpalatal suture remained fused in all of the patients (Figs. 5 to 7).

3.3. Daytime-Nighttime Appliance (DNA)

The DNA appliance has been advocated for the treatment of OSA. Although scant case reports with the use of DNA can be found, no peer-reviewed scientific evidence concerning the role of these devices in the treatment of OSA is currently available[23,24]. The two patients that underwent DNA treatment reported no improvement in their OSA symptoms. The clinical records and CBCT showed the maxillary expansion were purely dental and dentoalveolar in nature without separation of the midpalatal suture (Fig. 8).

Figure 7

21-year-old man underwent AGGA treatment. (a) Palatal view with AGGA appliance. (b) Palatal view at the completion of the AGGA activation. Note the edentulous space and the significant proclination of the dentition. (c) Frontal view before AGGA activation. (d) Frontal view at the completion of the AGGA activation. (e) Postero-anterior (PA) skull view pretreatment. (f) PA skull view post AGGA activation. (g) ¾ skull view pretreatment. (h) ¾ skull view post AGGA activation. (i) CBCT view pretreatment. (j) CBCT view post AGGA treatment. Note the alveolar bone destruction and recession.

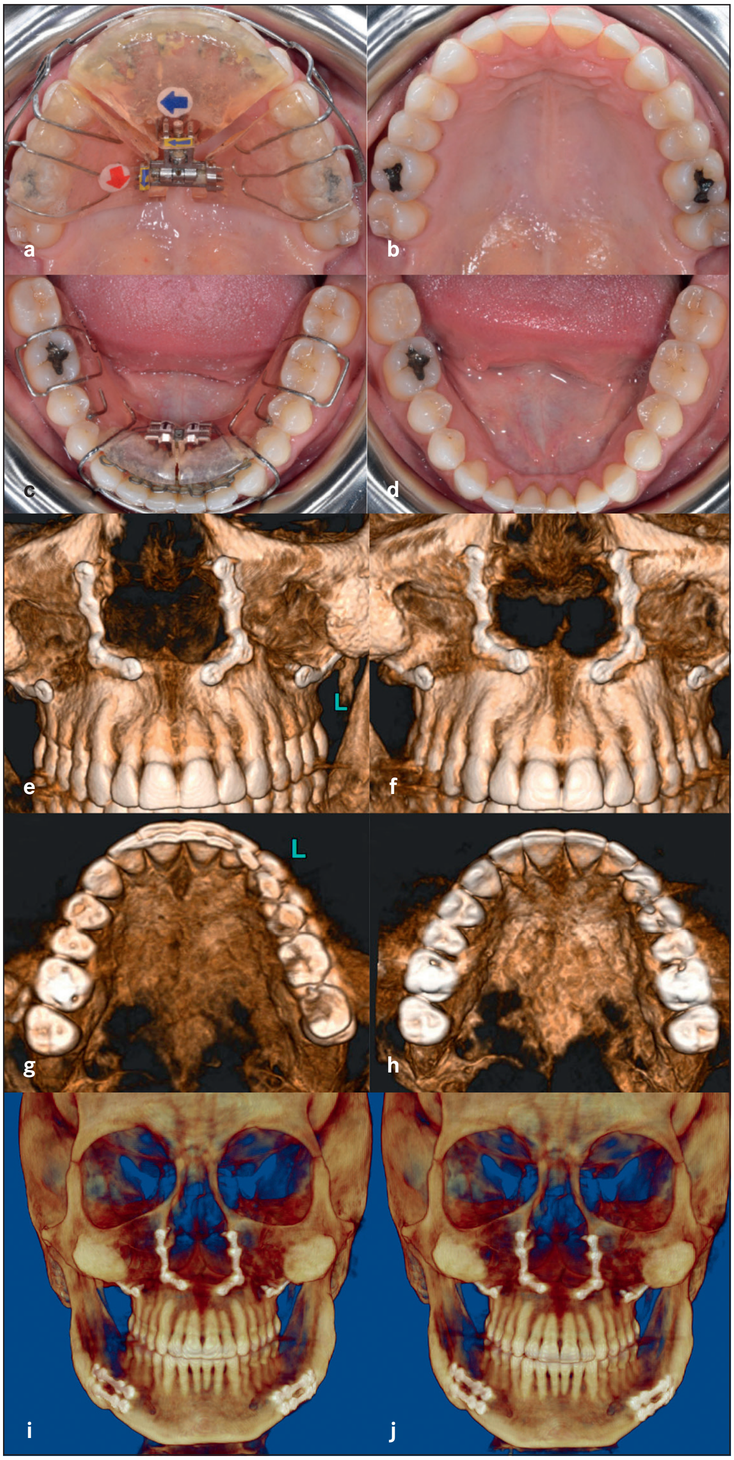

Figure 8
60-year-old woman with prior maxillomandibular advancement underwent DNA treatment. (a) Maxillary occlusal view with DNA appliance. (b) Maxillary occlusal view at completion of expansion. (c) Mandibular occlusal view with DNA appliance. (d) Mandibular occlusal view at completion of expansion. (e) Pretreatment CBCT frontal view. (f) Posttreatment CBCT frontal view. Note the lateralization of the alveolus without midpalatal suture separation. (g) Pretreatment CBCT maxillary occlusal view. (h) Posttreatment CBCT maxillary occlusal view. Note the intact midpalatal suture. (i) Pretreatment PA skull view. (j) Posttreatment PA skull view. Note the intact midpalatal suture with lateralization of the dentoalveolus.

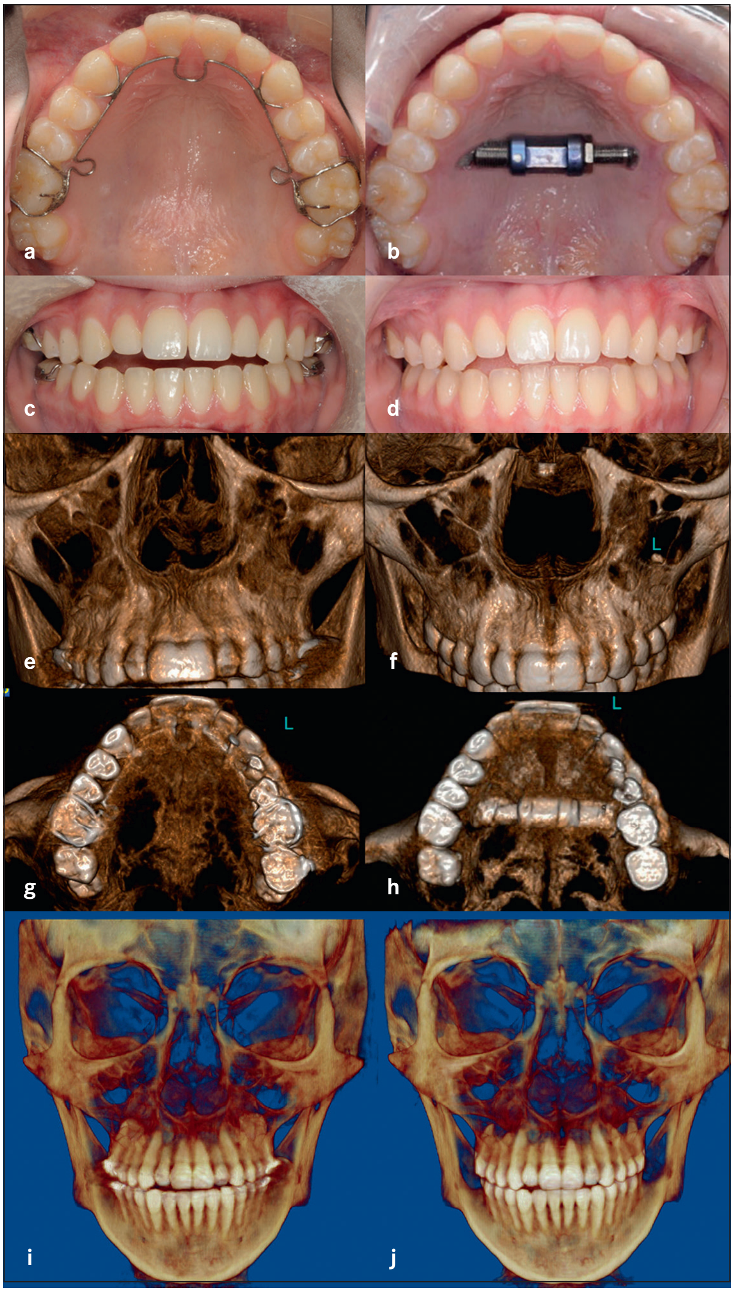

Figure 9

14-year-old girl underwent ALF treatment. (a) Palatal view with ALF appliance. (b) Palatal view posttreatment with transpalatal distraction (TPD) after removal of the ALF appliance. (c) Frontal view posttreatment with ALF appliance. (d) Frontal view posttreatment with TPD after removal of ALF appliance. (e) Posttreatment ALF CBCT frontal view. Note the intact midpalatal suture. (f) Posttreatment TPD CBCT frontal view. Note the nasal airway expansion with midpalatal suture separation. (g) Palatal view posttreatment with ALF. Note the intact midpalatal suture. (h) Palatal view posttreatment with TPD. Note the separation of the midpalatal suture. (i) PA skull view posttreatment with ALF. Note the intact midpalatal suture and lateralized dentoalveolus. (j) PA skull view posttreatment with TPD after removal of ALF appliance. Note the nasomaxillary expansion, midpalatal suture separation and normalization of the dentoalveolus.

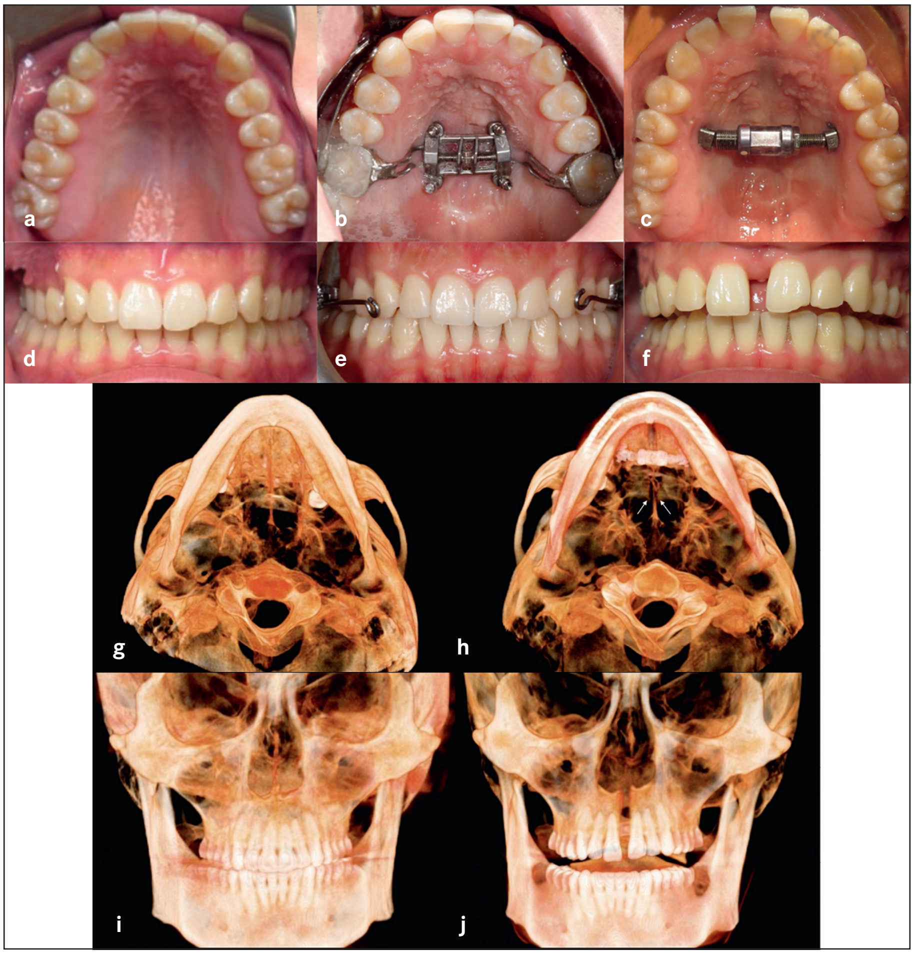

Figure 10

20-year-old man underwent MARPE treatment. (a) Pretreatment palatal view. (b) Posttreatment with MARPE without separation of the midpalatal suture. (c) Posttreatment with EASE after MARPE appliance removal. (d) Pretreatment frontal view. (e) Posttreatment with MARPE without separation of the midpalatal suture and the absence of diastema. (f) Posttreatment with EASE after MARPE appliance removal. Note the skeletal expansion without lateralization of the dentoalveolus. (g) CBCT palatal view after MARPE appliance removal. Note the intact midpalatal suture. (h) CBCT palatal view after EASE. Note the parallel midpalatal separation and opening of the posterior nasal spine (white arrows). (i) CBCT frontal view after MARPE appliance removal. (j) CBCT frontal view after EASE.

3.4. Advanced Lightwire Functionals Appliance (ALF)

OSA was the treatment indication for the four patients that underwent ALF therapy. The mean age was 22 years (range 14-21 years). Although ALF has been advocated in orthodontics by some practitioners[6,25], there is currently no objective evidence that ALF treatment improves OSA and, indeed, no peer-reviewed scientific evidence concerning the role of these devices in the treatment of OSA is currently available. All four patients reported no improvement of nasal breathing or OSA symptoms following ALF treatment. Lateralization of the dentoalveolus was evident in the clinical photos and CBCT in all the patients and the midpalatal suture did not separate in any of the patients (Fig. 9).

3.5. Mini-screw Assisted Rapid Palatal Expansion (MARPE)

MARPE has been advocated in recent years to achieve a greater skeletal expansion with improved skeletal anchorage and reduction of undesirable dental impact[4,11,27]. A review of MARPE in 264 patients showed an average age of 12.3 years[15]. Therefore, this approach may have limitations beyond adolescents and young adults.

All five patients that underwent MARPE expansion failed to achieve midpalatal suture separation, and the mean age was 26.2 years (range 20-36 years). Although some dental/dentoalveolar tilting occurred, it was less than the other dental expansion methods described in this report (Fig. 10). The palatal screws showed tilting/angulation or "cheese-wiring" through the nasal floor with limited lateralization of the dentition in all patients. No improvement of symptoms was reported.

4. Discussion

Nasal obstruction leads to compensatory oral breathing, resulting in increased airway resistance during sleep[7,26]. Oral breathing with mouth opening contributes to tongue retrodisplacement, upper airway collapse, and altered airway muscle activity[1,2,12,19,28]. Multiple investigators have shown that OSA can be induced in healthy volunteers when the nose is artificially obstructed by nasal packing[7,20,22,26,30]. Nasal surgery has been demonstrated to reduce nasal resistance and improve OSA[3,18]. Indeed, the nose is an important element in the development and treatment of OSA. Evidence suggests that maxillary expansion widens the mid-palatal suture and enlarges the nasal airway resulting in the reduction of nasal resistance[10,13,14,29]. This effect renders a less collapsible airway to negative intraluminal pressure, leading to OSA improvement[14]. Therefore, maxillary expansion must target the separation of the midpalatal suture, resulting in nasal sidewall lateralization to achieve nasal airway expansion.

It is well-known that separation of the midpalatal suture becomes increasingly more difficult with age due to ossification and maturation of the skeleton[17,21]. Therefore, the dental tipping, thinning, and destruction of the labial/buccal alveolar bone, gingival recession, and failure of midpalatal suture separation found in these adult patients that underwent non-surgical expansion were not surprising but expected. Unfortunately, the dental health and alveolar support were permanently compromised in some patients following their treatment, while OSA was not improved.

The addition of mini-screws to improve skeletal anchorage in minimizing unfavorable dental changes clearly makes physiologic sense. However, MARPE was unsuccessful in achieving skeletal expansion. Therefore, limitations exist in applying this approach to all patients, even in young adults. The limitation can be overcome when maxillary sutures were strategically separated along with the application of a skeletal distractor, despite prior failure of MARPE expansion (Fig. 10).

It should be emphasized that although surgically assisted maxillary expansion can achieve skeletal expansion with midpalatal suture separation, the expansion pattern can vary, as seen in the DOME patients. Additionally, the extent of dental expansion was much greater than the skeletal expansion, along with significant bone loss and dental devitalization. This is possibly related to the excessive expansion performed in an attempt to maximize the nasal expansion, thus resulting in complications. The asymmetric expansion and the lack of hemimaxilla lateralization are likely related to the slanted Le Fort I osteotomy performed in these patients, as all of the patients were noted to have non-horizontal but angulated Le Fort I osteotomy pattern.

5. Conclusion

The application of maxillary expansion has evolved from improving dental crossbites to improving breathing and sleep. This is a new and exciting arena for the dental profession. However, many maxillary expansion methods that are currently being used have minimal outcomes data. This deficiency is increasingly being recognized. A rigorous scientific approach and critical analyses of these methods are needed to determine their impact and whether the desired outcomes can be achieved.

Links of interest

The authors declare that they have no interest in the data published in this article.

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