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Comparison between RME, SME and Leaf Expander in growing patients: a retrospective postero-anterior cephalometric study

ABSTRACT

Aim *The aim of this study is to compare the dental and orthopaedic effects of the Leaf Expander with rapid and slow maxillary expanders.*
Materials and methods *The sample comprised 30 patients with a posterior crossbite divided into three groups: the rapid maxillary expander (RME) group (3 m, 7 f), average age 8.9 years; the slow maxillary expander (SME) group (7 m, 3 f) average age 12.2 years; the Leaf Expander (LE) group (7 m, 3 f), average age 7.9 years. Postero-anterior cephalometric studies have been obtained at the beginning of the therapy (T1) and after 9 months (T2). Nasal width, maxillary width, mandibular width, upper permanent molars width have been measured by a calibrated examiner.*
Results *All the measurements increased significantly after the treatment (paired t-test P=0.05). Maxillary average width increased of 4.2 mm (SD 3.6 mm) in RME; + 2.8 mm (SD 2.8 mm) in RSE and +3.6 mm (SD 2.2 mm) in LE group. Upper permanent molars width increased: + 5.4 mm (SD 3.31 mm) in RME; + 5.4 mm (SD 3.3 mm) in SME and + 3.8 mm (SD 2.1 mm) in LE group. No statistical differences between the groups have been found (t-student test P=.05).*
Conclusions *The effectiveness of the LE in transversal deficiency correction has been confirmed.*

Keywords *Compliance; PA cephalometrics; Rapid maxillary expansion; Slow maxillary expansion.*

Introduction

Posterior crossbite is a common malocclusion with a prevalence ranging between 8 and 22% in children in primary/mixed dentition [De Sousa et al., 2014; Lux et al., 2009]. Maxillary expansion is the main treatment used to correct this malocclusion and can be achieved with many different techniques; furthermore, various appliance designs have been proposed according to the clinical defects that has to be treated [Asanza et al., 1997; Prado et al., 2014].

The two main differences concern expansion rates and forces: Rapid Maxillary Expansion (RME) or Slow Maxillary Expansion (SME) [Petren et al., 2003; Zhou et al., 2014; Bazargani et al., 2013]. RME is the main treatment used for the correction of maxillary constriction and posterior cross-bite, with the intent to increase the transverse widths of the maxilla through the opening of the mid-palatal suture [Liu et al., 2015] The correction of a posterior crossbite in young patients is often accomplished by a combination of skeletal and dental expansion.

Maxillary expansion involves separating the palatal bones at the midpalatal suture and dental expansion results mainly from buccal tipping of the maxillary posterior teeth. RME appliances produce intermittent large forces at the sutural site over a short period. It is a mechanical procedure that is designed to produce maximum skeletal response with minimum tooth movements [Westwood et al., 2003]. Two of the main common limits of RME is that it may induce patient discomfort and also requires patients and parents cooperation in appliance activation.

Since the 1970 different authors have suggested that slow expansion is effective in suture opening and these procedures allow physiologic adjustments and reconstitution of the sutural region, thus reducing pain and discomfort for patients [Story, 1973; Ekstrom et al.,1977]. In 1993, Arndt developed a fixed-removable tandem loop nickel-titanium maxillary expander which might reduce also the need of patients and parents cooperation.

A nichel-titanium expander is capable of a uniform, slow, continuous force that allows maxillary expansion maintaining tissue integrity during repositioning and remodelling of midpalatal suture [Arndt,1993].

The design of the Leaf Expander (LE) (Fig. 1) is similar to that of a conventional rapid maxillary expander. Instead of a midline jackscrew, however, it has a double nickel titanium leaf spring that recovers its original shape during deactivation, resulting in a calibrated expansion of the upper arch [Lanteri et al., 2016].

Only few clinical studies have been done in order to evaluate nickel-titanium maxillary expanders [Donohue et al.,2004; Caniklioglu et al., 2004; Ciambotti et al., 2001; Marzban et al., 1999; Abdoney, 1995] and most of them are focused on the memory screw appliance [Halıcıoğlu et al., 2014; Wichelhaus et al., 2004].

One of the main difference between memory screw and LE appliance is the compliance of the patients: in the appliance that we have evaluated, due to its peculiar characteristics, parents/patients do not need to activate it at home but the expander is quickly and easily activated by the orthodontist.

The aim of this study was to evaluate and compare, through posteroanterior (PA) cephalometric studies, the dental and orthopaedic changes of the LE with RME and SME techniques.

Materials and methods

The retrospective study involved 30 patients (Caucasian ethnicity), 17 males and 13 females, with no previous orthodontic treatments, presenting a mixed dentition, treated by the same orthodontis in his private practice (AG), PA cephalometric films were obtained before (T1) and after treatment (T2).

The age, duration of treatment and sex characteristics of the three groups are indicated in Table 1.

1. The first group consisted of 10 patients (7 females, 3 males) aged between 6.8 years and 11.1 years, with unilateral crossbite in 6 cases and bilateral in 4 cases, which have been applied a Haas type RME (8 mm) (Leone SpA; Sesto Fiorentino, Florence, Italy).
2. The second group consisted of 10 patients (3 females, 7 male) aged between 8 years 2 months and 15 years 6 months, with a unilateral crossbite in 8 cases and bilateral in 2 cases, who were treated with SME appliance (ELA) (Leone SpA; Sesto Fiorentino, Florence, Italy).
3. The third group consisted of 10 patients (3 females, 7 males) aged between 6.4 years and 9.2 years, with unilateral cross-bite, who were treated with the LE (Leaf Expander®, Leone SpA, Sesto Fiorentino, Florence, Italy).

The clinical protocol for the RME and SME group have been already explained in a previous work [Gianolio et al., 2014].

FIG. 1 Occlusal view of the Leaf Expander.

	T1	T2	T2-T1	M	F
R.M.E.	8.9 y±1.6 y	9.3 y±1.6 y	7±3 m	30%	70%
ELA	12.2 y ±2.4 y	13.3y±2.5 y	10 ±1 m	70%	30%
NiTi L.E.®	7.11 y±1.3 y	8.11 y±2.1 y	11±2 m	70%	30%

TABLE 1 Distribution of Age, duration of treatment and sex characteristics of the three groups.

The activation protocol for the LE included an initial activation (the leaves are pre-activated in the laboratory to deliver 3 mm of expansion) followed by another after one month (10 activations of 0.1 mm each) and the following two months (10 activations of 0.1 mm each) for a total of 30 activations for further 3 mm of expansion. In this way a continuous force can be effectively applied in order to obtain 6 mm of expansion, enough for the correction of the cross bite, due to the transversal discrepancy.

The RME, SME and LE appliances were kept in place for 7, 10 and 11 months respectively on average.

The expansion was considered complete when the occlusal aspect of the maxillary lingual cusp of upper first molars contacted the occlusal aspect of the vestibular cusp of the mandibular first molars.

The PA cephalometric radiographs were taken before the placement of the appliances and at time of removal after the retention period. It has been used always the same device (Sirona® Orthophos XG) whose focus was always at the same distance from the patient (150 cm). Cephalometric analyses (Ricketts technique) were performed by the same operator, with a dedicated computer programme (OrisCeph® Elite Computers, Milan, Italy) on the posteroanterior film.

The following bilateral landmarks and measurements were considered.

Skeletal landmarks

- Lateronasal (Ln), the most lateral point of the nasal cavity.

- Maxillary (Mx), the point located at the depth of the concavity of the lateral maxillary contour, at the junction of the maxilla and the zygomatic process.
- Antegonion (Ag) the point located at the antegonial notch.

Dental points

- Upper molar (Um), the most prominent lateral point on the buccal surface of the upper first molar.
- Lower molar (Lm), the most prominent lateral point on the buccal surface of the lower first molar.

Consequently measurements obtained at T1 and T2 were:

- Maxillary width;
- Mandibular width;
- Lateronasal width;
- Maxillary first molar width.

To evaluate the measurement error in landmark identification and location all the measurements were measured twice by the same operator. The same films were measured after a two-week interval. The method error was calculated according to Dahlberg's formula √(d2/2n) [Sokal et al., 1981]. The d in the formula represents the difference between two measurements and n represents the number of double measurements.

The results were calculated using the software SPSS for Windows (release 10.0.0, SPSS Inc., Chicago, Ill). The pre-treatment and post-treatment measurements within groups (T1 and T2) were all studied using the paired t-test.

The differences between the groups were evaluated using a Student's t-test.

Results

The measurement errors were calculated and were close to 1.00 and thus within acceptable limits and non-significant differences.

All the patients demonstrated a correction of the crossbite centring the midlines with stable results.

The differences between pre-treatment and post-treatment are shown in Tables 2, 3, 4. The orthodontic changes, appreciable by measuring maxillary first molar, lateronasal, maxillary and mandibular width are always significative comparing pre-treatment vs. post-treatment (paired t-test P=.05). As shown in Tables 5 and 6, maxillary first molar width increased by 5.4 mm (SD 3.3) in the RME group, 5.5 mm (SD 3.5) in the SME and 3.8 mm (SD 2.1) in the LE group. In the RME group maxillary width increased of 4.2 mm (SD 3.6), in the SME of 2.8 mm (SD 2.8) and in the LE group of 3.6 mm (SD 2.2); thus highlighting the positive effects of the devices. The average mandibular width increase was 3.3 mm (SD 4.4) with the RME, 2.0 mm (SD 1.7) with the SME and 1.4 mm (SD 1.6) with the LE. The measurement of Nasal width were again increased significantly with an average value of 2.7 mm (SD 2.7) in the RME group, 1.5 mm (SD 1.1) in the SME group and 1.2 mm (1.3 SD) in the LE.

No significant differences between the groups were found using the Student's t-test.

Discussion

Transverse maxillary deficiency has been already

Patient	Group RME - PreTreatment				Group RME - PostTreatment			
	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width
1	40.7	18.5	43.5	59.7	54.0	25.7	57.7	73.7
2	46.4	23.8	50.5	61.3	55.7	28.3	54.5	66.5
3	50.0	25.2	56.2	72.4	54.5	25.4	58.0	72.7
4	40.9	19.6	45.9	61.8	43.2	23.5	47.8	64.8
5	53.7	24.0	57.9	73.8	57.4	24.0	61.4	75.1
6	44.4	19.6	52.7	68.4	47.8	19.7	57.5	68.6
7	43.5	14.4	47.7	59.3	47.6	20.4	50.0	65.2
8	44.6	17.7	49.6	66.2	49.5	21.1	52.4	68.3
9	43.1	21.5	50.1	68.1	47.4	21.5	54.4	66.6
10	39.4	18.4	47.4	65.1	44.1	20.2	50.3	67.5
MEAN	44.7	20.3	50.2	65.6	50.1	23.0	54.4	68.9
SD	4.4	3.3	4.5	5.1	5.0	2.8	4.3	3.7
Paired t-test	0.0006	0.01	0.005	0.04				

TABLE 2 Changes and comparisons of pre-treatment (T1) and post-treatment (T2) Values within the Group RME and comparison of the measurements with the paired t-test (*P=.05).

associated with many functional and aesthetic problems [Camacho et al., 2016; Cossellu et al., 2016; Di Blasio et al., 2009; Canuto et al., 2010] .

The correction of this malocclusion can be easily gained through maxillary expansion in growing subjects; thus, RME or SME are routinely performed in young patients.

RME has been studied in depth and different limitations have been associated with it such as bite opening, relapse, micro trauma of the temporomandibular joint and the midpalatal suture, root resorption, tissue impingement and pain, excessive tipping of anchorage teeth [Lagravère et al., 2005].

Otherwise, Slow Maxillary Expansions have been proposed and positively used concerning the reduction/eliminations of the RME limits.

From two recent literature reviews, no significant differences between SME, performed with the Quad-Helix or the Minne-expander, and RME, performed with the Hyrax expander, at maxillary intermolar, intercanine, interpremolar width and mandibular intermolar width have been found [Bucci et al., 2016; Agostino et al., 2014].

These studies suggest that overall result of rapid versus slow expansion is similar; however, with slower expansion, a more physiological sutural response should be obtained.

Patient	Group SME - PreTreatment				Group SME - PostTreatment			
	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width
1	50.4	25.5	52.5	66.0	53.1	25.8	52.6	67.3
2	43.5	16.0	44.8	55.8	47.9	18.4	50.2	57.2
3	46.5	16.2	47.6	67.1	50.8	18.3	48.8	67.2
4	45.2	23.8	51.4	69.0	49.2	24.0	51.7	69.0
5	47.5	24.9	48.0	65.5	50.8	25.0	48.7	67.5
6	46.5	21.5	53.7	71.5	58.6	22.1	59.6	76.0
7	41.2	23.9	45.2	66.5	49.3	26.5	51.3	69.7
8	47.9	20.7	53.1	73.3	56.9	23.7	60.0	77.7
9	44.3	25.0	53.2	74.3	51.5	26.2	55.0	76.9
10	48.8	20.8	53.1	68.7	49.0	23.1	53.2	68.7
MEAN	46.2	21.8	50.3	67.8	51.7	23.3	53.1	69.7
SD	2.7	3.5	3.5	5.2	3.5	2.9	4.0	6.1
Paired t-test	0.0008	0.0024	0.01	0.005				

TABLE 3 Changes and comparisons of pre-treatment (T1) and post-treatment (T2) Values within the SME group and comparison of the measurements with the paired t-test (*P=.05).

Patient	Group LEAF - PreTreatment				Group LEAF - PostTreatment			
	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width
1	62.8	30.4	61.4	81.4	65.9	30.6	64.3	81.7
2	62.7	34.1	71	82.4	66.5	34.2	74	82.6
3	56.5	26.4	57	76.5	60.2	26.7	61.2	76.9
4	53.3	26.9	59.9	75.1	59.7	28.8	63.9	78.5
5	59.3	33.2	65.7	83.4	60.8	34.5	65.9	83.5
6	62.2	25.8	62.8	82	67.3	29.1	69.7	85
7	60.9	34.9	64.2	79.4	68.3	35	70.2	83.3
8	61.2	29.5	60.8	81.5	62.1	33.1	66.8	83.9
9	57.9	29.9	65.8	87.1	59.7	30.1	66.9	87.2
10	64.1	33.7	70.8	87	68.2	34.8	72.9	87.3
MEAN	60.1	30.5	63.9	81.6	63.9	31.7	67.6	83.0
SD	3.3	3.4	4.5	3.9	3.7	3.0	4.1	3.3
Paired t-test	0.0003	0.01	0.0006	0.01				

TABLE 4 Changes and comparisons of pre-treatment (T1) and post-treatment (T2) Values within the LEAF group and comparison of the measurements with the paired t-test (*P=.05).

Our results are in agreement with the positive effects reported in previous studies confirming the incrementing width in maxillary structure due to the opening of the midpalatal suture.

In all the subjects treated significantly greater increments for both nasal cavity width and maxillary width has been reported.

As expected, we observed increments of the different widths (maxillary first molar, latero-nasal, maxillary and mandibular) in the LE comparable with those obtained in RME and SME groups with no statistical differences between them.

We have also observed another important outcome: after maxillary expansion, even though the expansion force was not applied on the lower teeth, mandibular intermolar width was found to be increased of 1.4 mm after treatment with the LE. The same results have been observed also in the other two groups with an increase of 1.7 mm and 4.4 mm for SME and RME respectively, supporting the hypothesis of spontaneous adaptation of the occlusion.

The difference on lower molars has been previously discussed and it is still not clear concerning the effect of SME. Howeverour results support the lower molar adaptation even in the SME group [Lagravère et al., 2005].

Patient	Group RME Difference Post-Pre				Group LEAF Difference Post-Pre			
	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width
1	13.3	7.2	14.2	14.0	3.1	0.2	2.9	0.3
2	9.3	4.5	4.0	5.2	3.8	0.1	3	0.2
3	4.4	0.2	1.8	0.3	3.7	0.3	4.2	0.4
4	2.3	3.9	1.9	3.0	6.4	1.9	4	3.4
5	3.7	0.0	3.5	1.2	1.5	1.3	0.2	0.1
6	3.3	0.1	4.8	0.2	5.1	3.3	6.9	3
7	4.2	6.0	2.3	5.9	7.4	0.1	6	3.9
8	4.9	3.4	2.8	2.1	0.9	3.6	6	2.4
9	4.3	0.0	4.3	-1.6	1.8	0.2	1.1	0.1
10	4.8	1.8	2.9	2.3	4.1	1.1	2.1	0.3
MEAN	5.4	2.7	4.2	3.3	3.8	1.2	3.6	1.4
SD	3.3	2.7	3.6	4.4	2.1	1.3	2.2	1.6
T-Student	NS	NS	NS	NS				

TABLE 5 Changes between pre- and post-treatment in RME and LEAF groups (T2-T1) and comparison between groups by means of the T-Student test (P=.05) NS=not significant.

Patient	Group SME Difference Post-Pre				Group LEAF Difference Post-Pre			
	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width	Maxillary first molar width	Lateronasal width	Maxillary width	Mandibular width
1	2.8	0.3	0.1	1.3	3.1	0.2	2.9	0.3
2	4.4	2.4	5.4	1.4	3.8	0.1	3	0.2
3	4.4	2.1	1.2	0.1	3.7	0.3	4.2	0.4
4	4.0	0.2	0.3	0.0	6.4	1.9	4	3.4
5	3.3	0.0	0.7	2.0	1.5	1.3	0.2	0.1
6	12.1	0.6	5.8	4.6	5.1	3.3	6.9	3
7	8.1	2.6	6.1	3.3	7.4	0.1	6	3.9
8	9.0	3.0	6.9	4.4	0.9	3.6	6	2.4
9	7.3	1.1	1.8	2.6	1.8	0.2	1.1	0.1
10	0.2	2.3	0.1	0.0	4.1	1.1	2.1	0.3
MEAN	5.5	1.5	2.8	2.0	3.8	1.2	3.6	1.4
SD	3.5	1.1	2.8	1.7	2.1	1.3	2.2	1.6
T-Student	NS	NS	NS	NS				

TABLE 6 Changes between pre- and post-treatment in SME and LEAF groups (T2-T1) and comparison between groups by means of the T-Student test (P=.05) NS=not significant.

The direct comparison of the three techniques pointed out with moderate evidence that no statistically significant difference exists within them. Therefore, the choice between the three expansion modalities is still determined by the clinicians' expertise.

The limit of this study is the absence of an untreated posterior crossbite control group in order to compare the possible spontaneous growth of the maxilla. Another possible bias might be that we have evaluated as unique groups patients with unilateral or bilateral crossbite: thus, in future studies, this difference could be considered increasing the sample size studied.

Conclusion

The results of our research confirm the effectiveness of the Leaf Expander in the correction of transversal deficiency in growing patients. The advantages of this device are that it is extremely easy to use, requires no compliance from the patient and their parents, the possibility of obtaining a predominant bodily tooth movement and a slow midpalatal suture opening with the use of predetermined and constant forces. The effects are similar to those reached with the RME and the SME appliances both clinically and radiographically; therefore it can be a good therapeutic option in the case of poor patient compliance or particular conditions as an alternative to RME/SME appliances.

Conflict of interest disclosure

The authors declare that they have no relevant financial relationships or any conflict of interests.

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