Complications From Surgically Assisted Rapid Maxillary Expansion With HAAS and HYRAX Expanders

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Abstract: The current study aimed at comparing the number and type of undesired outcomes during and after the maxillary expansion performed with HYRAX and HAAS expanders. A total of 90 patients (41 males and 49 females, 45.6% and 54.4%, respectively) aged 18 to 59 (mean age of 26.1; standard deviation [SD] = 7.4) underwent subtotal Le Fort I osteotomy and pterygomaxillary disjunction following surgically assisted rapid maxillary expansion (SARME) carried out using HAAS (n = 29; 48.3% male and 51.7% female; mean age = 27: SD = 7.7) and HYRAX (n = 61; 44.3% male and 55.7% female; mean age = 26; SD = 7.2) expanders. Post-SARME dento-gingival, radiographic, and clinical undesired outcomes were evaluated. A total of 16 (17.8%) patients experienced at least 1 undesired outcome—7 (7.8%) and 9 (10.0%) in HAAS and HYRAX group, respectively. The most common undesired outcomes were radiographic asymmetric expansion—2 (2.2%) and 3 (3.3%) in HAAS and HYRAX group, respectively—followed by pain during out-of-clinic expansion 4 (4.4%) in HAAS group only—dental darkening 5 (5.5%) in HYRAX group, only, requiring root canal treatment, and local infection—2 (2.2%), 1 in each HAAS and HYRAX groups. Excepting for complications arising from the acrylic stop plate in HAAS expander, the number and severity of complications observed in the current study did not differ due to the use of HAAS and HYRAX appliances to perform maxillary expansion. Hygiene issues do not rule out the use of HAAS. The wider maxillary expansion performed, the more frequent are the cases of asymmetric expansion.

Key Words: Complications, maxillary expansion, maxillofacial surgery, orthodontic appliances, palatal expansion technique

(*J Craniofac Surg* 2017;00: 00–00)

Transverse maxillary deficiency is a dento-facial deformity clinically characterized by unilateral or bilateral posterior crossbite, dental crowding, excessive lingual inclination of the posterior teeth, a triangular dental arch, deep palate, and predominant mouth breathing. Transverse maxillary deficiency may occur as an isolated condition resulting in functional implications, or associated with other esthetical features, such as narrow base of the nose, deep nasolabial folds, and hypoplasia of the zygomatic and paranasal area.[1,2]

The prevalence of surgical treatment of transverse maxillary deficiency varies between 3% and 18%.[3,4]

For adult patients with severe maxillary transverse deficiency—upper jaw over 5 mm narrower than the expected normal anatomic width—the treatment of choice is the surgically assisted rapid maxillary expansion (SARME).[5] Surgically assisted rapid maxillary expansion involves 2 fundamentals, the facilitation of maxillary expansion through convenient osteotomies and progressive mechanical expansion of the maxilla.[6]

Reports from the literature show that despite SARME involving potential risks, of which surgeons must be aware of it, is usually a successful treatment without serious negative outcome whether applying HYRAX or HAAS expanders, screw activated, tooth born expanding devices.[2,5–11]

The difference between these 2 expanding devices is that HAAS includes a palatal acrylic stop plate whose aim is preventing the tipping of teeth supporting the expanding device as well as any relative tilting of the right and left halves of the maxilla. They caused by resistance forces from soft tissue and osseous structures not surgically liberated that may occur during the process of forced sideway expansion. Such palatal support, however, is not expected to exert any considerable force against the palate during the expansion protocol.[7,8]

The elimination of the palatal support in Hyrax device provides an easier and better mouth hygiene thus favoring a faster and better healing of mouth tissues. The absence of the palatal support also simplifies the making and adapting of the expanding device. On the other hand, tooth tipping and occlusion problems resulting relative tilting of the maxilla halves must be treated orthodontically.[10]

Despite occasional excess bleeding, infection, sinusitis, periodontal bone loss, root canal damage, tooth loss, ulceration of palatal mucosa, and asymmetric expansion being referred to in patient and clinical series reports, the literature shows no consensus or clear evidence that one or another expander is consistently associated with better outcome.[12–24]

A number of studies have addressed the issue but as a whole, they do not seem to be conclusive as to which expanding device should be elected the one of choice, nor whether both producing equivalent outcome.

The present retrospective study aimed at assessing 2 series of SARME applying either HYRAX or HAAS regarding the occurrence of undesirable events observed at any point of the treatment of maxilla expansion with osteotomies performed by a same surgeon.

PATIENTS AND METHODS

This study received the approval of ethics committee for medical research of the Federal University of São Paulo (UNIFESP) under number 0290/04 and all patients enrolled signed an informed consent form.

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Received March 6, 2017.
Accepted for publication August 6, 2017.

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The authors report no conflicts of interest.

ISSN: 1049-2275
DOI: 10.1097/SCS.0000000000004079

Patients

A total of 90 patients in treatment at the Craniomaxillofacial Sector of the Plastic Surgery Department of UNIFESP undergoing SARME between May 2003 and November 2012 had their postoperative follow-up and expansion outcome analyzed.

All patients enrolled in the current study were 18 or older, showed skeletal maturity, and presented with bilateral crossbite and maxillary transverse deficiency >5 mm.

Patients with unilateral cross bite or presenting with craniofacial abnormality were not subject of this study.

Transverse Maxillary Assessment

The amount of transverse maxillary expansion was established after clinical examination and the study of full arch diagnostic casts and anteroposterior radiograph.

Follow-up assessment of maxillary expansion was carried out analyzing full dental arch casts, lateral teleradiograph of the head, and frontal panoramic, periapical radiographs of the central incisors, as well as the total occlusal radiograph of the maxilla taken just after the completion of maxillary expansion, and 4 and 10 months later.

Surgical Procedure

All patients were operated on under general anesthesia by the same surgeon. LeFort-I osteotomies as suggested by Betts et al and the release of the pterygomaxillary junction were performed in all patients.[2]

Expanding Device and Activation

The current study focused on HYRAX and HAAS expanding appliances only. It did not include any patient using a contention device after their removal.

HYRAX and HAAS expanding appliances Dentarum (Ispringen, Germany) were assembled for each patient by the same technician in a dental prosthesis laboratory and installed by the same orthodontist 1 week prior to surgery. The dental bands were bonded around the left and right upper first premolars and first molars with glass ionomer cement.

Expanders were first activated to expand 1.6 mm by the surgeon in the surgery room. From postoperative day 4 on, the expanding devices were activated to expand 0.2 mm at 1 stroke (1/4 of a turn) twice a day every day, until achieving the intended expansion.

A total of 29 and 61 patients underwent SARME applying HAAS and HYRAX expanding devices, respectively. Maxillary expansions performed with each appliance ranged from 6 to 11 and 6 to 12 mm, respectively, with 0.4 mm increment per day in both patients.

After the completion of the expansion required, the expanding devices were left in place inactivated for 4 months before their removal.

Study Outcome Variables

Any undesirable outcome arising from the protocol used for the correction of maxillary deficiency or occurring during follow-up period was recorded. The presumed possible ones included pain, bleeding, local infection, mucosal injuries, gingival recession, color changes in teeth, and asymmetric expansion (Fig. 1A-B).

Asymmetric expansion was assessed clinically and by comparing posteroanterior radiographs taken prior to intervention, and after the end of expansion (Fig. 1C-D).

Statistical Analyses

Chi-squared test and level of statistical significance of 0.05 were used to analyze the outcome data.

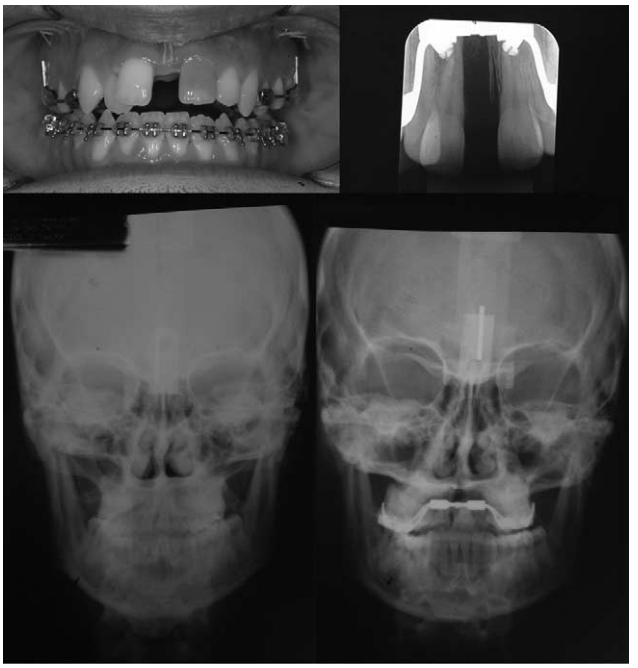

FIGURE 1. Photography and periapical radiography following SARME. (A) Front view showing darkening of the left maxillary central incisor. (B) Periapical radiographs of maxillary central incisors. Posteroanterior radiograph. (C) Prior to SARME. (D) Following SARME showing greater asymmetric expansion on the right side. SARME, surgically assisted rapid maxillary expansion.

RESULTS

A total of 16 (17.8%) individual undesired occurrences were observed among the 90 patients. Asymmetric expansion was common to both HAAS and HYRAX groups of patients, 2 out of 29 (6.9%) and 3 out of 61 (4.9%), respectively, with overall count of 5 out of 90 (5.6%).

Pain was felt by 4 out of 29 (14.0%) patients in group HAAS only whereas tooth darkening occurred in 5 out of 61 (8.2%) patients in group HYRAX only, which represent an overall rate among the 90 participants of 4.4% and 5.5%, respectively.

One patient in group HAAS and 1 in group HYRAX had local infection, mounting to 2.2% in the total of 90 patients enrolled in this study.

Table 1 shows the number of patients for each amount of expansion performed with HAAS and HYRAX expanding devices. Mean age and corresponding standard deviation are shown for groups in which the number of patients receiving the same amount of maxillary expansion was 6 or more, and thus, subject of statistical analysis.

Table 2 shows a measure of failure in accomplishing symmetric expansion expressed in terms of possible odds—number of asymmetric expansions per number of expansions performed—ascertained with Chi-squared test, encompassing amounts of expansion, which could bear a possible relationship among them, regardless of the type of expanding device used.

Table 3 shows no statistically significant difference in the comparison between the relative number of patients with unwanted outcome in HAAS and HYRAX groups using the Chi-Squared test.

DISCUSSION

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

TABLE 1. Amount and Number of Maxillary Expansion Performed With HAAS and HYRAX Expanders

	HAAS			HYRAX		
Amount of Expansion, mm	**Number of Patients**	**Asymmetric Expansion**	**Pain**	**Number of Patients**	**Asymmetric Expansion**	**Tooth Darkening**
6	2	—	—	1	—	—
7	**6** (24.8 ± 3.3)	—	—	**15** (26.5 ± 6.2)	**1**	2
8	2	—	—	**22** (24.6 ± 9.1)	—	3
9	**6** (32.0 ± 12.5)	**1**	2	**14** (27.5 ± 7.1)	**1**	—
10	**10** (27.1 ± 6.5)	**1**	2	**6** (24.8 ± 4.6)	**1**	—
11	3	—	—	2	—	—
12		—	—	1	—	—

Group mean age and standard deviation indicated between parentheses. Values presented in bold are selected for further statistical analysis in Table 2.

Among the orthognathic surgical procedures, SARME is reported to have the lowest levels of undesired outcome.[5–11]

Nevertheless, events ranging from excessive pain, infection, bruising, excessive bleeding and tissue necrosis to asymmetric expansion, gingival recession, periodontal bone loss, tooth darkening, and tooth loss have been reported.[12–24]

Sterile equipment and environment followed by a course of antibiotic postoperatively are normally effective to prevent infection in the areas affected by SARME. However, there are factors occurring after maxillary expansion that are out of medical prevention control, such as poor oral hygiene practice on the part of patients. The fermentation of food residues on the surgical incision before it being fully healed can result in inflammation due to bacterial proliferation.

Willians et al[15] in a study with 120 patients and Albuquerque et al[16] in another with 33 participants reported rates of infection of 6.7% and 6%, respectively, after surgical intervention.

In the current study, only 2 out of 90 patients (2%) developed infection, 1 using HAAS device whose palatine supports are expected to make a full oral hygiene more difficult, and 1 using HYRAX expander, with which oral hygiene is advocated to less complicated, according to the Biederman.[10] In both patients, the infection affected the vestibular mucosa and was located in the posterior range of the fornix, a site where food is compacted due to the natural movement of the tongue during mastication.

The lower rate of postoperative infection reported in the current study combined with the site of infection supports the argument that regarding oral hygiene both expanding devices have equivalent performances.

Although postoperative bleeding reported in SARME studies is not directly linked with expanding device, it may be of interest to make a point on this issue in the present discussion. Its prevalence reported in the SARME studies included in the reference section varies greatly. Dergin et al[17] reports a rate of 20% (12 in 60), whereas the study by Albuquerque et al[16] brings a rate of 3% (1 out of 33). Albuquerque et al[16] also report 1 patient with development of maxillary sinusitis after maxillary osteotomy, attributing it to bleeding during SARME intervention, which resulted in the formation of blood clot and blood collection. Other 2 studies involving LeFort I osteotomy also report infection caused by similar mechanism.[23,24]

The current study, in turn, reports no patient with unwanted bleeding during or after surgical intervention and attributes its absence to the preventive measure of cauterizing both anterior palatine arteries during surgery.

The present research work resulted from a review of all SARME performed from 2003 to 2012 with surgical intervention performed by the first author. For the comparative study of complications recorded for SARME using HAAS and HYRAX devices, patients with maxillofacial deformities, unilateral transversal maxillary expansion, and nonparallel transversal maxillary expansion were not included. The selection resulted in 90 patients of parallel, transversal maxillary expansion—29 using HAAS and 61 using HYRAX devices.

Only 3 types of unwanted outcome were found—complaint of persistent moderate to severe pain, tooth darkening requiring endodontic treatment and asymmetric expansion. The distribution in HAAS and HYRAX groups according to the amount of expansion performed is presented in Table 1.

Patients with persistent pain occurred in HAAS group only—2 of them without ascertained cause and 2 due to over-compression of the hemi-palatine vault on the acrylic stop plate, which prevents the hemi-maxilla from tilting. Apart from manufacturing causes, 2 factors can lead to excessive compression of the hemi-palate on the acrylic stop plate—expansion performed faster than the rate established in the expansion protocol, and not sufficient surgical release of bone structures. Pain due to such compression was relieved after extracting the expanding device and the removing some material off the palatal surface of the acrylic plate. The

TABLE 2. Statistically Possible Common Number of Asymmetric Expansion per Number of Expansions Performed Among Subgroups

Amount of Expansion, mm	Number of Patients (HAAS)	Number of Patients (HYRAX)	Possible Odds
7		15 (26.5 ± 6.2)	1/15 to 1/24
8		22 (24.6 ± 9.1)	1/15 to 1/24
9	6 (32.0 ± 12.5)	14 (27.5 ± 7.1)	1/8 to 1/12
10	10 (27.1 ± 6.5)	6 (24.8 ± 4.6)	1/8 to 1/12

Group mean age and standard deviation indicated between parentheses. Odds ratios are $P \leq 0.05$.

TABLE 3. Patients With and Without Complications From the HAAS and HYRAX Expanders

	HAAS (n = 29)	HYRAX (n = 61)	*P*
Total with complications	7	10	0.361*
Total without complications	22	51	

*Probability of finding statistical difference in the number of unwanted outcome resulting from the use of different expanders as estimated by applying the Chi-squared test.

extraction of HAAS expander is normally carried out with patient under local anesthesia.

Whereas patients with over-compression of the palate is directly linked to HAAS device, tooth darkening as indication of dental pulp necrosis results from the offense to the bundle of nerve fibers and blood vessel that innervate and irrigate the dental pulp. Such an offense is most directly linked to osteotomy. In the current study, 5 patients had tooth darkening and underwent endodontic treatment—3 patients had 1 central incisive affected, 1 patient had both central incisives affected, and 1 patient had 1 canine affected. As offense to a nerve bundle and blood vessels leading to a tooth pulp is something to avoid, its occurrence in a sequence of surgical interventions should occur following a random pattern. As shown in Table 1, tooth darkening occurred in 2 subgroups that had the greatest number of patients—HYRAX device and expansion amounts of 7 and 8 millimeters.

Comparing the number of complications linked to HAAS and to HYRAX devices individually yielded no statistical significance as shown in Table 3. Equally unsuccessful was admitting that both expanders worked identically regarding their mechanics and trying to find a same common odds rate for asymmetric expansion. Furthermore, the odds rate for asymmetric expansion for each amount of expansion within the group HYRAX was not the same.

However, further analysis putting together amounts of expansion and applying the Chi-squared test resulted in a common odds rate ranging from 1/8 to 1/12 linking HAAS and HYRAX groups for expansions of 9 and 10 mm. In addition, a distinct ratio ranging from 1/15 to 1/24 was found for 7 and 8 mm expansions in the HYRAX group indicating that smaller amounts of expansion are linked to a lower rate of failure (Table 2).

Regardless of the complexity that may be involved in maxillary expansion, the findings of the current study indicate that amount of expansion is one of them, certainly linked with resilience forces arising from the elasticity of body tissues rather than depending on the type of expander—HAAS or HYRAX.

In conclusions:

1. Hygiene is not an issue for ruling out the use of HAAS.
2. Excepting for occasional over-compression of the palate vault on HAAS stop plates incorporated to this device to prevent both hemi-maxillae from tilting, the types, number, and frequency of complications do not differ with statistical significance when comparing HAAS and HYRAX devices.
3. The frequency of asymmetric maxillary expansion is greater for greater amounts of expansion, regardless the expander used—HAAS or HYRAX.

REFERENCES

1. Handelman CS. Nonsurgical rapid maxillary alveolar expansion in adults: a clinical evaluation. *Angle Orthod* 1997;67:291–305
2. Betts NJ, Vanarsdall RL, Barber HD, et al. Diagnosis and treatment of transverse maxillary deficiency. *Int J Adult Orthodon Orthognath Surg* 1995;10:75–96
3. Kelly JE, Harvey CR. An assessment of the occlusion of the teeth of youths 12–17 year. *Vital HealthStat* 1977;162:1–65
4. Silva Filho O, Freitas SF, Cavassan AO. Prevalence of normal occlusion and malocclusion in schoolchildren in the city of Bauru (São Paulo): part I, sagittal relationship. *Rev Odontol USP* 1990;2:130–137
5. Cureton SL, Cuenin M. Surgically assisted rapid palatal expansion: orthodontic preparation for clinical success. *Am J Orthod Dentofacial Orthop* 1999;116:46–59
6. Silverstein K, Quinn PD. Surgically assisted rapid palatal expansion for management of transverse maxillary deficiency. *J Oral Maxillofac Surg* 1997;55:725–727
7. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. *Angle Orthod* 1965;35:200–217
8. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. *Angle Orthod* 1970;57:219–254
9. Lehman JA Jr, Haas AJ. Surgical-orthodontic correction of transverse maxillary deficiency. *Dent Clin North Am* 1990;34:385–395
10. Biederman W. A hygienic appliance for rapid expansion. *J Pract Orthod* 1968;2:67–70
11. Bays RA, Greco JM. Surgically assisted rapid palatal expansion: an outpatient technique with long-term stability. *J Oral Maxillofac Surg* 1992;50:110–115
12. Lanigan DT. Vascular complications associated with orthognatic surgery. *Oral Maxillofac Surg Clin North Am* 1997;9:231–250
13. Lanigan DT, Mintz SM. Complications of surgically assisted rapid palatal expansion: review of the literature and report of a case. *J Oral Maxillofac Surg* 2002;60:104–110
14. Koudstaal MJ, Wolvius EB, Schulten AJ, et al. Stability, tipping and relapse of bone-borne versus tooth-borne surgically assisted rapid maxillary expansion; a prospective randomized patient trial. *Int J Oral Maxillofac Surg* 2009;38:308–315
15. Willians BD, Currimbboy S, Silva A, et al. Complications following surgical assisted rapid palatal expansion: retrospective Cohort study. *J Oral Maxillofac Surg* 2012;70:2394–2402
16. Albuquerque GC, Gonçales AGB, Thieghi Neto V, et al. Complications after surgically assisted maxillary expansion. *Rev Odont UNESP* 2013;42:20–24
17. Dergin G, Aktop S, Varol A, et al. Complications related to surgically assisted rapid palatal expansion. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2015;119:601–607
18. Mehra P, Cottrell DA, Caiazzo A, et al. Life-threatening, delayed epistaxis after surgically assisted rapid palatal expansion. A case report. *J Oral Maxillofac Surg* 1990;57:201–204
19. Lanigan DT. Internal carotid artery and ophthalmic injuries. *Oral Maxillofac Surg Clin North Am* 1997;9:271
20. Filho C, Pastori CM, Marzola C, et al. Complications in surgically assisted rapid maxillary expansion literature review and case report. *Rev Odont* 2012;12:1003–1025
21. Watts A, Addy M. Tooth discolouration and staining: a review of the literature. *Br Dent J* 2001;109:309–316
22. Oztürk M, Doruk C, Özeç I, et al. Pulpal blood flow: effects of corticotomy and midline osteotomy in surgically assisted rapid palatal expansion. *J Craniomaxillofac Surg* 2003;31:97–100
23. Pereira-Filho VA, Gabrielli MF, Gabrielli MA, et al. Incidence of maxillary sinusitis following Le Fort I osteotomy: clinical, radiographic, and endoscopic study. *J Oral Maxillofac Surg* 2011;69:346–351
24. Bell CS, Thrash WJ, Zysset MK. Incidence of maxillary sinusitis following Le Fort I maxillary osteotomy. *J Oral Maxillofac Surg* 1986;44:100–103