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A Comparison of Two Rapid Palatal Expansion Appliances and their Effect on Palatal Cross-Sectional Area

William D. Scott

Abstract

A COMPARISON OF TWO RAPID PALATAL EXPANSION APPLIANCES AND THEIR EFFECT ON PALATAL CROSS-SECTIONAL AREA

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Two rapid palatal expansion appliances, acrylic-free and acrylic-reinforced, were compared for their effect on the cross-sectional area of the palate. Two groups, twenty-five patients in each, were selected so that they would match as closely as possible with regards to age and sex distribution. The pre-treatment and post-treatment maxillary models were duplicated, and this duplicate model was then trimmed in a specific manner to allow the cross-sectional area between the first permanent molars to be compared. The results indicate that there is no difference, at the five percent level of significance, between these two appliances. It is concluded that the acrylic-reinforced appliance does not give greater expansion of the palatal vault than the acrylic-free appliance.

LOMA LINDA UNIVERSITY

Graduate School

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Each person whose signature appears below certifies that this manuscript in his opinion is adequate, in scope and quality, in lieu of a thesis for the degree Master of Science.

Chairman
Alden B. Chase, Professor of Orthodontics

Logan W. Barnard, Associate Professor of Orthodontics and Speech Pathology

Lawrence E. McEwen, Assistant Professor of Orthodontics

Arthur J. Morgan, Associate Professor of Orthodontics

John K. Pearson, Associate Professor of Orthodontics

Guy D. Taylor, Assistant Professor of Orthodontics

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INTRODUCTION

Orthodontic patients may present with an insufficient width of the maxillary denture caused by a constricted palatal boney base. Various techniques have been employed to correct this insufficient width. Some of these techniques involve a rapid expansion, using heavy forces over a short period of time, which causes separation of the midpalatal suture.[3,4,5]

Two appliances that use this technique are very similiar with regards to the force employed and the time involved. They differ, however, in that one, the acrylic-reinforced appliance (Figure 2.), has acrylic applied to the framework in order to distribute forces to the alveolar process, and the second, the acrylic-free appliance (Figure 3.), does not.

It has been proposed that the acrylic exerts pressure against the walls of the palatal vault and deeper structures thus giving better expansion in the apical portion of the maxilla.[3,4,5,6,16,17] It is felt that the greatest disadvantage of the acrylic-free appliance occurs during the retention period.[6] These authors state that compressive forces tending to collapse the maxillary expansion exist for approximately six weeks. They feel that the acrylic is necessary to maintain the maximum amount of expansion in the palatal vault.

Numerous investigations since the first reported case of palatal expansion have examined the reaction of the palatal suture and dentition to the various rates and degrees of expansive forces used.[9,10,12,13,14,17,18] No known study, however, has contributed clinical data to quantitatively compare the acrylic-free and acrylic-reinforced appliances.

If the acrylic-reinforced appliance does indeed produce more apical base expansion with less relapse, it should be the appliance of choice; however, if it does not produce these desired effects any more than the acrylic-free appliance, the acrylic-free appliance should then be the appliance of choice due to ease of fabrication and improved tissue response under the appliance.[9,11]

Therefore, the purpose of this study is to examine and quantitatively compare the cross-sectional area of the palate, before and after treatment, between these two appliances in post-orthodontically treated patients.

MATERIAL

Fifty patients were randomly selected from two private practices of Loma Linda University staff members. The twenty-five patients making up the acrylic-free group came from one office and the twenty-five patients making up the acrylic-reinforced group came from the other.

Patient selection was based on the following criteria: (1) treatment without the use of extractions, (2) rapid expansion of the maxillary arch during the early stages of treatment by either the acrylic-reinforced appliance or the acrylic-free appliance, (3) a minimum of four millimeters of expansion as measured between the maxillary first molars, (4) the patients clinically demonstrated midpalatal suture opening, and (5) completion of active orthodontic treatment consisting of a light-wire edgewise appliance.

The two groups were selected so that they would match as closely as possible with regards to age and sex distribution. Both appliances were activated one quarter turn in the morning and in the evening, and retention of the appliances after activation was for a period of from ninety to one hundred twenty days.

METHODS

Measurements were made of the pre-treatment and post-treatment maxillary study models. The measurements were made by use of a divider and millimeter rule.

The first measurement made was the distance between the first molars, measured at the dento-gingival junction. All cases with less than four millimeters of expansion were eliminated from the study. The next area of measurement was the crown height. The distance from the dento-gingival junction to the tip of the mesio-lingual cusp was measured on both the right and left sides.

After these measurements were made, the models were duplicated by the author, using identical procedures. These models were then trimmed with a model trimmer so that the occlusal surface was parallel with the base of the model. The posterior surface of the model was then trimmed perpendicular to the base and occlusal surfaces, coming forward to a point on the right and left first molars (Figure 1.). This point was in the developmental groove, between the mesio-lingual and disto-lingual cusps, at its most occlusal point. The posterior surface of these trimmed models was then placed on Oxford, lenox grade precision rotary-cut cards, and the palatal vault area, including the dento-gingival junction, was traced. A line was drawn from the dento-gingival junction on one side to

the dento-gingival junction on the opposite side (the dento-gingival line), as illustrated in Figure 1.

On the pre-treatment tracing (template), a line (the palatal height line) was taken perpendicular from the dento-gingival line to the highest point of the palate. The length of this line was determined and recorded. A line was then drawn parallel to the dento-gingival line at the midpoint of the palatal height line. A measurement was made between the points where this line intercepted the walls of the palate (the interalveolus distance). On the post-treatment template the same thing was done except that the distance from the highest point of the palate to the midpoint of the palatal height line, on the pre-treatment template, was used as the point from which the interalveolus distance was measured. All of the above lines were drawn outside of the tracing of the palatal vault area in order to avoid marks that would affect the weight of the template.

A single edged razor blade was then used to cut out this cross-sectional template of the palatal vault. The weight of this cross-sectional template was determined by using a Mettler H6T balance.

All of the previous measurements and procedures were performed by the same individual (W.D.S.) and carried out in a single-blind manner.

Reproducibility of Measurements

For the purpose of verifying the reproducibility of the cross-sectional templates and their subsequent weights, an initial test and retest was conducted. A maxillary study model was duplicated six times. These models were trimmed as described previously, then four cross-sectional templates were made from each model. The templates were weighed on the Mettler H6T balance and an analysis of variance was computed. An F-ratio of 1.02 ($P>.25$) indicated that the reproducibility of the measurements from the templates was very good.

Statistical Analysis

Means and standard deviations were computed by group for each variable, and for the differences between the pre-treatment and post-treatment measurements for each variable.

Any significant difference of pre-treatment measurements between the two groups was analyzed by using the general linear hypothesis to determine if this would affect the outcome of the study.

The student's t-test was used to analyze the differences in pre-treatment and post-treatment measurements between group I and group II.

RESULTS

The means and standard deviations for all the variables and for the pre-treatment and post-treatment differences in these variables can be found in Tables 1 and 2.

The acrylic-free group consisted of eighteen females and seven males. The mean age was 14.28 with a standard deviation of 2.69. The acrylic-reinforced group consisted of seventeen females and eight males. The mean age was 12.92 with a standard deviation of 2.90. The distribution of males to females through each individual group was approximately the same when compared to each other.

The results of the student's t-test on the differences of the pre-treatment and post-treatment measurements, compared from group to group, can be found in Table 3. This shows that there is no significant difference between any of these variables when compared from group I to group II.

A significant difference was found in the pre-treatment inter-molar width and the pre-treatment weight of group I and group II. A general linear hypothesis was used to analyze the difference in weight, using the pre-treatment inter-molar distance, the pre-treatment weight, and the difference in pre- and post-treatment inter-molar distance as co-variates. As can be seen from Table 4, these

co-variates did not affect the final results of the study.

DISCUSSION

No known previous studies have contributed clinical data to quantitatively evaluate and compare two rapid palatal expansion appliances, one acrylic-reinforced and the other acrylic-free. Some authors have postulated that the acrylic-reinforced appliance is the better of the two for several reasons.[3,4,5,6,16,17] These authors state that the acrylic high in the palate exerts heavy forces against the palatal vault, both during active expansion and later during the retention phase. At first this gives better apical base expansion and later better retention of the maxillary halves against the residual forces built up during activation. They also feel the morphology of the vault appears better, due to the remodeling effect of the acrylic pads, and nasal airway resistance should be maintained at a lower level. The tissue response under the acrylic was not a problem according to these authors.

Other studies have suggested that the acrylic-free appliance will accomplish the same goals. Hershey, et.al., found no significant differences in molar expansion, initial nasal resistance, nasal resistance change, or nasal cavity expansion.[7] McPhie concluded from a study on rhesus monkeys that the two appliances were equally effective in widening the maxillary halves.[11] He also found that both appliances tipped the teeth to the same degree, but that the teeth

uprighted equally and that more soft and hard tissue necrosis occured with the acrylic-reinforced appliance. Kelson found that both appliances were very effective in achieving increased arch width, although the acrylic-free appliance permitted healthier soft tissue and a wider vault maintenance.[9]

If the teeth are tipped to a greater extent with the acrylic-free appliance and less apical base expansion is maintained during the retention phase, then the cross-sectional area across the palate should show a significant difference between the two groups.

Both groups were treated non-extraction and appliance activation and retention were the same as well as subsequent treatment of the case with a light-wire, edgewise technique. Three factors not considered in this study were the use of elastics, headgear, and growth.

All pre-treatment measurements were compared for significant difference between the two groups. The differences in inter-molar distance and cross-sectional weight were significant, so a general linear hypothesis was used to determine the effect on the study. The test indicated that these differences had no effect on the final results.

Another factor that could have affected the validity of the cross-sectional weight measurement was any change

in a vertical direction of the dento-gingival junction at the first molars. Studies by Zachrisson, Alstad, and Alnaes have shown that there is no significant statistical difference in gingival attachment and clinical crown length between orthodontically treated and non-treated patients.[1, 19, 20]

The pre-treatment and post-treatment crown length measurements in this study did not vary enough to affect the results.

As can be seen from the palatal height measurements, the acrylic-free group started with a deeper vault, which probably accounts for the higher pre-treatment template weight even though this group had the smallest pre-treatment inter-molar distance. Both groups demonstrated the same increase in length of the palatal height measurement, indicating the same response to both appliances or to other factors such as growth.

The interalveolus distance should have shown a significant difference between the two groups, but it did not. If the acrylic-free appliance tipped teeth more, gave less expansion higher in the palate, and retained less of the attained expansion, the difference between pre- and post-treatment measurements should have been significantly different. You would expect the acrylic-reinforced group to increase significantly more.

The results of the student's t-test show that there is no significant difference between any of the variables, at the five percent level of significance, when compared from group to group. These results indicate that the group treated with the acrylic-free appliance obtained the same results as the group treated with the acrylic-reinforced appliance.

SUMMARY

Fifty rapid palatal expansion cases were randomly selected from two orthodontic practices. Twenty-five from one office were treated with an acrylic-reinforced appliance, and the remaining twenty-five from the other were treated with an acrylic-free appliance.

The pre-treatment and post-treatment maxillary study models were duplicated. Three sets of measurements were made, then the models were trimmed so that the occlusal surface was parallel with the base. The posterior surface was trimmed perpendicular to both of these surfaces and brought forward to a point on the first molars.

A paper template was made of the cross-sectional area of the palate and three additional measurements were obtained from it. The validity of these measurements was previously determined by a test and retest method and subsequent P-value determination of the results.

Means and standard deviations were computed for all measurements and the student's t-test was used to compare the significance of measurements between the two groups. No significant difference was found. A general linear hypothesis was run due to the variability between the two groups of some of the pre-treatment measurements. An F-value of 1.4 showed that this variability did not affect the final results.

The conclusion reached was that there is no significant difference in palatal cross-sectional area between the group treated with the acrylic-reinforced appliance and the group treated with the acrylic-free appliance.

Clinically, due in part to the findings of this study, the acrylic-free appliance appears to be the appliance of choice. First, even though most patients tolerate the acrylic adequately, necrosis of both hard and soft tissues can occur and in some cases mild to severe infections require removal of the appliance to allow healing. These effects can be eliminated and still gain an apparently equal result. Second, it is possible that with only the wires of the acrylic-free appliance present, better oral hygiene might be maintained, and third, the ease of fabrication of the acrylic-free appliance is a consideration.

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APPENDICES

LEGENDS

Figure 1. Schematic drawing showing the point to which the posterior surface was trimmed, the cross-sectional area through the first molars, and the measurements made from the template.

Figure 2. The acrylic-reinforced rapid palatal expansion appliance used in this study.

Figure 3. The acrylic-free rapid palatal expansion appliance used in this study.

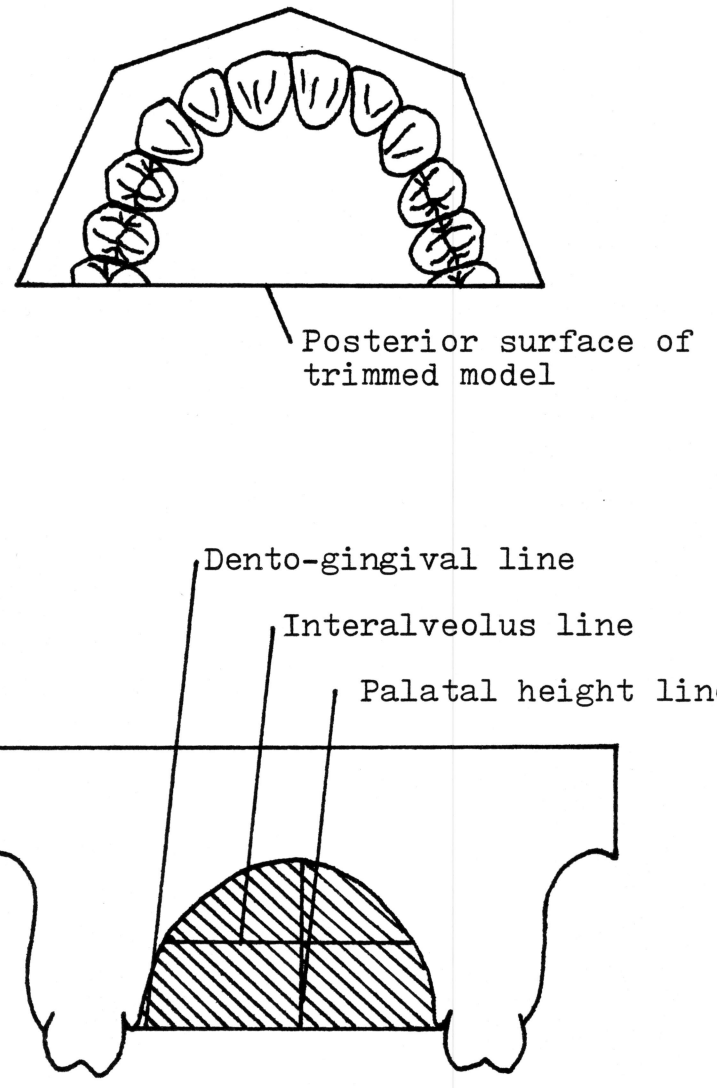
Posterior surface of
trimmed model
Dento-gingival line
Interalveolus line
Palatal height line

Figure 1.

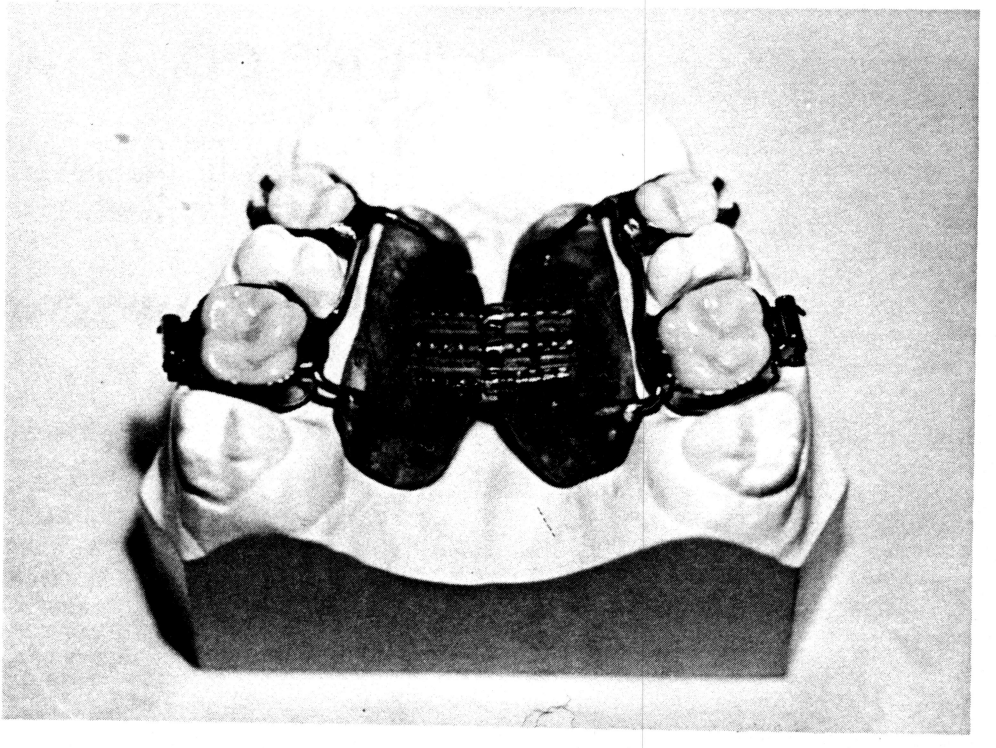

Figure 2.

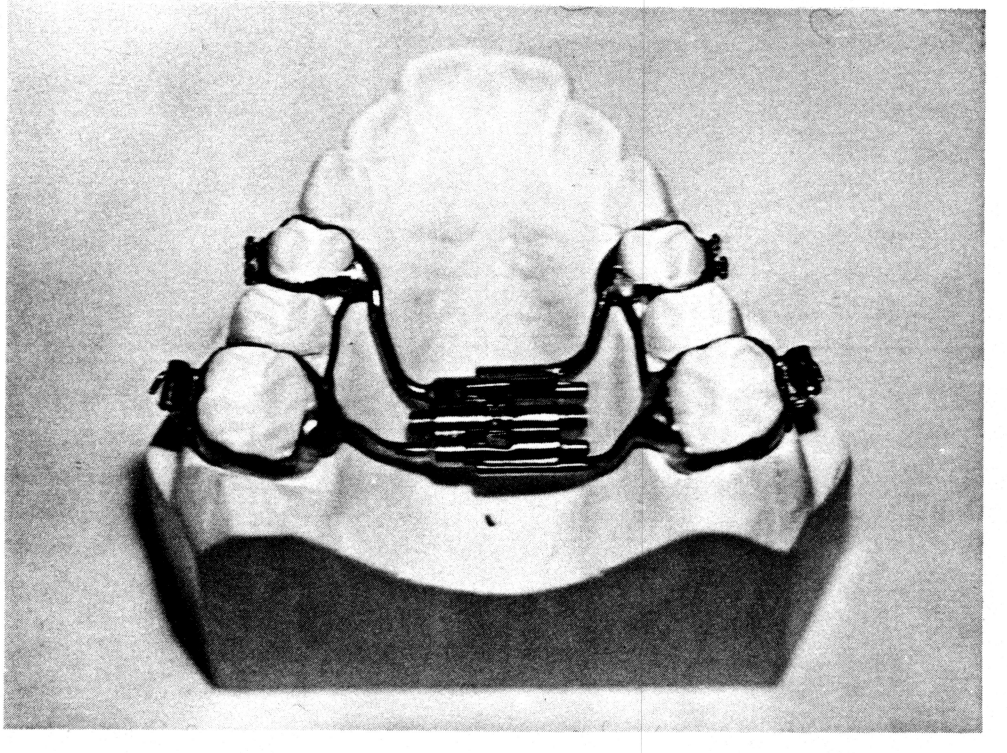

Figure 3.

LIST OF TABLES

Variable	GROUP I* Mean and S.D.	GROUP II Mean and S.D.
Pre-intermolar distance	28.020 ± 2.447	30.280 ± 2.720
Post-intermolar distance	33.580 ± 2.503	36.000 ± 2.673
Pre-interalveolus distance	19.260 ± 2.916	19.980 ± 3.277
Post-interalveolus distance	22.620 ± 2.559	23.900 ± 2.919
Pre-cusp tip to gingiva (right)	6.380 ± 0.711	6.240 ± 0.631
Post-cusp tip to gingiva (right)	6.140 ± 0.654	6.280 ± 0.630
Pre-cusp tip to gingiva (left)	6.300 ± 0.661	6.340 ± 0.590
Post-cusp tip to gingiva (left)	6.020 ± 0.757	6.260 ± 0.597
Pre-palatal height	15.400 ± 1.850	14.100 ± 2.420
Post-palatal height	16.500 ± 1.730	15.200 ± 2.400
Pre-template weight (mg.)	48.988 ± 9.018	45.644 ± 9.493
Post-template weight (mg.)	62.128 ± 8.204	58.804 ± 9.581

Table 1.

* Group I was treated with the acrylic-free appliance

Variable	GROUP I Mean and S.D.	GROUP II Mean and S.D.
Intermolar difference	5.560 ± 1.277	5.720 ± 2.047
Interalveolus difference	3.360 ± 2.334	3.920 ± 2.040
Cusp tip to gingiva diff. (right)	-0.240 ± 0.436	0.040 ± 0.611
Cusp tip to gingiva diff. (left)	-0.280 ± 0.647	-0.080 ± 0.400
Palatal height difference	1.100 ± 1.400	1.100 ± 1.030
Template difference*	13.140 ± 7.606	13.160 ± 5.818

Table 2.

* One square centimeter of template material weighed 10.7 mg.

			Pooled variance est.			Separate variance est.		
Variable	F value	2-tail prob.	T value	df	2-tail prob.	T value	df	2-tail prob.
Intermolar difference	2.57	0.025	-0.33	48	0.742	-0.33	40.23	0.74
Interalveolus difference	1.31	0.514	-0.90	48	0.371	-0.90	47.15	0.37
Cusp tip to gingiva diff.(right)	1.96	0.105	-1.87	48	0.068	-1.87	43.40	0.06
Cusp tip to gingiva diff.(left)	2.61	0.022	-1.31	48	0.195	-1.31	40.02	0.19
Template difference	1.71	0.196	-0.01	48	0.992	-0.01	44.92	0.99

Table 3.

	dw	Difference for weight
by	treat	Treatment group
with	prmd	Pre molar dist
	prw	Pre weight
	dmd	Difference for molar dist

Source of variation	sum of squares	df	mean square	F	signif of F
Covariates	790.050	3	263.350	8.401	0.000
prmd	55.006	1	55.006	1.755	0.192
prw	183.992	1	183.992	5.869	0.019
dmd	394.516	1	394.516	12.585	0.001
Main effects	43.940	1	43.940	1.402	0.243
treat	43.940	1	43.940	1.402	0.243
Explained	790.055	4	197.514	6.301	0.000
Residual	1410.690	45	31.349		
Total	2200.745	49	44.913		

Table 4.

Due to	df	ss	ms=ss/df	F-ratio
Factor	5	10.95	2.19	1.02
Error	15	32.26	2.15	
Total	20	43.21		

Table 5.