Torque changes of anchorage units in pre-adolescent patients treated with a digitally designed tooth-borne expander anchored to deciduous vs. permanent molars

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Abstract

Aim To compare the effects on permanent or deciduous anchorage dental units in patients treated with a digitally designed palatal expander.

Study Design Retrospective controlled study on consecutively treated patients.

Methods Inclusion criteria were the following: presence of maxillary transverse deficiency, no previous orthodontic treatment, no extractions, absence of agenesis, congenital pathologies and cranio-maxillofacial malformations. Twenty patients (11 males, 9 females, 11 ± 1.8 years) received a digitally designed and metal printed palatal expander anchored on first permanent molars and 1 activation per day for 30 days (Group 1). Twenty-one patients (12 males, 9 females, 8.6 ± 1.4 years) received a digitally designed and metal printed palatal expander anchored on second deciduous molars and 2 activations per day for 14 days (Group 2). Digital intraoral scans were taken before expansion and after device removal, and torque and the palatal transverse diameter were digitally measured. The FDI notation was used to indicate each tooth.

Results Significant intragroup differences over time were found in Group 1 considering the torque of teeth 1.6, 1.4, 1.3, 2.1, 2.4, 2.5, 2.6. Significant differences between groups were found regarding the longitudinal change in torque of teeth 1.5, 2.4 and 2.5. Significant intragroup differences over time were found in both groups considering all transverse diameter parameters. No significant differences were found between groups in the transverse diameter modifications over time.

Statistics Intragroup differences over time were tested by the Paired t-Test or Wilcoxon's signed rank test. To investigate the association of differences over time with groups, the Student's t-Test and Mann-Whitney U test were performed.

Conclusions Less dental torque augmentation was produced in Group 2.

KEYWORDS Digital technology, Maxillary Expansion, Permanent Dentition, Mixed Dentition, Palatal Expansion Technique

Introduction

The posterior crossbite is a frequent malocclusion associated with a transversal deficit of the maxillary bone [Harrison and Ashby, 2000; Fastuca et al., 2018] and to a mandibular shift [Ben-Bassat et al.,1993]. If not treated, it may lead to the development of craniofacial asymmetries and mandibular dysfunctions. Several studies have already shown that rapid maxillary expansion is an effective method to correct a narrow palatine vault by opening the median palatine suture [Liu et al., 2015], especially when the treatment is undertaken in the prepubertal period [Baccetti et al., 2015]. During this period, in fact, skeletal effects are significantly greater, because the palatine median suture is much less interdigitated [Melsen, 1975] and rapid maxillary expansion involves the deciduous dentition as well. However, more relapses have been observed within subjects treated during the deciduous dentition [Primožič et al., 2013], while subjects treated in the mixed dentition encountered less stability issues [Petrén et al., 2013].

Even though rapid maxillary expansion is an efficient procedure to correct the transversal dimension, high forces are generated during the expansion and they may influence the periodontium [Garib et al., 2006; Lo Giudice et al., 2018] and endodontium of anchorage teeth [Samandara et al., 2019]. Thus, some authors suggested anchoring the expansion device on deciduous teeth in the mixed dentition [Cozzani et al., 2007; Mutinelli et al., 2008].

On the other hand, it is important to consider the root length in order to avoid failures due to tooth exfoliation during the treatment.

Quinzi et al. [2021] introduced a criterion to assess the predictability of the deciduous molar used as anchorage, based upon the radiological position of the cusp of the second premolar with respect to a horizontal line parallel to the occlusal plane and bisecting the pulp chamber of the first molar.

Habeeb et al. [2013] showed that anchoring the expander on deciduous molars produces a greater movement of upper incisors with respect to the anchorage on permanent molars;

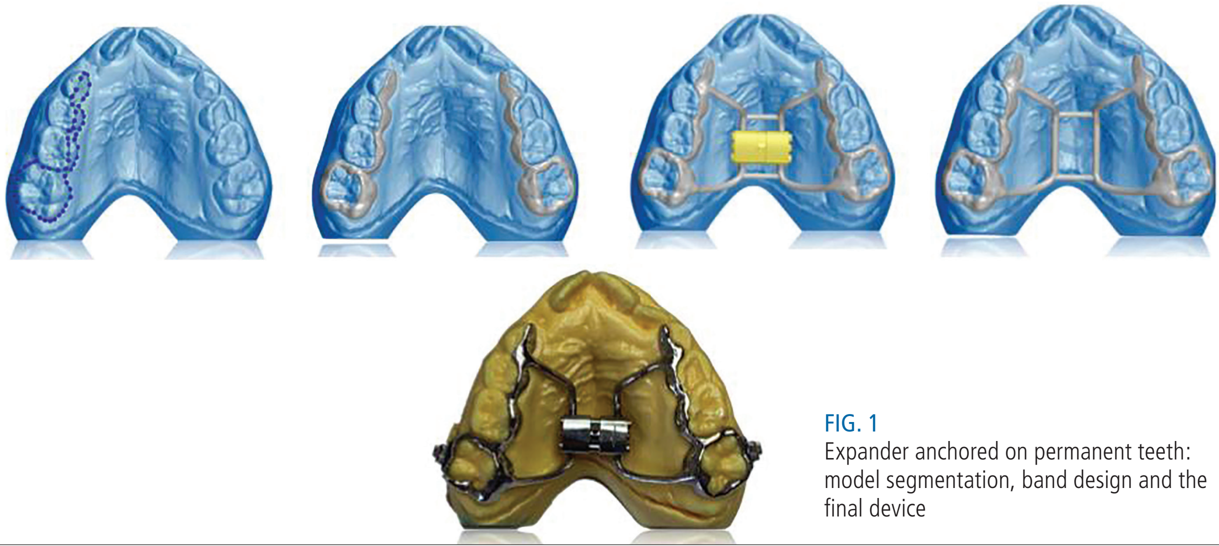

FIG. 1
Expander anchored on permanent teeth: model segmentation, band design and the final device

this could be due to a greater augmentation of the intercanine width, related to a more anterior position of the expansion screw. The greater expansion in the anterior zone may provide more space for central and lateral incisors, which are free to align and mesially rotate.

Another study found that IMPA significantly increases after an expansion where the device is anchored on deciduous teeth [Quinzi et al., 2021], probably because the upper incisor retraction may reduce the lower lip interposition, but further analyses are needed to clarify this point. The same study showed that the first upper permanent molar distally rotates in a significantly higher percentage when the device is anchored on deciduous molars, probably due to the maxillary resistance center position with respect to the screw position. Moreover, when the expander is anchored on the deciduous molars, the first permanent molars are free to adapt to the new occlusal position because they are not banded. Except for the variability of teeth position, palatal expanders anchored on permanent molars or on deciduous molars do not show any statistically significant difference from a skeletal point of view, moreover the anchorage displays the same efficacy and stability [Habeeb et al., 2013].

Currently, many authors believe that the reason to choose deciduous teeth as anchorage is a decreased risk of undesired effects produced by the expansion force on permanent teeth [Zimring et al., 1965], of plaque deposit around the bands, of root resorption [Da Silva et al., 1995; Vardimon et al., 1993; Baysal et al., 2012], bone loss [Pangrazio-Kulbersh et al., 2013; Brunetto et al., 2013], gingival recessions [Vanarsdall and Secchi, 2012], and white spots [Shungin et al., 2010].

Recently, rapid prototyping technologies have renewed the orthodontic workflow, presenting several advantages for the patient comfort and the project efficiency, such as digital scan of dental arches. In fact, the digital scan is not only time-saving and well tolerated by young patients, but it also allows technicians to directly use a 3D dedicated software to design the appliance to be printed [Battista et al. 2020]. Fitting and retention of custom-designed bands are increased and the cobalt chrome structures of the 3D printed appliances are more rigid, with an increased stability of the system. Moreover, custom bands partially cover the occlusal surface of the teeth, and contribute to separate the occlusion, giving the lower jaw an increased freedom to abandon the dysfunctional shift. To our knowledge, there are no previous studies considering tooth borne 3D-printed palatal expanders. In the present research, we evaluated two groups of patients treated by digitally designed palatal expanders: the first group received a palatal expander anchored on first permanent molars and 1 activation per day for 30 days, the second group received a palatal expander anchored on second deciduous molars and 2 activations per day for 14 days.

The primary aim of this study was to quantitatively evaluate longitudinal differences between anchorage units (permanent or deciduous) in dental torque. As secondary outcomes, longitudinal differences in dental tipping and transverse diameter were considered as well. The hypothesis of the experiment was the null hypothesis, i.e., that there would be no differences in the described parameters according to the device type and activation protocol.

Materials and Methods

2.1. Retrospective comparative study

The present retrospective comparative study received Ethical Committee Approval (no. 2023/17), and was conducted on consecutively patients treated by the same operator at the Department of Orthodontics of the University of Genoa. All the procedures of this research protocol adhered to the Declaration of Helsinki of 1975, as revised in 2000. A written consent was obtained from the parents of each patient. The collected data was anonymously recorded and the statistical analysis was blindly conducted.

2.2. Population

The criteria adopted for the inclusion in the study were: patients of both sexes aged under 13, presence of maxillary transverse deficiency except the case of monolateral cross-bite, no previous orthodontic treatment, no extractions, absence of agenesis, congenital pathologies and cranio-maxillofacial malformations, complete set of dental intraoral scans pre and post therapy. Therapy was defined as treatment with maxillary expansion and the consequent retention period.

2.3. Intervention

Each patient underwent a maxillary expansion by means of a digitally designed expander (hyrax type) anchored on first

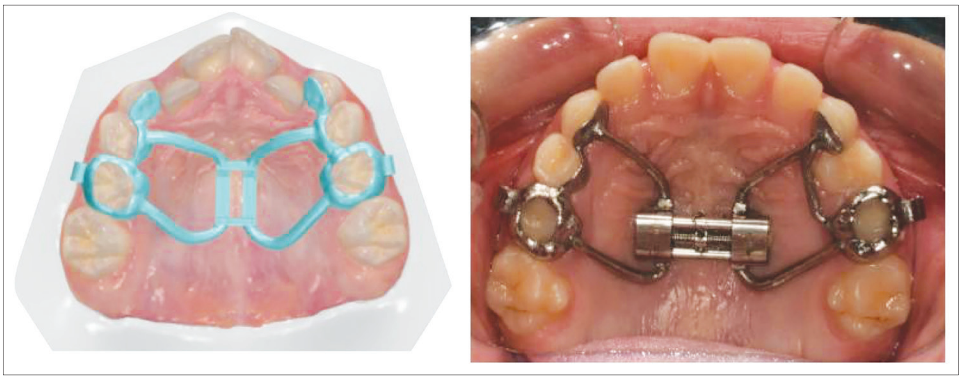

FIG. 2
Design of an expander anchored on deciduous teeth

permanent molars or second deciduous molars. The intraoral scan was exported in Standard Triangulation Language file (STL) format and used to design and adequately create the expander: the device design was digitally realised (Appliance Designer 2019 software, 3Shape, Copenaghen, Denmark) and the structure was 3D-printed using the selective laser melting (SLM) approach. Then the expansion screw (Forestadent, Pforzheim, Germany) was melted to the underlying structure and the device was polished and refined (Figs. 1 and 2). The appliance was bonded to the anchorage teeth with the standard adhesive technique protocol: 30 s enamel etching, rinsing, drying, and application of bonding on the bands and arms (Unitek Multi-Cure Glass Ionomer Orthodontic Band Cement, 3M, Maplewood, MN, USA), followed by 20 s of light curing on each interested surface.

2.4. Comparison

Two groups of patients were tested. Twenty patients (11 M, 9 F, mean age 11 ± 1.8 years) received a palatal expander anchored on first permanent molars and 1 activation per day for 30 days (Group 1). Then the expander was blocked and left in situ for a retention period of 12 months.

Twenty-one patients (12 M, 9 F, mean age 8.6 ± 1.4 years) received a palatal expander anchored on second deciduous molars and 2 activations per day for 14 days (Group 2), in this group the expander was blocked and left in situ for a retention period of 9 months.

2.4.1. Evaluation of the Results

An inter-group quantitative comparison of transverse arch diameters and dental changes over time was the primary outcome.

Transversal expansion values

Expansion values were observed at the end of treatment on digital models by means of the OnyxCeph software (Image Instrument, Chemnitz). The following teeth of the upper jaw were considered in the evaluation of the dental transversal variations: canine, premolars and first molar. Three points were considered for each element:

- Cusp: the buccal cusp was considered. For the first molar, the point was placed on the mesio-vestibular cusp
- Centroid: the center of the occlusal table
- Lingual point: the most palatal point at the level of the tooth collar.

The distance in millimeters (Fig. 3) was calculated between the respective points on the teeth of the contralateral arch on the 3D models, both pre- and post-treatment. The measurements were performed by two operators. A sample of 10 patients was examined to assess the accuracy of the measurements. Both operators evaluated the cusp-cusp, centroid-centroid and lingual point-lingual point distances at the level of the first upper molars.

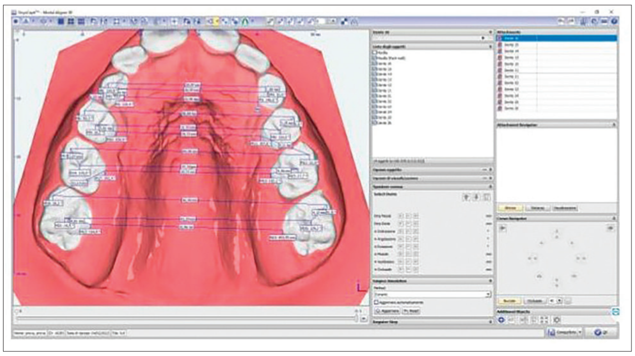

FIG. 3 Transversal values measurements

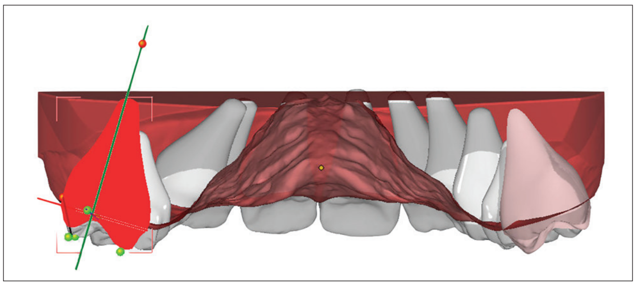

FIG. 4 Torque measurement

Dental torque and tip

Dental torque values were observed at the end of treatment on digital models (Fig.4). The torque value was obtained through the OnyxCeph software (Image Instrument, Chemnitz), following these steps:

1. The crowns of the teeth were selected through the ‘Segmentation’ option.
2. When the crowns were selected, the following sequence was followed: ‘Segment crowns’ > ‘Separate crowns’ > ‘Complete separation’. The reference plane is obtained considering the two more distal points of two posterior teeth and a point between the two central incisors.
3. Using the ‘Aligner’ option and selecting the ‘permanent teeth’ preference, the values were obtained by the ‘Tooth movement’ command.

The FDI notation was used to indicate each tooth.

2.5 Sample Size

The sample size estimation calculated that 20 patients per group would achieve 80% power to detect a mean difference

	Group 1 N = 20	Group 2 N = 21	p-value
Age (years)	11 ± 1.8	8.6 ± 1.4	<0.001*
Sex			
F	9	12	0.321
M	11	9	
Mean Screw nominal expansion (mm)	0.2	0.2	-
Mean activation time (days)	30	14	-

TABLE 1 Demographic and clinical characteristics of groups. p-value = Student's t-Test p-value adjusted by using Bonferroni method or Fisher's exact test.

Tip	Group 1 N = 20	Group 2 N = 21	p-value
N	20	21	
1.5	0.66 ± 14.30	5.24 ± 16.63	0.355
1.4	10.56 ± 8.35	14.81 ± 9.34	0.148
1.3	11.42 ± 7.24	16.04 ± 8.89	0.113
1.2	5.78 ± 8.60	6.39 ± 8.83	0.846
1.1	2.53 ± 8.54	-0.58 ± 6.79	0.213
2.1	6.28 ± 9.36	1.96 ± 7.12	0.112
2.2	6.92 ± 10.31	4.66 ± 7.56	0.476
2.3	14.22 ± 7.43	17.68 ± 8.29	0.217
2.4	9.14 ± 5.87	16.23 ± 7.68	0.004*
2.5	6.85 ± 13.52	6.25 ± 15.65	0.897
2.6	-8.99 ± 3.54	-8.28 ± 3.44	0.523

TABLE 2 Tip baseline characteristics in the whole population (N = 41). Results are expressed as Mean ± Standard Deviation or Median [Interquartile Range]; p-value = Student's t-Test p-value adjusted by using Bonferroni method or Mann-Whitney U test p-value adjusted by using Bonferroni method.

of 4.5° in the torque values, with an assumed standard deviation of differences of 5°, and with a significance level (alpha) of 0.05 using a t-test. The statistical sample was chosen based on data available from a pilot study (unpublished data).

2.6 Error analysis

Angular and linear measurements error estimation was performed by the means of Intraclass Correlation Coefficient (ICC); ICC values were 0.87 and 0,.91 for angular and linear values, respectively.

2.7 Statistical Analysis

Data were checked for normality with the Shapiro-Wilk test. Continuous variables are given as means ± standard deviations (SD) and medians with interquartile range, whereas categorical variables as number and/or percentage of subjects.

The parameters baseline differences between groups were tested by the Student's t-Test or Mann-Whitney U test. Intragroup differences over time were tested by the Paired t-Test or Wilcoxon's signed rank test.

In order to investigate the association of differences over time with groups, the Student's t-Test and Mann-Whitney U test were performed again.Differences with a p-value <0.05 were selected as significant. Data were acquired and analysed in R v3.4.4 software environment.

Torque	Group 1 N = 20	Group 2 N = 21	p-value
1.6	-9.35 ± 6.41	-6.78 ± 6.61	0.218
1.5	-6.68 ± 4.54	-1.40 ± 3.85	<0.001*
1.4	-6.62 ± 6.65	-3.38 ± 4.40	0.096
1.3	0.45 ± 5.85	2.86 ± 7.09	0.307
1.2	8.38 ± 10.42	11.84 ± 9.19	0.325
1.1	7.77 ± 10.20	8.77 ± 6.65	0.719
2.1	5.66 ± 9.23	9.28 ± 5.83	0.153
2.2	13.74 ± 8.76	12.66 ± 7.11	0.699
2.3	0.53 ± 7.32	1.95 ± 8.06	0.602
2.4	-7.03 ±7.53	-3.47 ± 5.58	0.125
2.5	-6.09 ± 5.09	-1.41 ± 4.37	0.003*
2.6	-9.67 ± 7.14	-5.95 ± 6.05	0.080

TABLE 3 Torque baseline characteristics in the whole population (N = 41). Results are expressed as Mean ± Standard Deviation or Median [Interquartile Range]; p-value = Student's t-Test p-value adjusted by using Bonferroni method or Mann-Whitney U test p-value adjusted by using Bonferroni method.

Transverse Diameter	Group 1 N = 20	Group 2 N = 21	p-value
III C	30.82 ± 2.50	30.19 ± 3.15	0.540
III cent	27.74 ± 2.18	27.21 ± 2.56	0.547
III L	23.63 ± 1.78	23.46 ± 2.39	0.825
IV C	37.33 ± 2.36	36.64 ± 2.44	0.420
IV cen	32.77 ± 1.96	32.77 ± 2.53	0.999
IV L	25.22 ± 2.03	25.67 ± 2.22	0.546
V C	41.44 ± 2.42	42.57 ± 3.05	0.202
V cent	37.48 ± 1.87	38.67 ± 2.86	0.124
V L	28.29 ± 2.08	28.78 ± 2.61	0.516
VI C	48.17 ± 2.73	49.25 ± 3.25	0.260
VI cent	43.46 ± 2.71	44.16 ± 2.93	0.440
VI L	31.55 ± 2.30	31.95 ± 2.70	0.612

TABLE 4 Transverse diameter baseline characteristics in the whole population (N = 41). Results are expressed as Mean ± Standard Deviation or Median [Interquartile Range]; p-value = Student's t-Test p-value adjusted by using Bonferroni method or Mann-Whitney U test p-value adjusted by using Bonferroni method.

Results

The sample that was included in the analysis was composed

	Group 1 T1-T0 N = 20	Group 2 T1-T0 N = 21	Intergroup p-value
Tip			
1.6 p-value	0.44 ± 4.53 0.668	0.09 ± 3.60 0.907	0.791
1.5 p-value	3.75 ± 13.80 0.251	5.88 ± 23.46 0.264	0.725
1.4 p-value	-0.29 ± 5.46 0.827	-2.45 ± 10.91 0.314	0.433
1.3 p-value	2.34 ± 9.85 0.407	-0.31 ± 8.21 0.865	0.427
1.2 p-value	0.01 ± 5.40 0.992	-0.04 ± 7.31 0.983	0.982
1.1 p-value	1.79 ± 1.91 <0.001*	4.07 ± 6.27 <0.001*	0.125
2.1 p-value	1.89 ± 2.36 0.002*	2.63 ± 4.13 0.008*	0.485
2.2 p-value	-0.21 ± 5.39 0.873	1.98 ± 8.30 0.354	0.379
2.3 p-value	-2.17 ± 6.31 0.220	-1.74 ± 6.01 0.221	0.847
2.4 p-value	-1.01 ± 9.43 0.664	-3.1 ± 11.55 0.270	0.561
2.5 p-value	1.64 ± 17.59 0.681	2.09 ± 22.31 0.671	0.942
2.6 p-value	0.23 ± 5.63 0.853	0.19 ± 3.55 0.804	0.978

TABLE 5 Tip differences over time in the whole population (N = 41). Results are expressed as Mean ± Standard Deviation or Median [Interquartile Range]; Intergroup p-value = Student's t-Test p-value adjusted by using Bonferroni method or Mann-Whitney U test p-value adjusted by using Bonferroni method. Intragroup T1-T0 p-value = Paired t-test p-value, or Wilcoxon's signed rank test p-value.

	Group 1 T1-T0 N = 20	Group 2 T1-T0 N = 21	Intergroup p-value
Torque			
1.6 p-value	4.13 ± 7.38 0.021*	2.07 ± 4.94 0.076	0.306
1.5 p-value	8.75 ± 5.61 <0.001*	-0.06 ± 6.37 0.964	<0.001*
1.4 p-value	5.65 ± 5.11 <0.001*	1.82 ± 7.95 0.306	0.081
1.3 p-value	6.74 ± 5.92 0.002*	2.49 ± 8.38 0.198	0.104
1.2 p-value	-0.05 ± 3.83 0.950	-3.28 ± 6.66 0.076	0.113
1.1 p-value	-1.36 ± 1.87 0.184	0.2 ± 4.21 0.829	0.253
2.1 p-value	-1.87 ± 2.87 0.010*	0.3 ± 5.68 0.811	0.132
2.2 p-value	-1.18 ± 3.80 0.215	0.93 ± 5.80 0.531	0.229
2.3 p-value	2.70 ± 6.42 0.138	3.80 ± 9.37 0.093	0.692
2.4 p-value	7.54 ± 5.52 <0.001*	1.12 ± 6.85 0.494	0.004*
2.5 p-value	8.34 ± 7.33 <0.001*	0.75 ± 6.67 0.608	0.001*
2.6 p-value	3.22 ± 5.15 0.011*	2.00 ± 4.43 0.050	0.426

TABLE 6 Torque differences over time in the whole population (N = 41). Results are expressed as Mean ± Standard Deviation or Median [Interquartile Range]; Intergroup p-value = Student's t-Test p-value adjusted by using Bonferroni method or Mann-Whitney U test p-value adjusted by using Bonferroni method. Intragroup T1-T0 p-value = Paired t-test p-value, or Wilcoxon's signed rank test p-value.

of 41 patients. The mean age was 10 years. Demographic and clinical characteristics of groups are shown in Table 1. All devices were successful, and no appliance's emergency was observed. One patient had palatal gingival inflammation due to poor hygiene/food impaction.

The baseline parameters differences between groups are shown in Table 2, Table 3, and Table 4. No significant differences were found, except for the tip of tooth 2.4 (Table 2, p-value: 0.004), and for the torque of teeth 1.5 and 2.5 (Table 3, p-value: <0.001, 0.003).

Significant intragroup differences over time were found in Group 1 with respect to the tip of teeth 1.1 and 2.1 (Table 5, p-value: <0.001 and 0.002 respectively). Significant intragroup differences over time were found in Group 2 with respect to the tip of teeth 1.1 and 2.1 (Table 5, p-value: <0.001 and 0.008 respectively). Significant intragroup differences over time were found in Group 1 with respect to the torque of teeth 1.6, 1.4, 1.3, 2.1, 2.4, 2.5, 2.6 (Table 6, p-value: 0.0021, <0.001, 0.002, 0.010, <0.001, <0.001, 0.011).

Significant differences between groups were found with respect to the longitudinal change in torque of teeth 1.5, 2.4 and 2.5 (Table 6, p-value: <0.001, 0.004, 0.001). Significant intragroup differences over time were found in both groups with respect to all transverse diameter parameters (Table 7). No significant differences were found between groups with respect to the transverse diameter modifications over time.

Discussion

Rapid maxillary expansion produces great forces in order to obtain a minimum dental movement and the maximum orthopaedic effect, so that the median palatine suture is widened and opened. The expansion force depends on the activation protocol: the expansion screw may be activated once or twice a day for 2-4 weeks, every activation producing a force of 3-10 pounds. The literature reports the same amount of periodontal inflammation in both groups [Mummolo et al., 2014], with the same transverse bone augmentation [De Almeida et al., 2017], and both methods result as effective in correcting a narrow palatine vault in the mixed dentition.

The present study found no differences between activation protocols with regard to the efficacy of expansion and both methods produced a significant effect in the transverse diameter differences over time. On the other hand, a significant difference over time was found in both groups for what concerns the dental tip of teeth 1.1 and 2.1, this is consistent

	Group 1 T1-T0 N = 20	Group 2 T1-T0 N = 21	Intergroup p-value
Transverse Diameter			
III C p-value	5.06 ± 1.53 <0.001*	5.16 ± 3.28 <0.001*	0.908
III cent p-value	4.75 ± 1.08 <0.001*	4.89 ± 2.96 <0.001*	0.857
III L p-value	4.21 ± 1.05 <0.001*	4.73 ± 2.71 <0.001*	0.328
IV C p-value	6.36 ± 1.45 <0.001*	5.60 ± 3.53 <0.001*	0.411
IV cent p-value	6.17 ± 1.44 <0.001*	5.28 ± 3.14 <0.001*	0.295
IV L p-value	5.09 ± 1.83 <0.001*	4.87 ± 2.53 <0.001*	0.775
V C p-value	6.60 ± 1.43 <0.001*	5.39 ± 3.19 <0.001*	0.127
V cent p-value	6.04 ± 1.31 <0.001*	5.08 ± 2.93 <0.001*	0.186
V L p-value	5.05 ± 1.39 <0.001*	5.11 ±2.62 <0.001*	0.929
VI C p-value	6.13 ± 1.85 <0.001*	4.64 ± 2.98 <0.001*	0.067
VI cent p-value	4.88 ± 2.70 <0.001*	4.22 ± 3.02 <0.001*	0.470
VI L p-value	5.39 ± 3.15 <0.001*	3.91 ± 2.58 <0.001*	0.111

TABLE 7 Transverse diameter differences over time in the whole population (N = 41). Results are expressed as Mean ± Standard Deviation or Median [Interquartile Range]; Intergroup p-value = Student's t-Test p-value adjusted by using Bonferroni method or Mann-Whitney U test p-value adjusted by using Bonferroni method. Intragroup T1-T0 p-value = Paired t-test p-value, or Wilcoxon's signed rank test p-value.

with the opening of the median diastema, which accompanies the expansion and its related closure during the following weeks. Moreover, statistically significant torque differences over time were noted in Group 1 with regard to upper first molars, premolars and cuspids; this gives evidence to the fact that the palatal expansion induces a dental tilt of anchorage teeth, in accordance with what is suggested by the literature on traditional expanders. Asanza et al. [1997] evaluated traditional expanders anchored on permanent teeth, by means of bands or bonding, and they observed a dental tilt of 3° on anchorage elements in both cases. Ferrario et al. [2003] describe a change of 17.6°, but this could be due to a less rigid NiTi expander.

Rosa et al. [2016] evaluated the effects of Haas type expanders anchored on second deciduous molars, assessed by CBCT, in patients with maxillary anterior crowding without posterior cross-bite, reporting significant spontaneous changes for the torque of the upper first molars, on the right (3.6°) and on the left (3.7°) side. The present results confirmed these changes, even though the differences observed in this study were lower and not significant over time, probably due to variations in the analysis method, the type of expander used, and the sample involved.

Different authors [Harrison and Ashby, 2000; Di Ventura et al., 2019] report that in the group treated with expanders anchored on deciduous molars the transverse diameter augmentation was 85% skeletal and 15% dental, while in the group anchored on permanent teeth the dental contribution was 45% of the obtained expansion. Further on, the research showed that in the group treated by means of an expander anchored on deciduous teeth the longitudinal changes in torque values on molars and cuspids were not significant, while in the group treated by an expander anchored on permanent molars 1.6 and 2.6 underwent a significantly increase in torque values. The present study results in accordance with these findings, since no significant longitudinal changes were found in torque values for the group treated by means of an expander anchored on deciduous teeth, and intergroup differences in torque changes were found for teeth in the premolar position; these teeth underwent a mean tilt of 1.2° in Group 2 and of 7.2° in Group 1. This suggests that a digital palatal expander anchored on deciduous teeth may reduce the torque undesired variations of anchorage teeth.

Additional advantages of a digitally-designed palatal expander are a reduction in chairside time and a major comfort, both due to the elimination of molar bands fitting and impression collection. Moreover, intraoral scans do not need to be quickly treated in order to prevent distortions, are less subject to errors and can be easily transferred to the lab. Finally, the immediate acquisition of a digital image of dental arches represents a valid support to communicate with the young patient and his/her family.

Limits of the present study are related to the short-term evaluation and the two different activation protocols, even though these are routinely adopted protocols, and can provide useful information on the SLM expander device effects. Considering the segmentation process the more reliable measurements to be considered are the differences between the before/after values, and not the absolute values.

Conclusions

No significant longitudinal changes were found in torque values for the group treated by means of an expander anchored on deciduous teeth.

Conflict of interest statement
The authors declare no conflict of interest.
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Data Availability Statement
The individual data used to support the findings of this study are available from the corresponding author upon request.

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