ORIGINAL ARTICLE

Comparison of skeletal and dental changes between 2-point and 4-point rapid palatal expanders

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Rapid palatal expansion has been a clinically accepted technique used by orthodontists for over 100 years. Its primary goal is to maximize orthopedic and minimize orthodontic movements of teeth. Historically, this was best accomplished by including 4 teeth in the appliance. However, including more teeth makes construction and insertion more difficult. The appliance also is less comfortable for patients and hinders oral hygiene. The 4-point hyrax expander can be modified by removing the 2 anterior wires, creating a 2-point expander between the first molars only. The purpose of this study was to determine the difference, if any, between midpalatal suture separation and dental expansion produced between 2-point and 4-point palatal expanders. Thirty subjects between the ages of 6 and 16 years were randomly assigned to either the 2-point (n = 15) or the 4-point group (n = 15). The groups were compared on dental and radiographic landmarks. The groups showed no statistical differences in total molar cusp width, molar gingival width, canine cusp width, canine gingival width, or diastema width. There were slight differences in arch perimeter and midpalatal suture separation. The results of this study showed that the 2-point appliance produced similar effects on the midpalatal suture and the dentition as did the 4-point appliance. It might therefore be considered instead of the 4-point appliance to successfully produce adequate skeletal and dental expansion. (Am J Orthod Dentofacial Orthop 2003;123:321-8)

Rapid palatal expansion therapy results in physical separation of the bony palate and the premaxilla, because these structures develop bilaterally and unite at medial sutures. Although expansion therapy has been used by orthodontists for well over 100 years, its popularity increased dramatically in the early 20th century because of the belief that it improved nasal breathing and general vitality. Its popularity waned with the advent of extraction-oriented treatment plans in the United States at midcentury.

More recently, a resurgence of interest in palatal expansion has developed as orthodontists seek more dentally conservative treatments that try to limit dental extraction if possible.

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Palatal expansion is usually performed during the deciduous or mixed dentition to correct crossbites or expand arch perimeters to alleviate dental crowding. Rapid palatal expansion seeks to coordinate maxillary and mandibular dentoalveolar bases by maximizing orthopedic jaw movement while minimizing orthodontic tooth movement. This has been accomplished historically by including as many teeth as possible in the expansion appliance.

However, including more teeth in the apparatus makes construction and insertion more difficult. The appliance can also be less comfortable for patients and hinder oral hygiene. The 4-point hyrax expander, banded to the maxillary first molars and first premolars, can be modified by removing the 2 anterior wires and bands, creating a 2-point expander including only the first molars. Two-point expanders are easier to construct, less expensive, and easier to insert than 4-point expanders. Two-point expanders are also more comfortable and easier to clean, and do not impair speech as much, thus enhancing patient compliance. The purpose of this study was to determine the difference, if any, between midpalatal suture separation and dental arch perimeter expansion produced by expanders that contain 2 anchor teeth rather than 4 teeth.

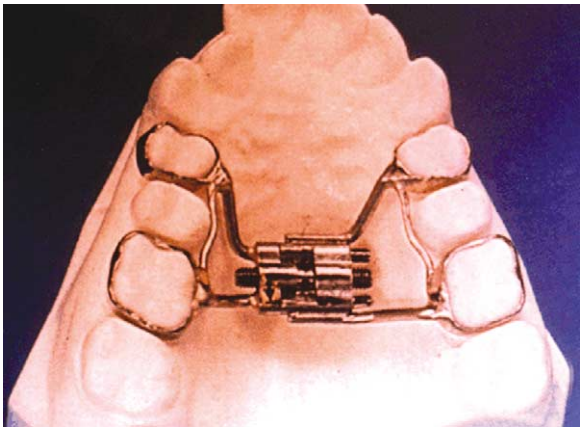

Fig 1. Four-point appliance.

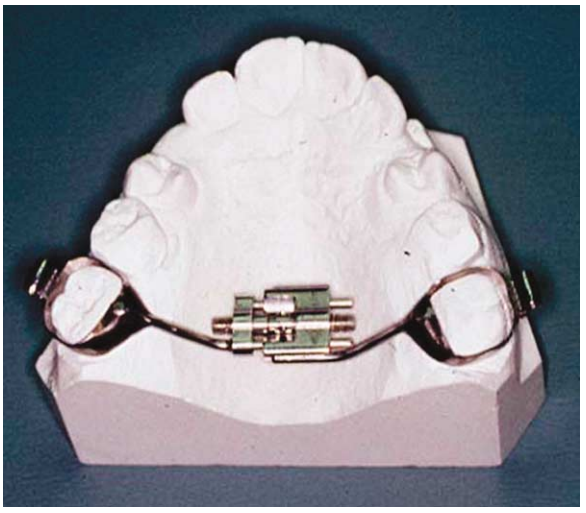

Fig 2. Two-point appliance.

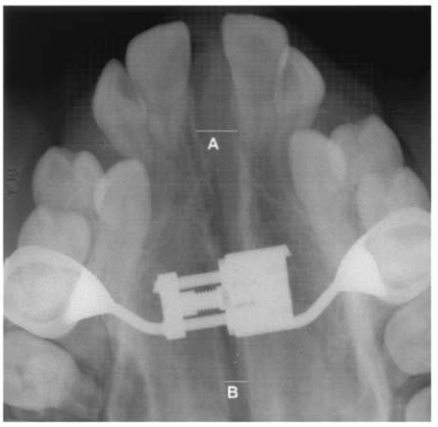

Fig 3. Radiographic measurement of expansion.

MATERIAL AND METHODS

This prospective study involved 30 white male and female patients, ranging in chronological age from 6.58 to 14.58 years (mean, 11.06 years), treated in a private practice by a board-certified orthodontist with 27 years of experience. The subjects were randomly assigned into either the 2-point group (n = 15) or the 4-point group (n = 15). All patients had maxillary first molars and either maxillary first premolars or deciduous first molars. Those with any systemic disease, dental pathology, or maxillary tori were excluded from study.

The 4-point expansion appliance (Fig 1) consisted of a hyrax expansion screw (3M Unitek, Monrovia, Calif) with bands cemented to the maxillary first permanent molars and either the maxillary first premolars or the maxillary deciduous first molars, representing a typical hyrax appliance in common clinical use. The 2-point expander (Fig 2) was banded only to the maxillary first permanent molars and had a similar jackscrew (a typical hyrax appliance with both anterior wires removed). Immediately before appliance insertion (T1), at the end of active expansion (T2), and immediately after removal of the appliance (T3), standardized occlusal radiographs and maxillary casts were taken, and appliance separation/expansion was measured with an electronic digital caliper that could measure accurately to a resolution of 0.01 mm (MAX-CAL Corp, Des Plaines, Ill).

For the radiographs, the patient's occlusal plane was positioned parallel to the floor, and the superior tip of the radiographic source cone was positioned to touch the subject's glabella in the same orientation for each exposure. The same radiographic technician, radiographic equipment, exposure settings (both kV[p] and mA), and film type were used for each trial. The radiographs were magnified to aid in measuring sutural expansion. To prevent magnification error, the occlusal radiograph was standardized by means of a wire grid consisting of 1-mm squares placed directly on the film (Fig 3). The length in millimeters of lines composing the 1-mm square grids was measured on the exposed film in the areas closely associated with measurement lines A and B (Fig 3) so that any magnification in that area could be corrected and the linear measurements adjusted accordingly.

At T1, an occlusal radiograph and dental impressions were taken. After insertion and cementation of the appliance, activation was started with 2 turns of the jackscrew. The patient's parent or guardian was instructed to turn the jackscrew 1 turn (0.25 mm) in the morning and again in the evening of each day of expansion treatment (2 turns, or 0.5 mm per day). The patient was examined weekly. When the lingual cusp

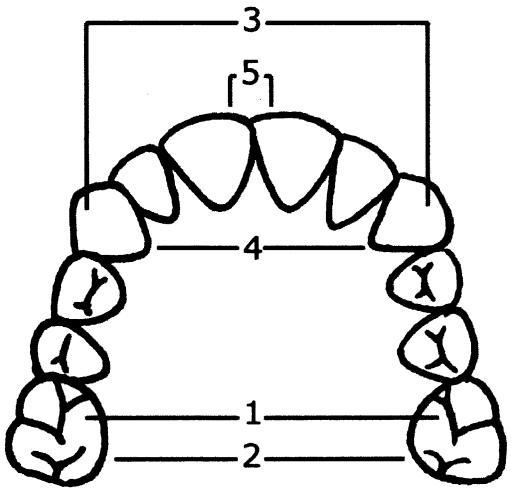

Fig 4. Arch width measurement.

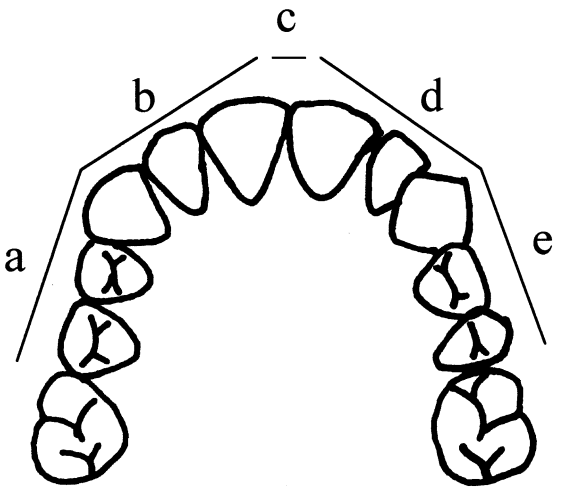

Fig 5. Arch perimeter measurement.

tips of the maxillary first permanent molars were in contact with the corresponding buccal cusp tips of the mandibular first permanent molars, expansion was terminated (T2). Then the screw was fixated by means of a steel ligature. Another occlusal radiograph and maxillary impression were taken, and the amount of appliance separation was measured. Expansion was retained with the appliance for 3 months. Then the appliance was removed (T3), and records were again taken.

The following linear measurements were made with a digital caliper:

1. Maxillary intermolar cusp width: the distance between mesiobuccal cusp tips of the maxillary permanent first molars (Fig 4, *line 1*)
2. Maxillary intermolar gingival width: the distance between the free gingival margins of the maxillary permanent first molars at their most lingual aspect (Fig 4, *line 2*)
3. Maxillary intercanine cusp width: the distance between cusp tips of the maxillary canines (Fig 4, *line 3*)
4. Maxillary intercanine gingival width: the distance between the free gingival margins of the maxillary canines at their most lingual aspect (Fig 4, *line 4*)
5. Maxillary diastema width: the distance between the mesial aspects of the maxillary permanent central incisors (Fig 4, *area 5*)
6. Arch perimeter: the maxillary arch perimeter as calculated from summing the following 5 measurements:
   - The mesial contact point of the left permanent first molar to the cusp tip of the left canine (Fig 5, *line a*)
   - The left canine cusp tip to the mesial contact point of the left central incisor (Fig 5, *line b*)
   - The space between mesial contact points of the central incisors (Fig 5, *area c*)
   - The mesial contact point of the right central incisor to the cusp tip of the right canine (Fig 5, *line d*)
   - The cusp tip of the right canine to the mesial contact point of the right first molar (Fig 5, *line e*)
7. Radiographic sutural expansion: separation of the suture was measured on the standardized occlusal radiograph at 2 points:
   - As far anterior where the margins of the suture could be identified (Fig 3, *line A*)
   - As far posterior where the margins of the suture could be identified (Fig 3, *line B*)
8. Magnification measurement: measurement of the standardization grid lines on the radiograph at 2 points:
   - Linear grid marks close to the line measured in Figure 3, *line A*
   - Linear grid marks near the line measured in Figure 3, *line B*

To determine interjudge and intrajudge reliability of measurements, 10 maxillary casts were measured by the primary investigator (D.G.L.) and by another orthodontic faculty member (D.J.R.) without reference to the primary investigator's initial digitization. These measurements were compared with the original data, and

Table. Total sample means and standard deviations in mm

Variable	*T1*	*T2*	*T3*
Molar cusp width	36.325 ± 3.169	42.754 ± 3.030	42.302 ± 2.926
Molar gingival width	29.112 ± 2.446	not measured	35.063 ± 2.230
Canine cusp width	29.725 ± 2.886	32.943 ± 2.913	32.759 ± 2.476
Canine gingival width	23.411 ± 3.247	26.637 ± 3.200	26.526 ± 2.914
Diastema width	0.719 ± 0.814	3.095 ± 1.447	not measured
Maxillary perimeter	73.526 ± 4.133	77.137 ± 4.224	76.157 ± 4.759
Screw separation	not measured	5.790 ± 1.141	not measured
Anterior suture separation	not measured	4.046 ± 1.115	not measured
Posterior suture separation	not measured	1.837 ± 1.000	not measured

Pearson product moment correlation coefficients and *t* tests were used to determine the degree of association between measurements. The correlation coefficients ranged from 0.637 to 0.998 for intrajudge reliability and −0.358 to 0.996 for interjudge reliability. None of the *t* tests for mean judge differences was statistically significant ($P > .05$). Reliability measurements were not done for measurement of sutural expansion on the radiographs; rather, the ability to measure each radiographic wire grid division as 1 ± 0.01 mm with the electronic digital caliper subsequent to suture measurements was our standard for reliability.

To determine intragroup and intergroup changes between pretreatment, posttreatment, and postretention measures for both groups, a 2 × 3 mulitvariate analysis of variance (MANOVA) (2-point and 4-point expanders × T1, T2, and T3) for a repeated measure design was used for molar cusp width, canine cusp width, canine gingival width, and maxillary perimeter. To determine intragroup and intergroup changes between pretreatment and posttreatment, a 2 × 3 analysis of variance (ANOVA) (2-point and 4-point expanders × T1 and T2) for repeated measures design was used for maxillary diastema. To determine intragroup changes between pretreatment and posttreatment and at anterior and posterior suture locations, a 2 × 2 ANOVA for a within-cases design was used. Post hoc tests were performed at the $P < .05$ level. These included tests for simple main effects and Fisher's least significant difference test.

RESULTS

The data were analyzed with a MANOVA for a mixed between-case and within-case design. The mean amount of appliance separation was 5.790 mm with a range of 4.490 to 8.620 mm (Table). Independent *t* tests were performed to determine whether any intergroup differences existed for age and appliance separation. No significant differences were found between the 2 groups in age ($P = .543$) or amount of appliance separation ($P = .356$).

Fifteen patients, 6 males and 9 females, were assigned to the 2-point expander group. Their mean age was 10.8 years with a range of 6.58 to 14.58 years. The mean amount of appliance separation was 5.986 mm with a range of 4.520 to 8.620 mm.

The 4-point expander group also consisted of 15 patients, 9 males and 6 females. Their mean age was 11.33 years, with a range of 7.75 to 13.92 years. The mean amount of appliance separation was 5.594 mm, with a range of 4.490 to 7.260 mm.

DISCUSSION

No significant differences in maxillary molar cusp width were found between the 2-point and the 4-point appliance ($P = .368$) (Fig 6). Because both appliances were attached directly to first molars, no differences were expected here. This agrees with the results of a similar study that found no significant difference in molar cusp separation between the 2 appliances.[4]

No significant differences were found in intermolar gingival width at either T1 or T3 (Fig 7). Measurements were not taken at T2 because orthodontic bands were still attached to the molars. As with molar cusp width, no differences were expected here because both appliances were attached directly to first molars ($P = .392$).

No significant difference was found between either molar cusp width or molar gingival width. Therefore, there was no difference between the appliances in molar tip caused by expansion. The overall molar cusp width increased 5.977 mm as measured at T3, and the gingival width increased 5.951 mm. The cusp width increased 0.026 mm more than the gingival width, meaning that the molars tipped slightly to the buccal (0.48% of width); this correlates with other studies.[5-7]

This buccal tipping was expected because of the response of the maxillary complex to expansion and dental tipping. The maxillary separation, when viewed

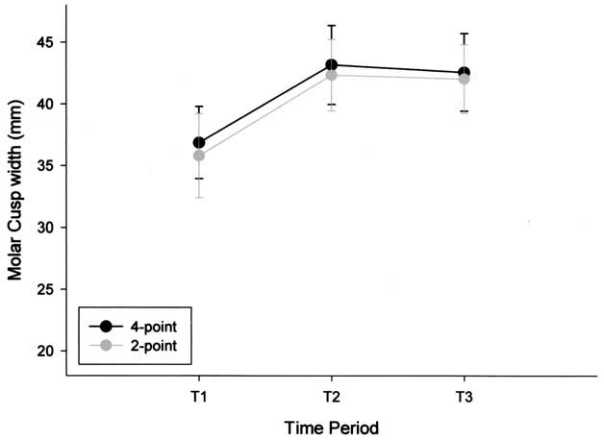

Fig 6. Molar cusp width separation.

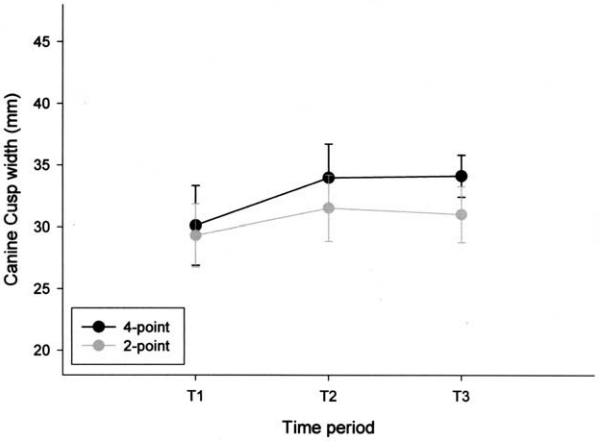

Fig 8. Canine cusp width separation.

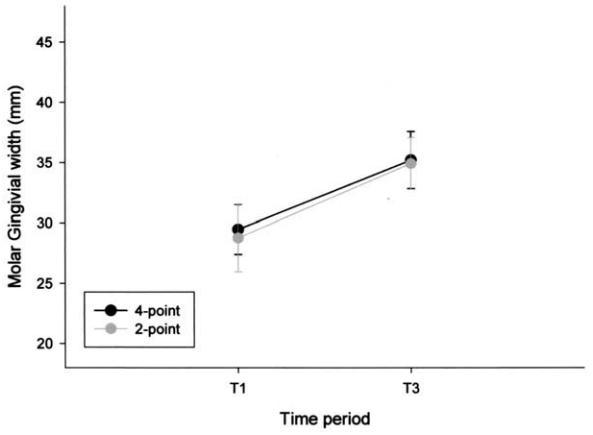

Fig 7. Molar gingival width separation.

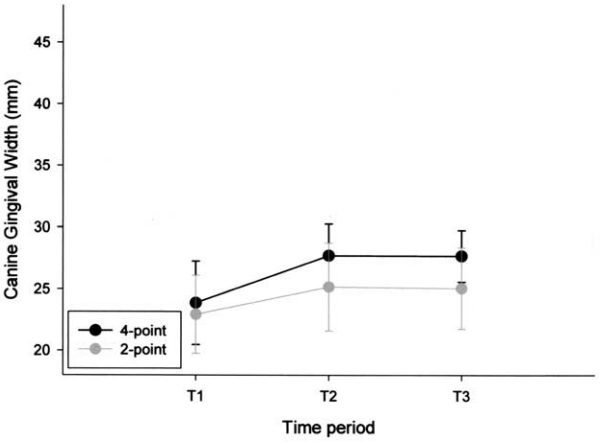

Fig 9. Canine gingival width separation.

from the frontal plane, is triangular, with its base adjacent to the oral cavity. Buccal tipping of the molar is explained by the configuration of skeletal separation.

Interestingly, Schneidman et al[4] found a difference in molar tip caused by expansion appliances. In that study, molars in the 2-point group tipped slightly to the lingual (0.5 mm), and those in the 4-point group tipped slightly to the buccal (0.3 mm). The authors attributed this to the possibility that the 2-point appliance had a different distribution of forces on the dentition and associated craniofacial sutures.

Canine cusp width between the appliances differed over time (Fig 8). Overall, the effect of the 2-point expander was not different from that of the 4-point expander ($P = .331$), but there was a significant difference in how the canine cusp width changed over time ($P = .002$).

Both the 2-point and the 4-point appliances had a significant amount of canine cusp separation (1.700 and 3.034 mm, respectively) between T1 and T3, but they achieved it by different ways. The 2-point appliance experienced a significant relapse ($P < .05$) between T2 and T3, but the 4-point appliance did not. This relapse, however, was not sufficient to determine that the 2-point appliance produced less total expansion than did the 4-point appliance ($P = .331$). It can therefore be concluded that the 2 appliances produced the same amount of expansion (Table), but the 2-point appliance displayed some relapse, while the 4-point did not. In other words, the 4-point appliance showed greater stability but no better treatment results. This was expected because the 4-point appliance had an anterior attachment that was beneficial for retention of the canines. The results from this study do not agree with the significantly greater amount of canine cusp separation that Schneidman et al[4] found in a study of 4-point versus 2-point appliances.

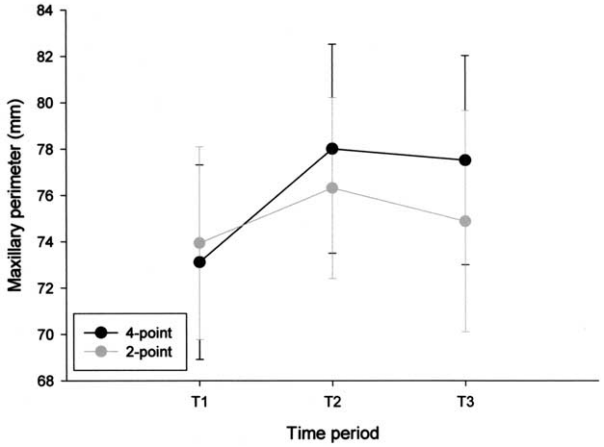

Fig 10. Maxillary perimeter expansion.

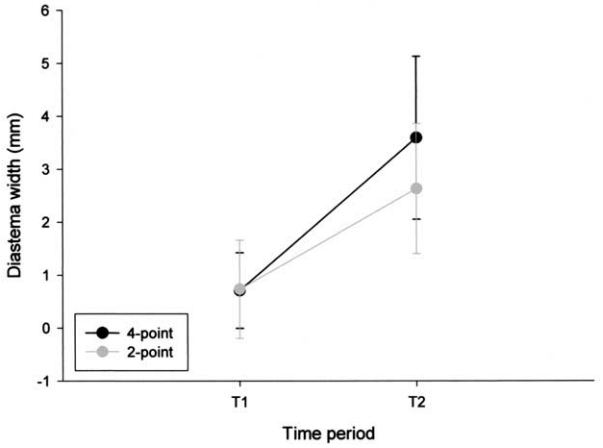

Fig 11. Diastema width.

Canine gingival width between the appliances differed over time (Fig 9). Overall, the effect of the 2-point expander was not different from that of the 4-point expander ($P = .346$), but there was a significant difference in how the canine gingival width changed over time ($P = .016$).

Both the 2-point and the 4-point appliances had a significant amount of canine gingival separation (2.134 and 3.812 mm, respectively) between T1 and T3. They both had nonsignificant amounts of relapse between T2 and T3 (-0.106 and -0.041 mm, respectively). This means that, although the 2 appliances did not produce a significantly different amount of total expansion, the amount of expansion produced by the 4-point appliance was greater over time than that by the 2-point appliance.

No difference in total expansion was found between either canine cusp width or canine gingival width. Therefore, there was no difference between the appliances in canine tip caused by expansion. The overall canine cusp width increased 3.034 mm, and the gingival width increased 3.115 mm, demonstrating that the canines tipped slightly to the lingual (0.081 mm, or 2.6% of width). Previous studies showed that canine tip in response to expansion is variable, tipping either buccally or lingually.[8-10]

Similar to the molar, buccal tipping of the canine was expected because of the configuration of sutural separation. However, average tipping was only 0.081 mm, an amount that could not be detected clinically. Perhaps perioral musculature or other physiologic forces prevented the canines from tipping toward the buccal. The fact that the molars showed slight buccal tipping, as expected, and the canines did not might be explained by the molars' rigid attachment to the appliance, thus preventing the perioral musculature and other physiologic forces from acting upon them.

Both appliances had a significant ($P < .001$) amount of maxillary perimeter increase between T1 and T2 (Fig 10). However, the 2-point appliance showed a marked relapse that resulted overall in a nonsignificant increase of 0.946 mm between T1 and T3 ($P > .05$). The 4-point appliance showed a relapse of only -0.493 mm. The 2-point appliance relapsed so much that the final expansion at T3 was not significantly different from T1. Therefore, the 4-point appliance did gain a statistically significant ($P < .001$) increase in arch perimeter at the end of this study, but the 2-point appliance did not. A basic difference in the appliances was that the 4-point is better at retention, although both are adequate for expansion. The increase for the 4-point appliance in this study agrees with the literature.[11,12] This study noted a statistically significant perimeter difference between appliances. No other investigations of 2-point expanders studied their effect on arch perimeter.

The 2-point and 4-point appliances produced significant ($P < .001$) increases (1.9 and 2.885 mm, respectively) in maxillary diastema width between T1 and T2 (Fig 11). Although the 4-point appliance created more expansion than did the 2-point appliance (2.885 vs 1.9 mm), there was no statistically significant difference between them ($P = .201$). On average, the 2 expanders did not differ, but the 4-point increased diastema width more from T1 to T2 than did the 2-point ($P = .029$).

The increase in diastema width agrees with previous studies.[5,9,13] Although diastema width was used in this study, it was probably not a reliable measure of sutural expansion. Several variables can influence the

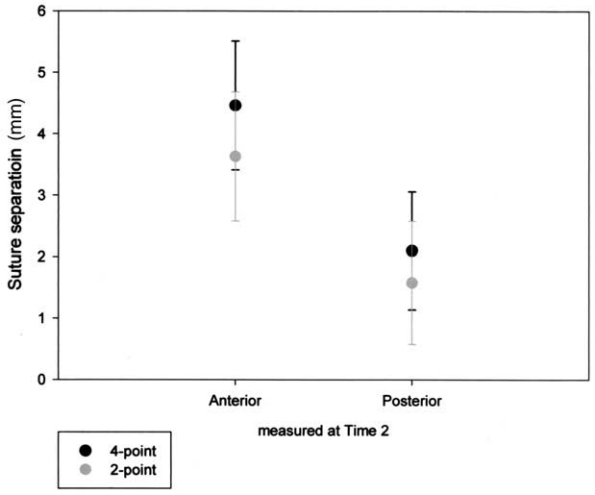

Fig 12. Anterior and posterior suture separation.

amount of diastema separation, including strength of transeptal fibers, frenum attachment, eruption status of lateral incisors, tongue posture, perioral musculature, and functional habits.[9,13,14] None of these factors was considered in this study. Diastema separation was included only to obtain an overall sense of any differences between the appliances.

There were statistically significant differences in the amount of midpalatal suture separation between the appliances (Fig 12). The anterior suture separation averaged 3.630 mm for the 2-point appliance and 4.462 mm for the 4-point appliance. The 4-point was significantly better ($P < .004$) at separation, probably because of its anterior attachment, which enables the appliance to exert more force to the anterior part of the suture than the 2-point appliance.

The 2 appliances were also significantly different in posterior palatal expansion ($P < .004$) (Fig 12). It would seem that the 2-point appliance should affect the posterior suture to a greater degree than the 4-point appliance. The fact that its expansion force is concentrated at the molars rather than spread out between the molars and the anterior attachment supports this view. However, the 4-point obtained greater separation. Its additional anterior attachment is probably more efficient at total suture separation by applying force over a greater area of the suture.

The overall configuration of suture separation—triangular with its base in the anterior portion of the suture—agrees with previous studies.[3,4,7,8] This is most likely due to the buttressing effect of other structures in the posterior region of the maxilla.[3] Both appliances affected the suture in the same way; neither appliance was better at either anterior or posterior separation. There was no difference in the ratio of anterior to posterior separation for the appliances. This is evidence that the 2-point appliance can successfully produce sutural separation similar to the 4-point appliance. There is a statistically significant difference in total suture separation between the appliances, about 16%; however, it amounts to only about 0.9 mm clinically. The 2-point appliance might be considered a valid method of producing sutural separation. Standard measurements of palatal expansion were first conducted during the era when metallic implants were used to determine patterns of craniofacial growth and effects of orthodontic treatment.[15,16] As with our results, these reports agree that it is possible to expand the anterior sutural areas more than the posterior areas. Our study, however, is the first attempt at studying the magnitude of suture separation from standardized occlusal radiographs while comparing 2 types of palatal expanders. No data from other studies are available for comparison.

Future research is needed to compare the effects of the 2-point and 4-point appliances several months or years after treatment. Perhaps the 4-point group will experience relapse in some of the same variables as did the 2-point group after removal. The appliances should be compared on both orthodontic and orthopedic factors. Also, further study is needed to assess whether they produce different effects on periodontal and pulpal structures. Differences between these appliances should also be studied on patients in the deciduous dentition, and differences in response between boys and girls should be investigated.

CONCLUSIONS

Based on the data and the statistical interpretation used in this study, the following conclusions were drawn:

1. The 4-point appliance produced more anterior and posterior suture separation than did the 2-point appliance for a given activation.
2. Both appliances affected the midpalatal suture in the same way. The differences in suture separation between the appliances were the same in the anterior and the posterior. In other words, the type of separation of the 2 appliances was not different.
3. There were no differences between the appliances in either molar cusp or molar gingival width. The molars in both appliance groups tipped an average of 0.5% of width increase.
4. There was no difference in the total amount of canine cusp separation between the appliances. The

canines in both groups tipped lingually an average of 2.6% of width increase.

5. There was no difference in total amount of canine gingival separation between the appliances; however, the 4-point's expansion was statistically more significant.
6. Although the 4-point appliance created more expansion than did the 2-point appliance, there were no statistically significant differences between them.
7. The 4-point appliance produced an overall increase in maxillary perimeter, whereas the result from the 2-point appliance experienced so much relapse that there was no statistically significant increase in perimeter.
8. Overall, the main difference was that the 4-point appliance is better at retaining the changes during the initial expansion phase of treatment.
9. The 2-point expander produced somewhat similar effects on the midpalatal suture and the dentition as did the 4-point appliance. It can therefore be used to successfully produce adequate skeletal and dental expansion.

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