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Maxillary tridimensional changes after slow expansion with leaf expander in a sample of growing patients: a pilot study

ABSTRACT

Aim *The aim of this study is to evaluate the dento-alveolar effects of slow maxillary expansion using the Leaf Expander in a sample of growing patients with maxillary transverse deficiency, unilateral cross bite and mandibular shift.*

Method *The study included 10 patients, 3 male and 7 female (mean age 7.5 ± 7 months), treated with Leaf Expander anchored on the upper deciduous teeth. Digital models were obtained by a lab scan of the pvs impressions at the beginning of the therapy (T1) and at the removal of the palatal expander (T2). Five parameters were measured: 1) the distance between the first upper permanent molars; 2) the distance between the upper second deciduous molars; 3) the distance between the upper canine cusps 4) the distance between the first lower permanent molars; 5) the distance of the lower canine cusps.*

Results *In all patients complete correction of posterior crossbite was achieved on average in 4 months, with a spontaneous expansion of the upper first permanent molars. Significant increases in the dento-alveolar transversal diameters were obtained. Increases were also observed in the anterior mandibular arch diameter (+ 1 mm).*

Conclusions *These findings suggest that slow maxillary expansion using Leaf Expander appliance could be a reasonable alternative to conventional maxillary expansion therapy in the early mixed dentition.*

Keywords *Early treatment; Posterior crossbite; Slow maxillary expansion.*

Introduction

Study of transverse maxillary deficiency is a central theme in dentistry [Tausche et al., 2004; Geran et al., 2006; Cossellu et al., 2016] because of its complex relationships to multiple pathological conditions and/or dysfunctions, as well as for the many aetiological factors that characterise it and the multiple subsequent therapeutical solutions proposed by numerous authors [Anghinoni et al., 2009] G. Cacciatore, S. Allegrini, L. Franchi, and C. Lanteri have systematically collected, in relevant questionnaires, the opinions of participants in the Workshop on Early Treatment, SIDO (Italian Society of Orthodontics) International Spring Meeting, Turin 2014: "The most commonly known orthodontic problem addressed with one phase of early treatment was posterior cross bite (according to 92.31% of the speakers)." However, clinical evidence, in the form of a considerable wealth of research and therapeutic protocols gathered over the years, does not provide such clear scientific proof.

A valuable work of Harrison and Ashby [2001] states that early crossbite correction seems to be effective in preventing this malocclusion from being perpetuated to the mixed and permanent dentitions With a unilateral crossbite the mandible must shift laterally to allow the teeth to come into contact. This side shift may result in the long time in negative outcomes for the development of the dentition and the jaws. Multiple treatments have therefore been employed to correct the crossbite and stop the negative movement [Kecik et al., 2007; Kilic et al.,2008].

The Harrison and Ashby study [2001] also shows that comparison of the different treatments based trials does not provide conclusive results because the studies were too small. Lagravère et al. [2005] in their review stated that they found no previous systematic reviews or meta-analysis on SME (slow maxillary expansion). In their study they considered skeletal and dental modifications after slow expansion with fixed devices in patients with maxillary transverse deficiency. The authors found only

	T1		T2		T2-T1	
	Mean	SD	Mean	SD	Mean	SD
Age of subjects	7y5m	7.36	8y2m	9.1	9m	1m

TABLE 1

a low level of evidence.

Lippold et al. [2013] carried out a randomised clinical trial to evaluate the effect of early treatment with respect to normal growth on functional posterior unilateral crossbite in late and early mixed dentition using a three-dimensional analysis of digital models. Results showed significant differences between the control group and the post-treatment group regarding the anterior, mid and posterior dimension of the maxilla, the depth of the palate, the length of palatal base, the length of maxillary arch, the deviation of the midline, overjet and overbite. This RCT concluded that "Dental occlusion is significantly improved and the prognosis for normal craniofacial growth is enhanced". We can find the same data in other studies too [Petrèn et al., 2011]. Frequency of crossbite in the population can vary from 3.7% [Ferro et al., 2016] to 30% in other studies. This data was confirmed by a recent revision of 38 articles, published during the last ten years, chosen on a base of 650, and carried out by Bazzini et al. [2016]. Chances for spontaneous correction, in cases of cessation of aetiological factors, are likewise reduced (from 0% to 9%). At the same time the probability of a later onset on the cross bite is low; 7% according to Kennedy [2005]. Instead, it is well known that the possibility to expand the maxillary bases decreases with age. Thus, the necessity for an accurate early diagnostic evaluation to classify the patients according to the type of maxillary deficiency and address them to the most appropriate clinical protocols.

The Leaf Expander [Lanteri et al., 2016], object of this study, represents the most recent evolution of a device initially called ELA (Espansore Lento Ammortizzato, Slow Palatal Expander). It was widely used for more than 10 years [Lerda, 2007; Mobrici et al., 2012]. Gianolio et al. [2014] compared the dental and skeletal effects of the rapid palatal expander (RPE) and the slow palatal expander (SPE) in a sample of young patients with transversal maxillary deficiency. This study, based on antero-posterior cephalometric analysis, led to the conclusion that the effects obtained clinically and radiographically overlap those reached with the RME. The Leaf Expander, thanks to its new technology, allows to achieve the expansion of the maxilla through dento-alveolar remodeling with light, continuous and predetermined forces. This device [Lanteri et al., 2016] is apparently similar to a rapid palatal expander but is actually radically different in various technical and mechanical aspects. In fact, the active elements are represented by nickel titanium springs shaped like leaves and their activation can be visually inspected and even easily measured.

The aim of this study performed on digital models is to evaluate the dento-alveolar effects of slow maxillary expansion using the Leaf Expander in a sample of growing patients with maxillary transverse deficiency, unilateral cross bite and mandibular shift.

Methods

The initial sample of the present study consisted of 22 patients treated with Leaf Expander by the same operator from private practice (VL). Signed informed consent for releasing diagnostic records for scientific purposes was available from parents of patients. Among all patients only those who satisfied inclusion criteria were selected for the final group.

The inclusion criteria for this study were as follows.

1. Age between 6 and 10 years.
2. Mixed dentition with E+E well preserved.
3. Unilateralcross bite.
4. Mandibular shift.

The exclusion criteria were as follows.

1. Presence of complex malocclusions.
2. Deterioration or lack of teeth on which to set the device (E+E).
3. Presence of oral and/or gingival pathologies.
4. Inadequate diagnostic records.
5. Non valid informed consent forms.

From the initial sample of 22, 10 patients (mean age 7.5 ± 7 months; 3 male and 7 female) who satisfied inclusion criteria were selected. All subjects presented unilateral crossbite due to maxillary transverse deficiency with mandibular side shift (Table 1).

There are at present four types of Leaf Expander available on the market [Lanteri et al., 2016], for different expansion amounts and different types of force generated:

1. 6 mm - 450 g.
2. 6 mm - 900 g.
3. 9 mm - 450 g.
4. 9 mm - 900 g.

In this study the Leaf Expander 6 mm – 450 g anchored on deciduous teeth was used [Mutinelli et al., 2015], considered adequate for the detected discrepancy.

The design of the Leaf Expander is similar to that of a conventional rapid palatal 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.

The Leaf Expander is typically anchored on deciduous teeth, with the upper first permanent molars left to expand spontaneously (Fig. 1). The 11 mm × 12 mm × 4 mm screw is readily adaptable to a narrow palate or an arch with transverse deficiency. It delivers a maximum expansion of 6mm by activating (compressing) the spring, which generates a light (450 g) and constant force. The

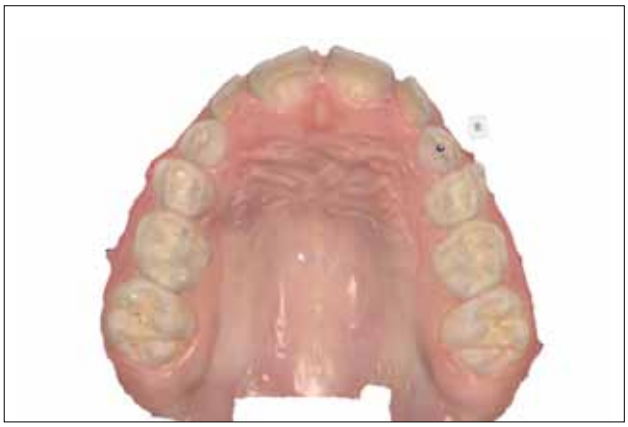


FIG. 1A, 1B The Leaf Expander with 6 mm screws on a prototype model from intraoral scan.

leaves are preactivated in the laboratory to deliver the first 3 mm expansion. The screw is blocked with metal ligatures or a special clip, which is removed after cementation. Reactivation is performed in the office by 10 quarter-turns of the screw per month until expansion has been completed (Fig. 2). One-quarter turn corresponds to 0.1 mm of activation; therefore, 10 activations of the screw generate 1 mm of activation and, consequently, 1 mm of spring compression. The maximum number of activations is 30 (for a total amount of 6 mm of expansion). Active expansion generally takes about five to six months, after which the Leaf Expander should be maintained passively in place for three months of retention.

Patients taking part in the research study were examined monthly and the springs were re-activated, following the above protocol. During every clinical controls oral hygiene was also checked (signs of plaque) as well as the periodontal tissue conditions and also the patient compliance (discomfort) through use of appropriate questionnaires. Expansion was judged clinically adequate after obtaining the desired transversal relationships and the correction of the cross bite and side shift (Fig. 3). Overcorrection was not considered necessary due to the

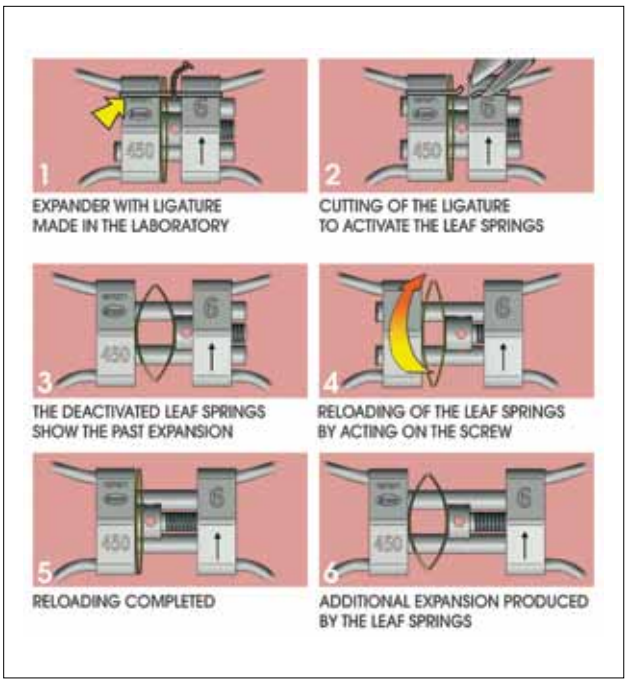
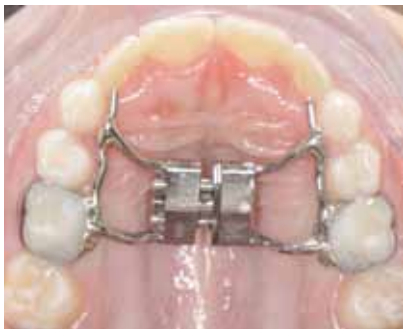
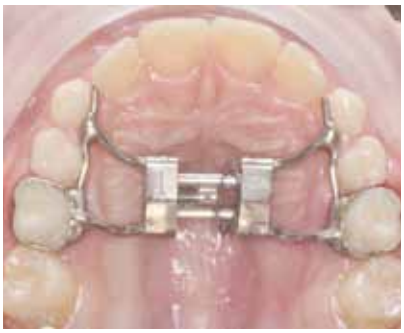


FIG. 2 Activation and reactivation of the double leaf springs



3A



3B

3C

3D

FIG. 3A-3C Example of expansion using Leaf Expander 450 gr/6 mm for cross bite and side shift correction

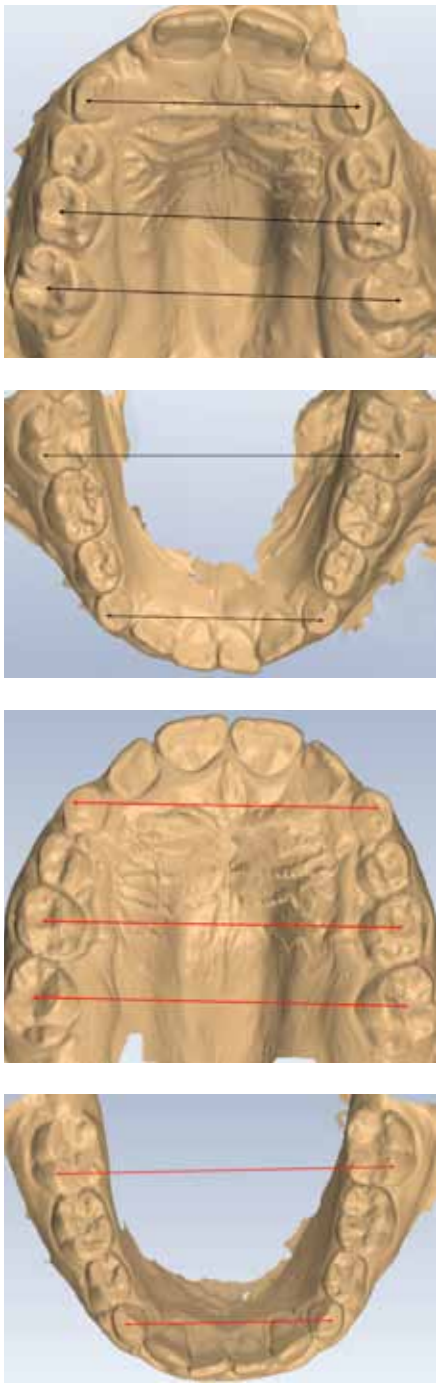


FIG. 3A-3C digital models before (T1), after expansion (T2).

biological particularities of the expansion and time that the Leaf Expnader remained in situ. The Leaf Expander was removed at the end of the retention time (T2), after approximately 9 months.

Analysis of digital models

For all ten patients digital models of the dental arches were made (Fig. 4) from scans of the pvs impressions before (T1) and at the end of treatment, that is, when the Leaf Expander. was removed (T2). The duration of treatment (difference T2 – T1) was on average 9 months and 8 days (min. 8 months and 11 days – max 11 months and 29 days – S.D. 1 month)

To perform measurements 3SHAPE Ortho Analyzer was used; The relevant parameters are as follows.

1. Upper intercanine width (C+C): distance between the upper canine cuspids (UCW).
2. Upper intermolar width (deciduous molars E+E): distance between the central point of the occlusal surface of the second upper deciduous molars (UEW).
3. Upper intermolar width (permanent molars 6+6): distance between the mid point of the distobuccal and the mesio-palatal cuspids of the first upper molars (U6W).
4. Lower intercanine width (C-C): distance between the lower canine cuspids (LCW).
5. Lower intermolar width (6-6): distance between the mid vestibular cuspids of the lower molars (L6W).

Statistical analysis

To analyse the data obtained, descriptive statistics were performed. Normal distribution for values of all variables was checked for the study group with the Shapiro-Wilk test. All measurements were calculated on average and standard deviations for T1, T2 and differences T2-T1. The T test was run for paired data to report any significant change between data from T1 and T2. The statistical significance was set at $p < 0.05$. For all models, all measurements were taken twice by the same operator and repeated after 15 days and any error between the two successive measurements was evaluated. All coefficients of error in the measurements were close to 1.00 and thus within acceptable limits.

	T1		T2		T2-T1			
Variables	Mean	SD	Mean	SD	Mean	SD	T.Test	P
UCW	30.25	1.79	36.31	1.56	6.07	0.83	***	0.00001
UEW	38.65	2.39	44.82	1.91	6.17	0.78	***	0.00001
U6W	43.87	2.17	47.47	2.43	3.60	0.72	***	0.00001
LCW	26.18	1.59	26.53	11.27	0.77	0.65	***	0.00931
L6W	48.45	1.75	48.52	2.35	-0.02	1.07	***	0.833721

TAB. 2

Results

Cross bite and the mandibular shift were corrected in all the patients. The arch form was improved, the maxilla was expanded enough for eruption of the upper lateral incisors and the first permanent molars had spontaneously expanded and rotated.

The average duration of treatment (T1 - T2 difference) was 9 months and 8 days (min 8 months and 11 days - max 11 months and 29 days) (Table 2).

Average variations obtained, taken from Table 2, are as follows.

1. UCW – Upper canine width (C+C): +6.07 mm.
2. UEW –Upper intermolar width (E+E): +6.17 mm.
3. U6W – Upper intermolar width (6+6): +3.60 mm.
4. LCW – Lower intercanine width (C-C): +0.77 mm.
5. L6W – Lower intermolar width (6-6): -0.02 mm.

Significant, from a statistical point of view ($p < 0.05$) were transversal changes between T1 and T2 observed at the upper canines level (UCW), at the upper deciduous molars (UEW) and permanent upper molars (U6W), likewise the lower intercanines width (LCW).

Not significant: changes at permanent lower molars (L6W).

Discussion

Changes at the upper arch through the use of the Leaf Expander with 6 mm – 450 gr screws have led to the correction of the posterior crossbites in 100% of cases treated. Martina et al. [2012] in a trial comparing rapid and slow maxillary expansion based on low dose CT, stated that the RME is not more efficient than the SME in correcting the posterior cross bite. In our study changes in the diameter of the deciduous intermolar width (E+E) were almost the same of the excursion of the screw (+ 6.17 mm in average). Increase in the intermolar diameter at the permanent teeth (6+6), not directly involved in the appliance, was significant (average +3.60 mm), indicating substantial morphological remodeling of the jaw and not simply an orthodontic movement which in any case would be inexplicable given that no force was applied to the molars. This increase, probably due to the activation of the perimaxillary sutures, matches other works reported in the literature. For example, as a result in the metanalysis conducted by Zhou et al. [2014] on non-surgical maxillary expansions, the SME proved to be effective in achieving maxillary expansion and could even produce results superior to the RME in the molar region. Leonardi [2011] demonstrated the response of the circumaxillary sutures to RME, observing that the effect changes with differentsutures which act directly on the maxilla. Recently Rosa et al. [2016] demonstrated the self-expansion of the upper permanent molars that did not undergo any force before, during or after rapid maxillary expansion. Linear values resulting at the level of the upper molars (6+6), 3,46 mm- SD 1,16, can be compared to those in our research, equal to mm 3,60 – SD 0,7. In our study the deciduous intercanine maxillary diameter (+6.07 mm on average) showed a change equal to the excursion of the screw, itself as proof of an expansion similar to what is sometimes seen in an orthopaedic expansion. Mossaz et al. [1989] proved that the intercanine diameter grew less than the intermolar in the maxillary arch in a sample of 10 patients between the ages of 8 and 12 years treated with a slow expander (Minnie–expander without touching the canines) with two different anchoring systems, that is, with bands and with direct bonding on the teeth. Given that these plates had no canine support, the result differs from results in our sample where the Leaf Expander has no bonded extensions on the canines. The comparison of results, even if not exactly matching, indicates the solution with the extensions on the canines. The intercanine diameter in the mandible, which we analysed, increased by an average of 0.77 mm because of the auto expansion resulting from the upper expansion, matching results from Perillo et al. [2014] and Grassia et al. [2015], who concluded, "RME and MME can be considered two effective treatment options to improve transverse arch dimensions and gain space in the dental arches. A greater lower arch expansion was observed in the MME group, which might be attributed to the "lip bumper effects" observed in the MME protocol". The lower intermolar diameter in our study in was reduced because of the effect of self-correction of the torque subsequent to the upper expansion and to modifications of the intercuspidation deriving from it, but the resulting data did not prove statistical significance. Similar studies post RME did however report an increase to the intermolar diameter [Ugolini et al., 2015].

Conclusions

The results of our preliminary study, even if on a small sample, demonstrate the efficiency and utility of the Leaf Expander anchored on deciduous teeth for the correction of the maxillary transverse deficiency in growing patients. The main advantages for the use of this device lies in its easy activation and the absence of cooperation (no compliance therapy) within the possibility of obtaining controlled movement of the teeth using light, predetermined and constant forces. Considering the relevance of these data, the Leaf Expander tcan be considered the first therapeutic choice to treat maxillary transverse deficiency in growing patients, as it can promote positive anatomical and functional changes. Comparing these results with those of other studies [Wonga, 2011], in the future comparisons should be performed with other similar devices, considering type of the forces generated (i.e. Quad Helix or Ni-Ti expander) and the stability of long-term results. The Leaf Expander might present an efficient, comfortable and predictable

alternative for maxillary expansion, using simple and mistake proof clinical procedures.

References

› Anghinoni ML, Magri AS, Di Blasio A, Toma L, Sesenna E. Midline mandibular osteotomy in an asymmetric patient. Angle Orthod 2009 Sep;79(5):1008-14.
› Bazzini E, Ciapponi E, Tomatis F, Garattini G.: Valutazione della prevalenza dei differenti tratti malocclusivi: revisione della letteratura. Il Dentista Moderno 2016; 3:84-105.
› Cossellu G, Farronato G, Nicotera O, Biagi R. Transverse maxillary deficit and its influence on the cervical vertebrae maturation index. Eur J Paed Dent 2016; 17(2):147-150.
› Ferro R, Besostri A, Olivieri A, Quinzi V, Scibetta D. Prevalence of cross-bite in a sample of Italian preschoolers. Eur J Paediatr Dent 2016 Dec;17(4):307-309.
› Geran RG, McNamara JA Jr, Baccetti T, Franchi L, Shapiro LM. A prospective long-term study on the effects of rapid maxillary expansion in the early mixed dentition. Am J Orthod Dentofac Orthop 2006;129:631-40.
› Gianolio A, Lanteri V, Chierchi C. Rapid and slow maxillary expansion: a postero-anterior cephalometric study. Eur J Paediatric Dent 2014; 15(4): 415-8.
› Grassia V, D'Apuzzo F, Jamilian A, Femiano F, Favero L, Perillo L. Comparison between rapid and mixed maxillary expansion through an assessment of arch changes on dental casts. Prog Orthod 2015;16:20.
› Harrison JE, Ashby D. Orthodontic treatment for posterior crossbites. Cochrane Database Syst Rev 2001;1:CD000979.
› Kecik D, Kocadereli I, Saatci I. Evaluation of the treatment changes of functional posterior crossbite in the mixed dentition. Am J Orthod Dentofacial Orthop 2007;131:202-15.
› Kennedy D, Osepchooc M. Unilateral posterior crossbite with mandibular shift:a review. J Can Dent Assoc 2005;71(8):569–73.
› Kilic N, Kiki A, Oktay H. Condylar asymmetry in unilateral posterior crossbite patients. Am J Orthod Dentofacial Orthop 2008;133:382-7.
› Lagravere MO, Major PW, Flores-Mir C. Skeletal and dental changes with fixed slow maxillary expansion treatment: a systematic review. J Am Dent Assoc 2005 136:194–199.
› Lanteri C, Beretta M, Lanteri V, Gianolio A, Cherchi C, Franchi L. A new way for no compliance palatal expansion: The Leaf Expander. J Clin Orthod Vol 2016; 50(9): 552-60.
› Leonardi R, Sicurezza E, Cutrera A, Barbato E. Early post-treatment changes of circumaxillary sutures in young patients treated with rapid maxillary expansion. Angle Orthod 2011 Jan;81(1):36-41.
› Lerda F. Cambiamenti dimensionali d'arcata con l'espansore lento ammortizzato su un campione di pazienti a fine crescita. Ortognatodonzia Italiana 2007;14179-85.
› Lippold C, Stamm T, Meyer U, Végh A, Moiseenko T, Danesh G. Early treatment of posterior crossbite - a randomised clinical trial. Trials 2013;14:20.
› Martina R, Cioffi I, Farella M, Leone P, Manzo P, Matarese G, Nucera R, Cordasco G. Transverse changes determined by rapid and slow maxillary expansion—a low-dose CT-based randomized controlled trial. Orthod Craniofac Res 2012;15:159-68.
› Mobrici P, Beretta M. et al. Slow maxillary expansion in adult patients: a pilot study. Mondo Ortodontico (2012),doi:10.1016/j.mor.2012.01.003
› Mobrici P, Beretta M et al. Dental and skeletal modifications in adult patients treated with Slow Maxillary Expander. Mondo Ortodontico (2012), http://dx.doi.org/10.1016/j.mor.2012.04.003
› Mossaz-Joëlson K, Mossaz CF. Slow maxillary expansion: A comparison between banded and bonded appliances. Eur J Orthod 1989; 11(1):67-76.
› Mutinelli S, Manfredi M, Guiducci A, Denotti G, Cozzani M. Anchorage onto deciduous teeth: effectiveness of early rapid maxillary expansion in increasing dental arch dimension and improving anterior crowding. Prog Orthod 2015;16:22.
› Perillo L, De Rosa A, Iaselli F, Fabrizia D'Apuzzo F, Grassia V, Cappabianca S. Comparison between rapid and mixed maxillary expansion through an assessment of dento-skeletal effects on posteroanterior cephalometry. Progress in Orthodontics 2014; 15:46.
› Petrén S, Bjerklin K, Bondemark L. Stability of unilateral posterior crossbite correction in the mixed dentition: a randomized clinical trial with a 3-year follow-up. Am J Orthod Dentofacial Orthop 2011;139:e73-81.
› Rosa M, Lucchi P, Manti G, Caprioglio A. Rapid Palatal Expansion in the absence of posterior cross-bite to intercept maxillary incisor crowding in the mixed dentition: a CBCT evaluation of spontaneous changes of untouched permanent molars. Eur J Paediatric Dent 2016; 17 (4): 286-94.
› Tausche E, Luck O, Harzer W. Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need. Eur J Orthod 2004;26:237-44.
› Ugolini A, Cerruto C, Di Vece L, Ghislanzoni LH, Sforza C, Doldo T, Silvestrini-Biavati A, Caprioglio A. Dental arch response to Haas-type rapid maxillary expansion anchored to deciduous vs permanent molars: a multicentric randomized controlled trial. Angle Orthod 2015;85(4):570–6.
› Wong CA, Sinclair PM, Keim RG, Kennedy DB. Arch dimension changes from successful slow maxillary expansion of unilateral posterior crossbite. Angle Orthod 2011 Jul;81(4):616-23.
› Zhou Y, Long H, Ye N, Xue J, Yang X, Liao L, Lai W: Sistematic review. The effectiveness of non surgical maxillary expansion: a meta-analysis. Eur J Orthod 2014; 36(2): 233-42.