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Rapid maxillary expansion in early-mixed dentition: effectiveness of increasing arch dimension with anchorage on deciduous teeth

ABSTRACT

Aim *To assess the effectiveness of a Haas expander anchored to deciduous teeth in changing dental arch dimension and improving crowding and to evaluate stability of changes until permanent dentition.*

Materials and methods *Study Design: closed cohort retrospective and case-control study. Eighteen patients undergoing early treatment for lateral crossbite (mean age 7.6 yrs; SD 1.0) at two practices located in La Spezia and Massa (Italy) were analysed. The treated group was compared with 72 control subjects divided into: 32 untreated adolescents with and without lateral crossbite and the same canine dental class as treated patients before expansion (Class II Division 2), 18 adults and 18 adolescents with dental Class I. All groups were matched for gender (ratio males:females, 8:10). The dental casts images of treated patients were digitally measured before and after treatment, and in permanent dentition. Patients at the last follow-up were compared with control subjects.*

Results *In treated patients the increase in intermolar width and the improvement in anterior crowding were significant and stable until adolescence. Untreated adolescents with lateral crossbite showed the narrowest transversal widths and the highest irregularity. No difference was found among treated patients, adolescents without lateral crossbite, and adolescents and adults with a normal occlusion.*

Conclusions *The Haas expander anchored on deciduous teeth is effective in improving dental arch constriction and crowding in patients treated for lateral crossbite. The result is stable until permanent dentition. In absence of treatment, constriction of dental arch may persist, with a higher level of irregularity.*

Keywords *Crossbite; Dental arch; Orthodontic anchorage; Primary teeth; Rapid palatal expansion*

Introduction

Rapid maxillary expansion is widely used to treat transverse deficiency [Bishara and Staley, 1987] by opening the mid-palatal suture [da Silva Filho et al.,1995; Lione et al., 2012], which has not yet completely ossified in growing individuals [Melsen, 1975]. The randomised clinical trial by Thilander et al. [1984] identified the early-mixed dentition as the best timing to initiate expansion in patients with a posterior crossbite.

In the retrospective study by Mutinelli et al.[2008], expansion before the end of eruption of the maxillary permanent lateral incisors, i.e., the first transition period [van der Linden and Duterloo, 1976] seemed to have a positive influence on the stability of maxillary dental arch dimension during the mixed-dentition stage.

The Haas expander [Haas, 1970], designed for opening the mid-palatal suture with a midline expansion screw, is a tissue-borne fixed appliance anchored to the first bicuspids and molars by means of 4 abutment bands and to the palatal vault by acrylic masses. Dental anchorage exclusively to the deciduous teeth is a variation on the traditional design, with the deciduous second molars and the deciduous canines replacing the permanent teeth for anchorage. The effectiveness of this modified expander has been reported by some authors [da Silva Filho et al., 1995; Mutinelli et al., 2008; Cozzani et al.,2003; Cozzani et al., 2007; Rosa et al., 2012; Eichenberger and Baumgartner, 2014; Cozzani et al., 2014; Ugolini et al., 2014]. The main reason for anchorage to the deciduous teeth is to prevent negative side-effects on permanent teeth as a consequence of high expansion force [Zimring and Isaacson, 1965] and of increased plaque accumulation: root resorption [da Silva Filho et al., 1995; Vardimon and Pitaru, 1993; Baysal et al., 2012], bone loss [Pangrazio-Kulbersh et al., 2013; Brunetto et al., 2013], gingival recession [Vanarsdall and Secchi, 2012], and white-spot lesions (WSL) [Shungin et al., 2010]. However, an open question remains regarding the long-term effect on the dental arch of early rapid maxillary expansion with anchorage to deciduous teeth. A stable outcome of early maxillary expansion in the permanent dentition was confirmed by Lima et al. [2005] and Wong et al. [2011], but these authors evaluated expanders anchored mainly to permanent teeth.

The aim of this study is to investigate the effectiveness of the Haas expander anchored to deciduous teeth in performing a stable dental arch dimension increase in a group of patients treated exclusively in the early-mixed dentition and monitored until the end of dental arch growth. The adolescent patients at the final follow-up were compared with four control groups of untreated adolescents and adults to analyse how the dental arch would have developed without treatment.

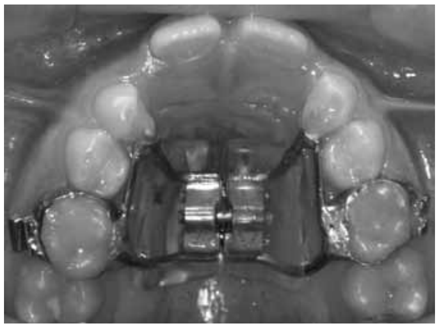

FIG. 1 Haas expander with non-traditional anchorage to deciduous cuspids and deciduous second molars.

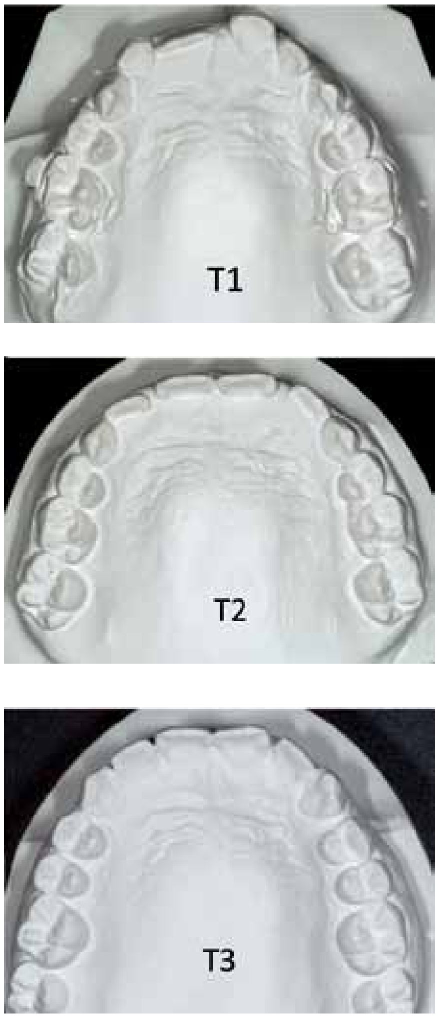

FIG. 2 A-C Scanned dental casts at T1, T2, and T3.

Materials and methods

Participants

The sample was comprised of the dental casts from 90 Caucasian individuals (40 males and 50 females), divided into five balanced groups of 18 subjects each: one group of children with a unilateral or bilateral cross-bite, who had been treated with a Haas expander anchored to the deciduous teeth (Fig. 1); and three control groups of adolescents and one of adults who had never been treated with an orthodontic appliance. The control population was selected from among patients who required a consultation with either the general dentist or the orthodontist.

Study design and clinical procedure

To determine the changes in dental arch dimensions following expansion, we selected a group of treated patients, sequentially and retrospectively, from the records of two orthodontists, M.C. (La Spezia, Italy) and A.G. (Massa, Italy), who had followed the same treatment protocol: expansion in the first period of transition [van der Linden and Duterloo, 1976] with the same type of Haas expander anchored to deciduous teeth [Cozzani et al., 2003; Cozzani et al., 2007], no retention after appliance removal, and no treatment with a fixed appliance in the permanent dentition.

The expander had to be activated once or twice a day, and this was performed by the parents (each activation was equal to 0.2 mm; mean activation period, 28 days). The patients were checked weekly, and the expansion was terminated when the first permanent molars were in correct transverse occlusion, i.e., without lateral crossbite. The first permanent molars were not over-expanded, which is normal practice in standard treatment with anchorage to the permanent dentition [Cozzani et al., 2003].

The dental casts were analysed as follows (Fig. 2): at T1, before expansion (mean age, 7.6 yrs; SD, 1.0); at T2, at appliance removal (mean age, 8.7 yrs; SD, 1.0); and at T3, in the permanent dentition (mean age, 12.8 yrs; SD, 1.3). The mean ages and the observation times are reported in Table 1. Before treatment, the prevalence of canine dental classes was: Class II, seven patients (3 males and 4 females); and monolateral Class II, 11 patients (5 males and 6 females).

It is known that canine Class II [Moyers et al., 1976] and lateral crossbite [Thilander et al., 1984] do not self-correct during growth. Additionally, dental Class II [Moyers et al., 1976; Bishara et al., 1996;] and female gender [Thilander, 2009] can be characterised by narrower dental arch widths than for dental Class I

	Pre-treatment (T1)	Appliance removal (T2)	Permanent dentition stage (T3)	Retention time (T2-T1)	Out-of-retention time (T3-T2)	Observation time (T3-T1)
Full sample (n=18)						
mean (SD) in yrs	7.6 (1.0)	8.7 (1.0)	12.8 (1.3)	1.1 (0.3)	4.1 (1.0)	5.3 (0.8)
Male group (n=8)						
mean (SD) in yrs	7.6 (1.1)	8.5 (1.2)	13.8 (1.1)	1.1 (0.4)	4.7 (1.1)	5.7 (0.8)
Female group (n=10)						
mean (SD) in yrs	7.6 (1.1)	8.7 (1.0)	12.4 (1.3)	1.2 (0.3)	3.7 (0.7)	4.9 (0.7)

TAB. 1 Descriptive statistics for the treated group: mean age and standard deviation (SD) at T1, T2, and T3, and mean retention, out-of-retention, and observation times and standard deviations (SD).

	Full sample (n=18)	Male group (n=8)	Female group (n=10)
Treated group			
mean age (SD) in yrs at T3	12.8 (1.3)	13.5 (1.2)	12.4 (1.3)
Adolescents in canine dental Class II and with a lateral crossbite			
mean age (SD) in yrs	13.1 (1.6)	13.7 (1.6)	12.7 (1.5)
Adolescents in canine dental Class II and without a lateral crossbite			
mean age (SD) in yrs	12.8 (1.8)	13.2 (2.1)	12.5 (1.5)
Adolescents in dental Class I			
mean age (SD) in yrs	13.5 (1.7)	13.8 (1.8)	13.3 (1.7)
Adults in dental Class I			
mean age (SD) in yrs	30.1 (7.1)	27.1 (5.6)	32.5 (7.6)

TAB. 2 Descriptive statistics of the mean ages and standard deviations (SD) of the treated group at T3 and of the control groups.

and male gender. Moreover, growth of dental arches is completed in the permanent dentition with the eruption of the canines [van der Linden and Duterloo, 1976; Thilander, 2009; Sillman, 1964].

To define the long-term effect of expansion on the permanent dentition, and to evaluate how the dental arch would have developed without a lateral crossbite, we matched each case from the treated group, at the follow-up in adolescence, with four case-controls of untreated individuals (Table 2; Fig. 3). Each individual had to have a full natural permanent dentition including the first or second molars, which were sometimes in eruption in the adolescent groups, and no abrasion of or defects of the dental cusps.

The first control group was matched for gender (8 males and 10 females), dental age, canine dental class, and crossbite, i.e., a control group with the same malocclusion (dental Class II) as the treated group before expansion (mean age 13.1 yrs; SD 1.6). The second control group (individuals with the same canine dental class as the treated group before expansion, but without a lateral crossbite) was matched for gender, dental age, and canine dental class, but not for crossbite

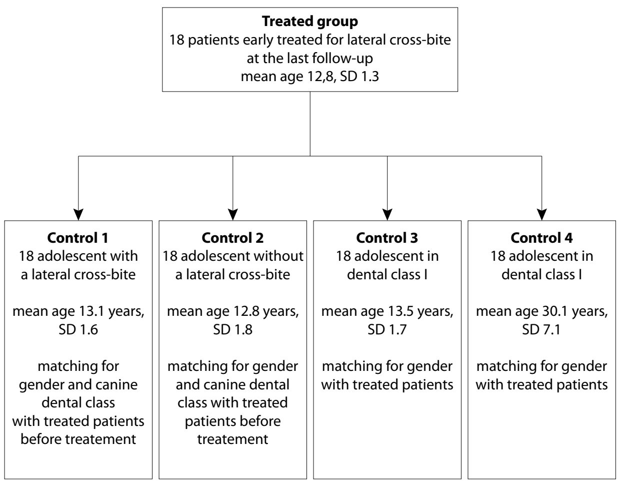

FIG. 3 Design diagram of case-control study.

(mean age 12.8 yrs; SD 1.8).

The last two control groups were adolescents in normal occlusion (mean age 13.5 yrs; SD 1.7), matched for dental age and gender, and adults in normal occlusion (mean age 30.1 yrs; SD 7.1), matched for gender only. The subjects had to have a bilateral canine and molar dental Class I, and no open bite, deep bite, crossbite, or crowding.

Data acquisition

Scanned images of the occlusal surfaces of the dental cast were processed [Mutinelli et al., 2004]. After the reference points were selected, a software (Daf®, Omedra software, Rovereto, Italy) was used for calculation of the following measures (Fig. 4):

- intercanine width (distance between canine cusp tips);
- intermolar width (distance between mesio-buccal cusp tips);
- arch length (distance between the interincisive point and the intermolar width);
- irregularity index [Little, 1975].

Moreover, changes in the anterior crowding of the treated group were calculated. Crowding was considered as the difference between the length of the anterior curve, the elliptical curve drawn between the mesial points of first bicuspids or first deciduous molars, and the sum of the mesiodistal widths of 6 permanent anterior teeth. Therefore, only permanent tooth dimensions were considered in the mixed dentition. It followed that the dental arch length was variable over time, influenced by growth and treatment, and that the dental size was constant, for comparison and clear display of the changes from T1 to T3.

To assess the reliability of the measurements, the operator repeated the selection of points in 11 dental casts (209 values). The interclass correlation coefficient (ICC) was 99.95%.

Statistical analysis

A one-way analysis of variance (ANOVA) for repeated measures and the Tukey and Bonferroni tests were performed for estimation of the quantitative variables (intercanine and intermolar widths, crowding, and arch length). The Kruskal-Wallis and the Wilcoxon signed-rank tests were applied to changes in the arch length in the treated group from T1 to T3, which violates the ANOVA assumption of homoscedasticity, and also to the prevalence of the irregularity index, which was transformed from a continuous to a binary variable (low and moderate irregularity). The cut-off point of 5 mm defines the level of irregularity: low for values less than 5 mm, and moderate for values equal to or higher than 5 mm. The cut-off point was chosen to clarify the clinical amount of irregularity. To control for the confounders gender and dental class (indicator variables) in comparison among matched groups, multiple and mixed-effects linear regressions were estimated on clinically relevant differences (intercanine and intermolar widths). The α level of significance was selected at 0.05 and adjusted to the number of tested hypotheses (Bonferroni correction). The power calculation was estimated *a posteriori*.

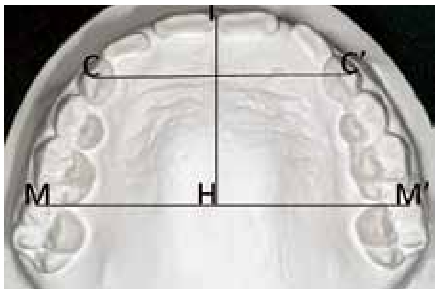

FIG. 4 Inter-canine (CC'), inter-molar width (MM'), and arch length (IH) drawn on the dental cast.

The requisite sample size of about 17 was calculated *a priori* based on data published by Lima et al. [2005]. All data were statistically analysed with STATA12 (StataCorp LP, College Station, TX, USA).

Results

Changes in the treated group (T1-T3)

At the permanent dentition stage (T3), the transverse dimensions in the 18 treated patients retained a significant amount of the increase produced by early rapid maxillary expansion (Table 3). None of the patients showed a relapse of lateral crossbite.

No relapse in intermolar width was recorded at T3. The one-way ANOVA ($F_{2,34} = 98.54$; $P < 0.001$) and the Tukey multiple-comparison test identified a significant difference between T1 and T2 and between T1 and T3, but not between T2 and T3.

At permanent dentition stage, the intercanine width showed a partial relapse of the increase produced by expansion, and all outcome differences estimated among T1, T2, and T3 were statistically significant ($F_{2,34} = 121.06$; $P < 0.001$).

Crowding also improved after treatment, with a minor relapse in the permanent dentition ($F_{2,34} = 48.97$; $P < 0.001$). The difference between comparisons was significant.

In contrast, in the sagittal plane, the arch length preserved the same dimension until the follow-up at T3 (Kruskal-Wallis test, $P = 0.2846$).

Comparison between the treated group at the follow-up in the permanent dentition and the control groups

The group of adolescents with a lateral crossbite was the only control group in which the inter-molar width was smaller than that of the adolescents treated in the early-mixed dentition ($F_{4,68} = 20.48$; $p < 0.001$) (Table 4). The intercanine width was also smaller in the adolescents with a lateral cross-bite than in the treated group. The ANOVA ($F_{4,68} = 6.30$; $p = 0.02$) and the Tukey test showed a significant difference between the adolescents with a lateral cross-bite and

	Pre-treatment T1 (n = 18)	Appliance removal T2 (n = 18)	Permanent dentition stage T3 (n = 18)	p-value	Power of the test	Effect size (Ω2)*
Mean (SD) age, yrs	7.6 (1.0)	8.7 (1.0)	12.8 (1.3)	-	-	-
Intercanine width						
mean (SD), mm	28.6 (1.5)	35.5 (2.1)	33.7 (1.6)	< 0.001†	100%	1.69
95% CI for the mean, mm	27.8 to 29.3	34.5 to 36.6	32.9 to 34.5			
Intermolar width						
mean (SD), mm	46.7 (2.0)	51.8 (2.4)	51.3 (2.3)	< 0.001‡	100%	0.73
95% CI for the mean, mm	45.7 to 47.7	50.6 to 53.0	50.1 to 52.4			
Arch length						
mean (SD), mm	30.1 (1.1)	31.0 (1.1)	30.0 (1.1)	0.2846§	not applicable	not applicable
95% CI for the mean, mm	29.3 to 30.9	29.9 to 32.0	29.0 to 31.0			
Crowding						
mean (SD), mm	-8.1 (3.4)	-1.3 (3.3)	-3.4 (2.3)	< 0.001‖	100%	0.69
95% CI for the mean, mm	-10.0 to -6.1	-3.0 to 0.4	-4.5 to -2.2			

* Effect size. A value of 0.01 is small, 0.06 is moderate, and 0.14 is strong.
†One-way ANOVA (rho = 0; F(2,51) = 77.76). The groups were not dependent (rho = 0). Differences were significant between comparisons (Bonferroni test: T1 vs. T2, P < 0.001; T1 vs. T3, P < 0.001; T2 vs.T3, P = 0.009). Comparisons between intercanine widths calculated at T3 and either T1 or T2 were not reliable, because the reference landmark was on primary canine cusp tips at T1 and T2 and on permanent canine cusp tips at T3.
‡Repeated-measures ANOVA (rho = 0.11; F(2,34) = 98.54). Differences were significant between T1 vs. T2 and T1 vs. T3 (Tukey test).
§Kruskal-Wallis test. The data were normalised after logarithmic transformation (Shapiro-Wilk test, p = 0.75), but the variance of each group was not equal (Breusch-Pagan test for heteroscedasticity, p = 0.02).
‖Repeated-measures ANOVA (rho = 0.13; F(2,34) = 48.97). Differences were significant between comparisons (Tukey test).

TAB. 3 Descriptive statistics (mean, SD, and 95% CI) of treated sample for inter-canine and inter-molar widths, for arch length (distance between the inter-incisive point and the inter-molar width), and for crowding recorded at pre-treatment (T1), at appliance removal (T2), and at permanent dentition stage (T3), and comparison among measurements at T1, T2, and T3 (ANOVA and Kruskal-Wallis test).

	Treated group at T3 (n=18)	Control group (n = 72)				p-value	Power of the test	Effect size (Ω2)*
		Adolescents in canine dental Class II and with a lateral cross-bite (n=18)	Adolescents in canine dental Class II and without a lateral crossbite (n=18)	Adolescents in dental Class I (n=18)	Adults in dental Class I (n=18)			
Mean (SD) age, yrs	12.8 (1.3)	13.1 (1.6)	12.8 (1.8)	13.5 (1.7)	30.1 (7.1)			
Intercanine width								
mean (SD), mm	33.7 (34.5)	31.6 (32.8)	32.7 (33.6)	33.9 (35.0)	34.4 (35.6)	0.02†	95%	0.43
95% CI for the mean, mm	32.9 to 34.5	30.3 to 32.8	31.7 to 33.6	32.9 to 35.0	33.2 to 35.6			
Intermolar width								
mean (SD), mm	51.3 (2.3)	45.4 (2.8)	49.3 (3.0)	51.5 (2.9)	51.4 (3.5)	0.001‡	99%	0.46
95% CI for the mean, mm	50.1 to 52.4	44.0 to 46.7	47.8 to 50.8	50.1 to 52.9	49.6 to 53.1			
Arch length								
mean (SD), mm	30.0 (2.1)	30.5 (1.9)	30.1 (2.2)	29.6 (2.0)	28.4 (2.8)	0.0587§	57%	0.25
95% CI for the mean, mm	29.0 to 31.1	29.6 to 31.4	29.0 to 31.2	28.6 to 30.6	27.1 to 29.8			

* Effect size. A value of 0.01 is small, 0.06 is moderate, and 0.14 is strong.
† Repeated-measures ANOVA (rho = 0.13; F(4,68) = 6.30). Differences were significant between the control group of adolescents in malocclusion with a lateral crossbite and all other groups.
‡ Repeated-measures ANOVA (rho = 0.09; F(4,68) = 20.48). Differences were significant between the control group of adolescents in malocclusion with a lateral crossbite and all other groups (Tukey test).
§ One-way ANOVA (F(4,85) = 3.37). Differences were not statistically significant and not clinically relevant. The groups were not dependent (rho = 0).

TAB. 4 Descriptive statistics (mean, SD, and 95% CI) of treated group (T3) and of control groups for intercanine and intermolar widths, for arch length (distance between the interincisive point and the intermolar width), and comparison among groups (ANOVA).

all other groups, with the exception of the adolescents with malocclusion but without a lateral cross-bite. No difference between and among the groups was found in arch length dimension ($F_{4,85}$ = 3.37; p = 0.0587).

Since in the analysis stage, the matching factors had to be controlled, as they were still confounders, a multiple linear regression on the inter-canine width (LR test vs. linear regression, p = 0.1675) and a mixed-effect linear regression on the inter-molar width (LR test vs. linear regression, p = 0.0233) were performed (Table 5). The comparison among the groups confirmed the results of ANOVA for adolescents with a malocclusion and a lateral cross-bite. However, after adjustment for gender and canine dental class, a significant difference in intermolar width was also estimated between the treated group and adolescents with malocclusion but without lateral crossbite. It must be noted that gender only, and not canine dental class, influenced the outcomes: intercanine and intermolar widths were narrower in females than in males -1.5 mm (95% CI, -2.4 to -0.7 mm, p = 0.001) and -2.2 mm (95% CI, -3.6 to 0.8 mm, p = 0.002), respectively, after adjustment for the other exposures.

Similarly, the prevalence of differences in the moderate irregularity index (Table 6) was significant in the comparison between the adolescents with a lateral

	Coefficient (β)	Standard error	95% CI	z	p
Intercanine width*					
Intercept	33.8	1.0	-	-	-
Adolescents in canine dental class II and with a lateral cross-bite	-2.1†	0.7	-3.5 to -0.8	-3.20	0.002
Adolescents in canine dental class II and without a lateral cross-bite	-1.1†	0.7	-2.4 to 0.3	-1.60	0.113
Adolescents in dental class I	1.0†	1.1	-1.3 to 3.2	0.87	0.389
Adults in dental class I	1.5†	1.1	-0.8 to 3.7	1.29	0.199
Gender	-1.5‡	0.4	-2.4 to -0.7	-3.6	0.001
Canine dental class	0.5§	0.6	-0.6 to 1.6	0.85	0.398
Intermolar width‖					
Intercept	52.5	1.5	-	-	-
Adolescents in canine dental class II and with a lateral cross-bite	-5.9†	0.8	-7.5 to -4.3	-7.42	<.0001
Adolescents in canine dental class II and without a lateral cross-bite	-1.9†	0.8	-3.5 to -0.4	-2.42	0.016
Adolescents in dental class I	-0.2†	1.5	-2.7 to 3.1	0.13	0.896
Adults in dental class I	0.1†	1.5	-2.9 to 3.0	0.04	0.972
Gender	-2.2‡	0.7	-3.6 to -0.8	-3.12	0.002
Canine dental class	-0.03§	0.8	-1.6 to 1.5	-0.04	0.967

* Adjusted R2= 0.26.
† Difference in width compared with the treated group (mm).
‡ Difference in width between females and males (mm).
§ Difference in width between Class I and Class II (mm). The Class II subdivision was omitted because of inadequate sample size in terms of the number of combinations. No changes in coefficients were produced by the addition or removal of the 'dummy variable' canine dental class (absence of confounding effect).
‖R2= 0.50.

TAB. 5 Multiple (intercanine width outcome) and mixed-effect (intermolar width outcome) linear regression models quantifying the effect of the indicator variable group (adolescents in canine dental Class II and with a lateral crossbite, adolescents in canine dental Class II and without a lateral cross-bite, adolescents in dental Class I, adults in dental Class I) for intercanine and intermolar widths, while controlling for confounding by gender and canine dental classes. Gender and presence of a lateral crossbite significantly influenced both intercanine and intermolar widths.

			Control group (n = 36)				
	Treated group at T3 (n = 18)		Adolescents in canine dental Class II and with a lateral crossbite (n = 18)		Adolescents in canine dental Class II and without a lateral crossbite (n = 18)		p value
Irregularity index Median (interquartile range), mm	1.5 (3.0)		5.6 (6.8)		3.6 (4.9)		
	< 5 mm	≥ 5 mm	< 5 mm	≥ 5 mm	< 5 mm	≥ 5 mm	
Prevalence, n	16	2	8	10	12	6	0.0197*

* Kruskal-Wallis test. Differences were significant only between the treated group and the control group with malocclusion and a lateral crossbite (Wilcoxon signed-rank test, p = 0.0053).

TAB. 6 Descriptive statistics (median and interquartile range) for the irregularity index of the treated group at T3 and of control groups, and comparison among groups (Kruskal-Wallis test).

crossbite and the group of early-treatment adolescents (Kruskal-Wallis test, p = 0.0197; Wilcoxon signed-rank test, p = 0.0053). Due to the absence of crowding, individuals with normal occlusion were not compared.

Discussion

This study demonstrated that early rapid maxillary expansion with anchorage to the deciduous teeth was effective in the correction of lateral crossbite and in the reduction of crowding. These positive effects were stable until permanent dentition. In the absence of treatment, at the conclusion of dental arch growth, the transverse discrepancy did not improve, and the anterior irregularity reached a higher level than in the early-treatment patients.

The long-term effect on transverse dimensions did not differ from that produced with the traditional expander anchored to the permanent dentition. The net increase in the intermolar width was equal to the amount reported by Lima et al. [2005]. Only the type of Haas expander anchorage, together with canine dental class, constituted the relevant differences between the two studies. Moreover, the effect of expansion in the intercanine area did not differ from that reported in the study by Wong et al. [2011], who also performed slow expansion with different types of expanders, primarily anchored to the permanent dentition. It must be noted that, in the present paper as in the last-quoted work, the comparison of intercanine widths was not completely reliable, because of the change in reference points from the deciduous to the permanent teeth.

Early expansion and the subsequent resolution of lateral cross-bite re-established a normal growth pattern. Actually, the expansion and the low rate of transverse relapse transformed the constricted dental arch of the young patients in a dental arch as wide as that of the individuals with normal occlusion at the end of growth. For the period between 7 and 12 yrs of age, Moyers et al. [1969] reported growth of 3.84 mm of intercanine width and 2.97 mm in inter-molar width. The expansion was performed in children with a mean age of 7.5 yrs. At the time of appliance removal (mean age, 9.6 yrs), the intercanine and intermolar widths of the children were not different from those of adolescents and adults with normal occlusion. On the contrary, the matched untreated adolescents with a lateral cross-bite showed a clinically relevant transverse deficiency in both the intercanine and intermolar areas. Also, the adolescents in dental Class II without a lateral crossbite showed a narrower intermolar width. However, the difference compared with the other groups was not so pronounced as to give a clinically relevant result, similar to that discussed by Shu et al. [2013].

Similarly, lateral crossbite influences the level of maxillary anterior irregularity. It is known that severe misalignment of the teeth is subject to a high prevalence of relapse after orthodontic treatment [Surbeck et al., 1998]. Sixteen of the 18 early-treatment adolescents had an irregularity index lower than 5 mm (median, 1.5 mm) vs. eight of 18 adolescents with a lateral crossbite (median, 5.6 mm). Indeed, the crowding improved with expansion (from -8.1 mm at T1 to -3.35 mm at T3). Therefore, it can be assumed that the increase in arch length before the eruption of maxillary lateral incisors allows these teeth to erupt in a straighter position. The transseptal fibers of the periodontal ligament can penetrate the roots of better-aligned teeth [Kusters et al., 1991]. A consequent reduction in the risk of severe rotation may be hypothesised and could support the results reported by Canuto et al. [2010], that the RME applied later in the permanent dentition does not influence the long-term stability of maxillary anterior alignment.

Our research was designed in two parts: a closed-cohort retrospective study, and a case-control study. It is well-known that the best design in a study such as this is a randomised clinical trial (RCT); however, there are ethical concerns regarding the postponement of expansion until permanent teeth have fully erupted. A better time for treatment is when patients are checked at an earlier dental stage [da Silva Filho et al., 1995; Melsen, 1975]. We matched and balanced cases and controls on the basis of strict inclusion criteria. Matched analysis improves the control for the matching-confounder factors, but it is not as efficient as in an RCT, which controls for known and unknown confounders. Moreover, the analyses were restricted to treated patients of dental Class II, without evaluation of the skeletal pattern. Therefore, it may be difficult to generalise the results of this study to patients with a lateral cross-bite and of either dental Class I or Class III. In fact, further research is needed to expand the analysis to a larger sample, more representative of the general orthodontic population and characterised by the maximum number of dental and skeletal patterns.

Conclusion

This study provides evidence that, in patients in canine dental Class II, early treatment of lateral crossbites with a modified Haas expander anchored to deciduous teeth is effective and produces stable results until the stage of permanent dentition. On the contrary, the persistence of a lateral crossbite is an obstacle to normal development of the dental arch.

The advantages of anchorage to deciduous teeth are clinically relevant. Initially, the risk of exposing permanent molars and premolars to root resorption, to periodontal problems, and to white-spot lesions (WSL) is greatly reduced. Second, misalignment in the anterior maxillary dentition improves spontaneously toward a low level of irregularity, which may reduce the prevalence of patient requests to align the anterior maxillary dentition. Moreover, when fixed orthodontic treatment is performed, the better the pre-treatment alignment of the permanent dentition, the better the long-term stability.

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