

Comparative analysis of rapid maxillary expansion using three brands of fan-type expander screw: Laboratory trial using typodont

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Abstract

Introduction: Cleft lip and palate patients usually have severe maxillary deficiencies, particularly in the anterior region of this arch and their treatment should include maxillary expansion. **Objective:** To evaluate the expansion pattern of three brands of fan-type expander screws to correct transverse deficiencies. **Methods:** Eighteen expansions on typodonts were performed with 6 simulations for each group: G1 - Dentaurum® screw; G2 - Leone® screw; and G3 - Morelli® screw. For each trial 13 activations of 2/4 of a turn each were made with a 5.2 mm screw opening. Measurements were made at baseline (T1), after half of the activations (T2) and at the end of the trial (T3). A caliper was used to make the following measurements: Inter-first premolars (IP1), inter-second premolars (IP2) and intermolar (IM) widths and arch length (AL). The Kolmogorov-Smirnov, Tukey, Friedman and ANOVA tests were used to analyze data. **Results:** All groups had a “V” shaped opening pattern and the greater expansion was found in the anterior region of the arch, which was more evident in the G3 (29.58% in IP1 and 9.73% in IM). The increase in AL was similar in G1 and G3 (+12.65% and +12.13%) and the lowest value was found in G2 (+8.23%). **Conclusions:** All the fan-type expander screws used in this study may be used to treat dental arch transverse deficiencies. However, the use of the Morelli screw resulted in a greater opening in the anterior region than in the posterior region, an important characteristic in the treatment of cleft lip and palate patients. Further clinical studies should be conducted to confirm these findings.

Keywords: Cleft lip and palate. Expansion screw. Rapid maxillary expansion.

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INTRODUCTION

The orthodontic condition of cleft lip or cleft lip and palate patients has received special attention in recent years. Although the characteristics of patients with dentofacial anomalies are often similar to those of patients without clefts, the limitations associated with the cleft, as well as those resulting from surgical interventions, should be taken into consideration. The treatment of these patients who have a substantial arch deficiency in the anterior region often requires rapid maxillary expansion (RME) with a greater opening in this region. Cleft patients often have a correct transverse relation in the posterior region of the arch, but a crossbite in the anterior region. Therefore, treatment should rehabilitate the anterior region without negatively affecting the posterior region. The transverse opening rates of conventional expander screws are the same in the anterior and posterior regions, whereas fan-type expander screws provide gradual expansion that is practically zero in the molars region and reaches its maximum value in the canines region. However, it is not clear whether all fan-type expander screws achieve the same results when activated. To find out more about this issue, three commercial brands of fan-type expander screws were compared and their performance in laboratory trials was evaluated.

LITERATURE REVIEW

The dental arch of cleft patients who have not undergone surgery may have transverse deficiencies that are more severe towards the medial and anterior regions because of the mesial displacement of the palatal segments, particularly the smallest segment. In patients who have undergone surgeries, mesial displacements, added to anteroposterior growth limitations, are much greater.^{11,18,24,26,28} Cheiloplasty and palatoplasty can reduce the width and length of the maxillary arch. The muscle belt created by cheiloplasty produces a force strong enough

to explain maxillary sagittal deficiencies, which result in maxillary retrognathism, reducing the height of the middle third of the face and contributing to maxillary transverse deficiencies. Palatoplasty, in turn, is only associated with the reduction of the width of maxillary medial and posterior regions.^{4,11,22,24,26,27,29} Because palatal segments may collapse, bilateral cleft lip and palate patients often need rapid maxillary expansion.^{6,28} At birth, infants with bilateral cleft lip and palate have a greater maxillary arch width in the anterior and posterior regions than infants without clefts. The separation of the palatal processes at this phase leads to an increase in maxillary transverse width, while the lack of lip retention favors the buccal projection of the anterior end of the larger segment, which also results in an increase in the sagittal dimension of the dental arch. After the surgical intervention on lip and palate, there is a decrease in the maxillary arch width.^{18,24,28} The comparison of the shape of the maxillary arches of bilateral cleft lip and palate infants with that of infants without clefts reveals that the first one has a more triangular shape composed of three segments: Anterior, which is the premaxilla and may be centralized or laterally displaced; and two lateral, or palatal, segments.²⁴ Therefore, RME is an option to create additional space in the dental arches. In cleft lip and palate patients, orthodontic treatment is usually restricted to lateral repositioning of palatal segments and alignment of teeth and alveolus.²⁸ Treatment with RME results in the physical separation of the premaxilla and the maxillary palatal segments due to the fact that these are bilateral structures united by the midpalatal suture.^{13,19,20} An factor that must be taken into account in RME is the resistance of the facial bones, assigned to the presence of sutures, such as the midpalatal suture.^{15,19} Expanders produce an orthopedic movement that separates the maxillary bones and, at a lesser degree, buccally moves the teeth. The increase in

maxillary arch width and its orthopedic effect may correct the maxillary transverse relation.^{1,13} As a direct result of expansion, suture opening may move the maxilla forward and downward, which opens the bite and moves point A forward. In several cases, however, these effects are temporary.^{8,14,28}

In the non-cleft patients, the opening of the midpalatal suture results in a diastema between the maxillary central incisors, which is not the case in cleft patients.^{7,8,9,25,28} In patients with clefts, however, the separation occurs in the suture between the maxilla and the premaxilla, and there is no bone gain because the midpalatal suture is not involved.^{5,28} The expansion pattern is also triangular as in non-cleft patients and there is a greater opening in the anterior region.^{6,8} Once the desired expansion is achieved, the screw is fixed in place using acrylic resin. The appliance is kept in the mouth for 3 months for retention and to reduce the chances of relapse.^{9,13,17,20}

Adkins et al¹ found that every millimeter increased in palatal width in the premolars region produces a 0.7 mm increase in the maxillary arch perimeter. RME using expanders promotes molars buccal tipping due to the lateral rotation of the alveolar processes and tooth tipping in the alveolar bone, which is followed by some extrusion.^{3,19} Therefore, the maxilla of cleft patients may be seen as segments that RME may spatially reposition.²⁸ In these patients, the narrowing of the maxillary arch is found at a more anterior position and the transverse relation is usually adequate in the posterior region.⁴ Therefore, an expansion screw should provide greater expansion in the anterior region of the arch. In the study conducted by Doruk et al,¹² the group treated using an appliance with a fan-type expansion screw had less posterior teeth tipping and extrusion, which produced an increase in facial height, than the group treated with a conventional expansion appliance. The activation of the fan-type appliance produces gradual expansion that is practi-

cally zero in the posterior region and reaches the greatest value in the anterior region.^{5,12} The results of RME using conventional screws are well documented in the literature. However, studies using fan-type expansion screws should be conducted to evaluate their clinical response, particularly in cleft lip and palate patients. This study evaluated the opening pattern produced by three brands of fan-type expansion screws in laboratory trials using typodont models.

MATERIAL AND METHODS

The sample comprised three types of fan-type expansion screws for maxillary expansion: A Leone[®] one-piece fan-type expansion screw, a Dentaurum[®] two-piece fan-type expansion screw and a Morelli[®] two-piece fan-type expansion screw. To evaluate the opening pattern of each screw, the characteristics of malocclusion usually found in cleft lip or cleft lip and palate patients were reproduced in a typodont. Maxillary deficiency was replicated in typodonts 6 times for each expansion screw, at a total of 18 simulations. To ensure that malocclusion characteristics were reproduced in all trials, a silicone impression was taken for each typodont and an acrylic resin model was fabricated to be used as a reference in the reproduction of malocclusion characteristics. The expansion appliance was manufactured according to the characteristics designed by Haas¹³ and fixed with glass ionomer cement. In a bath with water at a constant temperature of 50 °C, each typodont and its expander was immersed for about 3 minutes. After that, the screw was activated 2/4 of a turn and the typodont was immersed for 2 more minutes for the wax to dissipate the pressure generated by the activation. After that, the typodont was kept under running water for 2 minutes to reach room temperature and to stabilize the activation. Activations were repeated 13 times for each appliance, at a total of 5.2 mm for each screw. At the time of each activation, the following measurements were made: Inter-first premolars (IP1), inter-second



FIGURE 1 - Fan-type expansion screws used in this study. **A)** Morelli®. **B)** Dentaaurum®. **C)** Leone®.

premolars (IP2) and intermolar (IM) widths. In addition, the maxillary arch length (AL) was measured before and after activations, as well as the height between the tip of the cusp (buccal) of the maxillary first premolars (BD1) and first molars (BD2) and the typodont base to check possible changes in the vertical dimension of these teeth. A Dentaaurum® caliper with precision of 0.01 mm was used for the measurements. The complete activation sequence (13 activations) was repeated for each expansion screw (3 types) and their corresponding expansion appliances for 6 times, at a total of 18 immersions and 13 activations for each one. Data were recorded in spreadsheets for later analysis. Measurements were made at three time points: Before activations (T1), after half of the activations had been done (T2) and after activations (T3). Data were analyzed statistically. To check whether data were normally distributed, the nonparametric Kolmogorov-Smirnov test was used. Analysis of variance (ANOVA) and the Tukey test for multiple comparisons were used to compare groups to each other. The nonparametric Friedman test was used for the comparisons between activations because data were paired.

RESULTS

The analysis of the transverse width of the arch at IP1 revealed that all screws had similar performances in amount of expansion. However, the Leone group, particularly halfway through and after activations, had the greatest IP2 and IM values resulting from expansion. When comparing the increase obtained after activations with baseline (T1) values, results revealed again that the Leone screw had the greatest expansion values, particularly in IP2 and IM widths (Tables 1, 2 and 3).

DISCUSSION

This study is a laboratory trial and results must be interpreted cautiously. Conventional expansion screws have a characteristic pattern of midpalatal suture opening. They produce a considerable increase in intermolar and interfirst premolar widths. This clinical response may be useful when maxillary deficiency is not severe because anterior and posterior crossbites are usually associated in these cases. Adkins et al¹ studied 21 teenagers, nine of them with cleft lip or cleft lip and palate. They used Hyrax

TABLE 1 - IP1, IP2 and IM width increases (percentage) after activations compared with values before activation between groups.

Comparison	n	Mean increase (%)	Standard deviation	p
IP1				
Dentaurum group	6	30.60 ^A	2.84	0.07
Leone group	6	27.29 ^A	1.87	
Morelli group	6	29.58 ^A	2.10	
IP2				
Dentaurum group	6	20.95 ^A	2.70	0.01*
Leone group	6	27.10 ^B	1.63	
Morelli group	6	18.83 ^A	2.09	
IM				
Dentaurum group	6	12.33 ^A	0.17	0.01*
Leone group	6	19.18 ^B	1.08	
Morelli group	6	9.73 ^C	2.17	

* mean values followed by the same letter do not differ from each other.

TABLE 2 - Comparison between groups of IP1 width increase (percentage) in relation to IM after activations.

Comparison	n	Mean increase (%)	Standard deviation	p
Dentaurum group	6	148.37 ^A	24.79	0.01*
Leone group	6	43.00 ^B	16.21	0.01*
Morelli group	6	213.14 ^C	51.37	0.01*

* mean values followed by the same letter do not differ from each other.

TABLE 3 - Comparison between groups of maxillary arch increase (percentage) after activations in relation to AL before activations.

Increase % comparison	n	mean	Standard deviation	p
Dentaurum group	6	12.65 ^A	0.70	0.01*
Leone group	6	8.23 ^B	0.68	0.01*
Morelli group	6	12.13 ^A	1.28	0.01*

* mean values followed by the same letter do not differ from each other.

screws fixed to the bands around the maxillary first premolars and first molars and found similar values of intermolar and inter-premolar widths (about 6.5 mm), whereas the intercanine width had a 50% lower expansion than

the other regions. Capelozza Filho et al⁷ conducted a study on non-surgically assisted RME in adult patients and found that the increase of intermolar and inter-premolar widths was similar (about 3.5 mm), whereas the increase of intercanine width was negligible. Handelman¹⁶ also evaluated non-surgically assisted RME in adults and found increases of 3.9 to 7.5 mm in intermolar width, whereas inter-premolar width increased 1.7 to 9.1 mm. In another study using a group of children whose mean age was 9.5 years and a group of adults with a mean age of 30 years, all without cleft lip or palate, Handelman et al¹⁷ reported the following expansion results: Intermolar width – 5.7 mm (children) and 4.6 mm (adults); inter-premolar width – 4.9 to 5.7 mm (children) and 4.7 to 5.5 mm (adults); and intercanine width – 4.2 mm (children) and 2.8 mm (adults). However, Lamparski et al²⁰ found that appliances using conventional screws and anchored to 2 or 4 teeth had an equivalent mean width (about 5 mm) in the intercanine and intermolar regions. McNamara et al²³ found that the intermolar, inter-premolar and intercanine widths did not differ statistically from each other after expansion with a conventional screw. Cavassan et al⁹ measured the expansion in a cleft lip and palate patient treated with a conventional expansion screw. Intermolar and inter-premolar widths were similar, but the intercanine width was smaller. Therefore, maxillary expansion with a conventional screw corrects deficiencies in anterior region as well as in the posterior region. Table 4 summarizes some of the studies about RME. Cleft lip and palate patients, however, usually have a good transverse relation in the intermolar region, but a deficiency in the anterior region of the arch. Therefore, fan-type expansion screws seem to be appropriate to correct this type of maxillary deficiency. However, few studies have used this type of expansion screw, although they have been available in the market for several years,

Author	n	Age	IC	IP1	IP2	IM
Adkins et al ¹	21	11-17 yr	2.9	6.1		6.5
Capelozza et al ⁷	38	20 yr 8 mo	1.4	3.6		3.2
Handelman et al ¹⁷	47	9 yr 5 mo	2.8	4.7	5.5	4.6
	47	29 yr 9 mo	4.2	4.9	5.7	5.7
Baccetti et al ²	29	11 yr				9.3
	13	13 yr				8.9
McNamara et al ²³	112	12 yr 2 mo	3.9	4.9	4.9	4.4
Doruk et al ¹²	17	12 yr 5 mo	8.1			2.6
Lagravère et al ²¹			4.5 – 8.8			4.3 – 6.3

TABLE 4 - Comparison of measurements obtained in some studies about RME.

and it is complicated to compare the results of the present study with findings in the literature. Moreover, this study is a laboratory trial and typodont models have not been used for the evaluation of even conventional screws.

The analysis of the mean increase percentage between IP1 and IM widths revealed that the Leone screw had an IP1 expansion about 43% greater than the IM width. The Dentaurum screw, in turn, produced an IP1 increase about 143% greater than the IM width. However, the best response was obtained with the Morelli screw, in which the mean increase of the IP1 width was 213% over IM width. The ratio of increase of the transverse width of the anterior region in comparison with the posterior region was 2:1 for the Dentaurum screw, 3:2 for the Leone screw and 3:1 for the Morelli screw. The comparison of the three brands revealed that the Morelli screw had the best expansion pattern for cases in which a greater opening in the anterior region is required. The anterior region had a much more intense response than the posterior region, which had a much smaller expansion. Such results are in agreement with those reported by Capelozza Filho et al⁵, who

found 7 mm of expansion in the intercanine region and only 3 mm in the intermolar region using a Dentaurum fan-type expansion screw. Doruk et al¹² also found an expansion ratio of 3:1 between the intercanine and intermolar regions when using a Leone fan-type expansion screw. These findings define the opening pattern for this type of screw, which has the shape of a triangle with its base turned to the anterior region of the arch. In this study, however, the Leone screw produced the greatest opening in the IM region, similar to that found in IP1, which was similar to the behavior of conventional screws. Moreover, it is an imported screw in Brazil and its prices are high compared to others. The Dentaurum screw had a satisfactory performance in terms of pattern and amount of expansion obtained. However, its performance is not comparable to the results obtained when the Morelli screw was used. The Dentaurum and the Leone screws are imported and have a high cost in Brazil. The Morelli screw was the one that corresponded most to the expectations in this study. It had the best expansion pattern, being manufactured in Brazil and its cost is much lower than that of the other two brands.

The analysis of AL revealed that the increase of this measure was similar for the Dentaurum and the Morelli screws (about 12%). The Leone screw, in turn, had the lowest AL increase. Adkins et al¹ found an arch length decrease of about 0.4 mm after expansion with Hyrax screws, probably due to the palatal tipping of maxillary central incisors. In contrast, McNamara et al²³ found a mean increase of 0.2 mm in this measure after RME using a conventional expander.

The evaluation of the vertical dimension of the teeth that served as anchorage for the appliance revealed that both BD1 and BD2 in all test groups increased after activations, and this difference was greater in the Dentaurum group (mean 6%). Handelman et al¹⁷ compared RME characteristics in a study of conventional Haas appliances used to treat children whose mean

age was 9.5 years and adults about 30 years old. They found that only in the group of children there was some molar extrusion (1.5 mm).

The analysis of our results may provide an estimation of the clinical performance of these screws. As mentioned above, in patients with cleft lip and palate RME does not separate the palatal maxillary processes, but spatially repositions them. Our study may serve as subsidy for further investigations about this issue but, most of all, should motivate other authors to clinically test these screw brands to determine whether they are a treatment option to correct transverse maxillary deficiencies, particularly in the anterior region of the dental arch.

CONCLUSIONS

The results of this study suggest that:

- » Both the Morelli and the Dentaurem screws have a “V” shape opening pattern and greater expansion in the anterior region of the arch, whereas the Leone screw had a more parallel expansion pattern in the anterior and posterior regions of the arch.
- » The increase in arch length (AL) was similar for the Dentaurem and Morelli screws and lower for the Leone screw.
- » There was some increase in the vertical dimension of the teeth that anchored the appliance in all trials, regardless of the brand of the fan-type expansion screw.

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