The Effect of Mandibular Plane Angle on Space Loss Following Premature Loss of a Primary Molar.

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CERTIFICATE OF APPROVAL

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Introduction

Even in the year 2007 dental decay is the most common childhood disease. Carious teeth can lead to abscess development and the need for tooth extraction prior to the age of normal exfoliation. In an ideal situation, following the extraction a space maintainer is placed immediately or shortly after the procedure. However, this does not always occur. Without a space maintainer the adjacent teeth would be expected to drift into the open space. Although space loss occurs in many instances, there are also patients in which a significant amount of tooth movement does not occur. Why do some children loose space following a premature primary molar extraction, while others do not? The purpose of this research is to evaluate if an individual's mandibular plane angle has an association with the propensity to loose or maintain space following the premature loss of a primary molar. This was accomplished via evaluation of cephalometric radiographs and initial study casts from orthodontic patients at Oregon Health and Science University.

Background/Review of Literature

In 1951, Breakspear wrote a paper about the sequelae of the early loss of deciduous molars. In his paper he stated that a "well built child" may not ever loose space or require a space maintainer, whereas a "weedy child" may loose the critical amount of space present very quickly.[1] Since 1951 there has been much research in the areas of occlusion, early loss of primary teeth, and space loss, yet today we still do not have better predictors factors to determine which child may lose space and which child will not. Most dental practitioners would agree that the premature loss of a primary molar is not a benign situation. Premature loss of a primary molar can result in deepening of the bite, midline displacement, cross-bites, crowding, impaired canine eruption, impaction of permanent predecessor, and arch asymmetries.[2,3,4] Although much individual variation exists, general patterns of space loss have been determined. Research by Northway and Cuoghi has demonstrated that space loss begins immediately following the premature loss of a tooth, with about 75% of the space loss occurring in the first six months following the loss.[5,6] Space loss in the maxilla differs from that in the mandible. In general, extractions in the maxilla result in significantly more space loss than extractions in the mandibular arch and is a result of rotation of the permanent first molar and a mesial drift of the permanent first molar and/or primary second molar.[5] There is also data that indicates that regaining of space can occur during the growth and development of the occlusion with a prematurely lost primary maxillary first molar, a phenomenon that does not occur in the mandibular arch. The source of mandibular space loss appears to arise from both mesial migration of posterior teeth and the distal migration of the anterior teeth.[5] The majority of mandible space loss is a result of distal movement of the primary cuspid.[2] Since space loss patterns differ between arches, this study will focus on the changes that occur only in the mandibular arch. A confounding element concerning the early loss of a primary molar, that Breakspear so colorfully noted, is that space loss does not always occur. Brauer studied the incidence of space closure following the premature extraction of primary molars. In his results he observed that 36% of the cases with a premature extraction of the first primary molar and 62% of the cases with a premature extraction of the second primary molar resulted in space closure and malocclusion as a result.[7] Thus, 64% of first primary molar and 38% of second primary molar extractions did not have space closure or an amount of space closure great enough to significantly affect the occlusion. What was different between these subjects that would account for space loss in some but arch stability in others?

The developing occlusion is a complex system. As noted by Cuoghi, "there are lots of morphogenetic and environmental influences which manage the occlusal development and a disorder in any of these elements may influence the occlusion."[6] One factor that plays an important role in the development of occlusion, and hence space loss, is the growth rotation of the condyle. Björk stated that it "is essential to take into consideration that the rotation of the jaws during growth exerts an influence on the path of eruption of the teeth and hence on the occlusion and tooth spacing."[8] Variations in the amount of rotation of the jaws during grow will dictate the degree of compensatory tooth adaptation during eruption.[8] Different facial types (a result of the extent and type of condylar rotation) result in different compensatory mechanisms for the erupting dentition. These compensatory changes in the path of eruption of the teeth occur to even out positional changes between the jaws so that the teeth will occlude in a homeostatic way.[8] According to Björk, in subjects with condylar growth associated with the extreme vertical growth pattern, resulting in a flat mandibular plane angle, the mandibular anterior and posterior teeth have primarily a mesial direction of eruption. In subjects with condylar growth associated with a mean vertical growth pattern, resulting in an average mandibular plane angle, the mandibular anterior and posterior teeth have a primarily vertical direction of eruption. In subjects with condylar growth associated with an extreme sagittal pattern of growth, resulting in a steep mandibular plane angle, the anterior teeth would have a distal direction of eruption while the posterior teeth would have a primarily vertical direction of eruption.[9] According to Björk, the extreme sagittal growth pattern is a pattern of growth that encourages the distal movement of the canines.[8] Knowing that the major cause of space loss in the mandible is a result of distal movement of the canine, one would then suspect that if there is already a tendency for distal movement of the canine, removal of the distal stop, the primary molars, would result in a more exacerbated loss of space than in an individual who had condylar growth resulting in a flat or average mandibular plane.

The purpose of this study is to determine if the mandibular plane angle has an impact on a patient's tendency to maintain or lose space following the premature loss of a primary molar or in the presence of a missing or impacted second premolar. The null hypothesis is that children who have a steep mandibular plane angle are no more likely to lose space following a premature loss of a primary molar than an individual with an average or flat mandibular plane angle.

Materials and Methods

The research was completed at Oregon Health and Science University. The pretreatment (initial records) casts from current and past orthodontic cases present in the on campus storage facility were utilized. Inclusion criteria included: unilateral loss of a primary mandibular molar or a unilaterally missing or impacted mandibular second premolar. No extractions of primary or permanent molars on the contralateral side were permitted, as this side will serve as the control. If an impacted premolar was the experimental condition, the antagonistic premolar had to be present and erupted into occlusion. Other inclusion criteria include: between 6 to 17 years of age, the presence of a dental chart with radiographs verifying the premature loss of primary mandibular molar or missing or impacted second mandibular premolar and a cephalometric film associated with the initial orthodontic records.

Premature loss was defined by Breakspear as "the loss of one or two primary teeth on one side of the mouth while the corresponding teeth on the opposite side of the mouth were retained." [1] For the purpose of this research a similar definition was utilized. A prematurely lost tooth was defined as a tooth that is not present in the arch while the contralateral tooth is still present with at least ¼ of the root remaining, and/or bone still present over the developing permanent tooth below the missing tooth. This was determined via bitewing or panoramic radiograph analysis. This procedure was completed in order to verify that the situation present on the cast did not simply represent the normal exfoliation process. Cases that met these criteria were selected.

3,844 models were evaluated. Based solely on cast evaluation, 55 possible cases were identified. The associated orthodontic records for these patients were accessed to determine if the space was a result of normal exfoliation and that the subjects met the additional inclusion criteria. Twelve cases were eliminated because the chart was not able to be located. Eight cases were eliminated because there were no bitewing radiographs or a panoramic film to verify premature tooth loss or impaction. Six cases were eliminated because the radiographs demonstrate that normal exfoliation had occurred. One case was eliminated because no cephalometric film was present. One case was eliminated because the subject was out of the age range. Four additional cases were eliminated because bilateral loss was present and hence no true control existed. A total of 23 patients were included in the study. The initial record casts with the prematurely lost tooth were marked with a sticker on the base of the model for easy identification by the researchers.

As in the research done by Lin et. al and Northway, et al. regarding unilateral space loss, measurement of the D/E space was used to obtain data for this paper.[2,5] For the purpose of this study the D/E space was defined as the distance between the most mesial point of the mandibular permanent first molar to the most distal midpoint of the primary or permanent canine.(Figures 1,2,3 and 4) In the absence of a fully erupted permanent canine and exfoliated primary canines, the most distal point of the lateral incisor was used as the reference point. (Figures 5 and 6) The D/E space of the side with intact primary molars was used as a control.

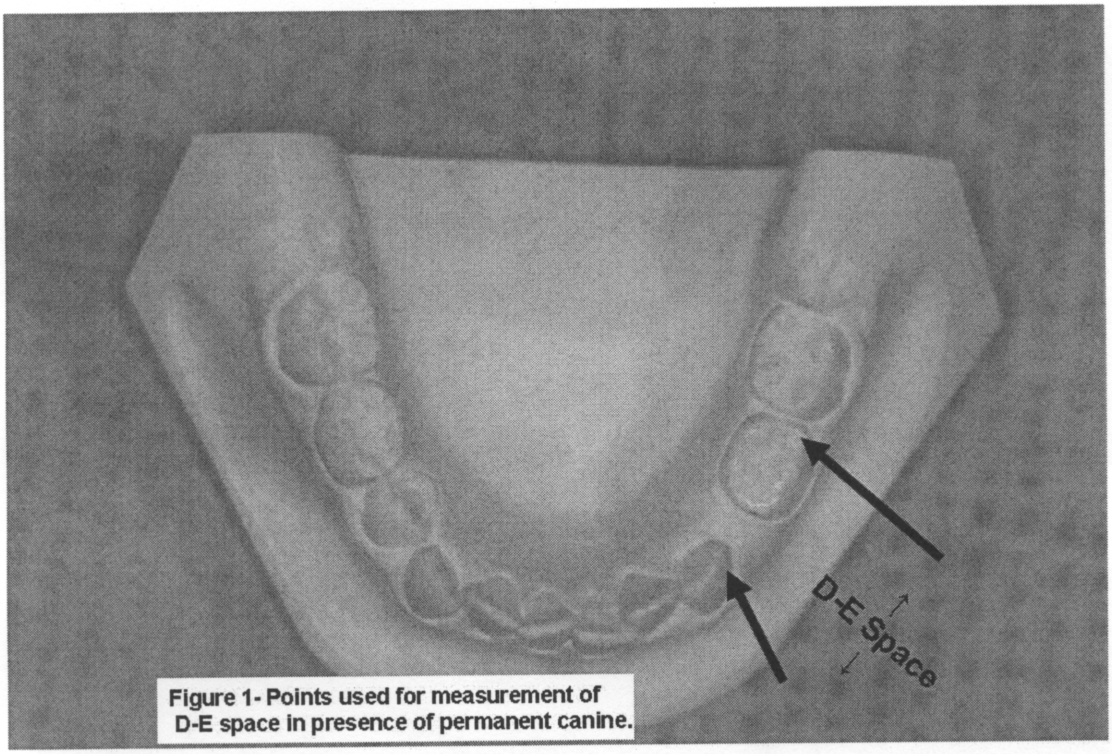


Figure 1- Points used for measurement of D-E space in presence of permanent canine.

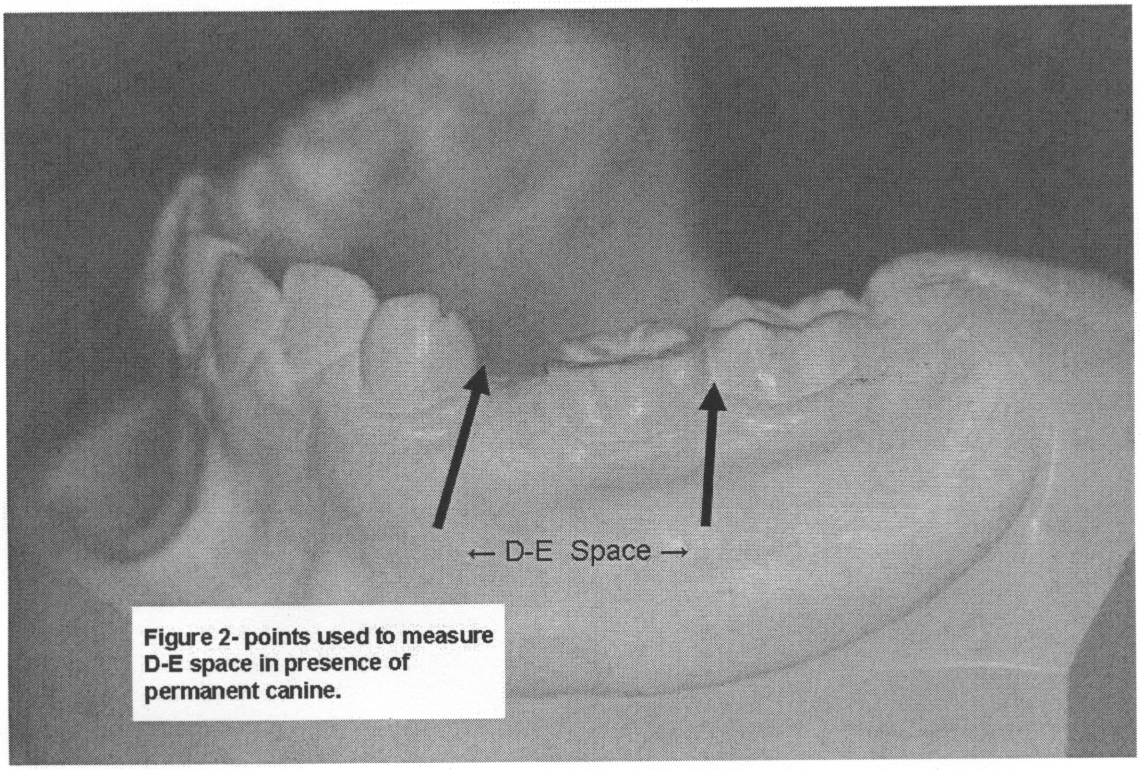


Figure 2- points used to measure D-E space in presence of permanent canine.

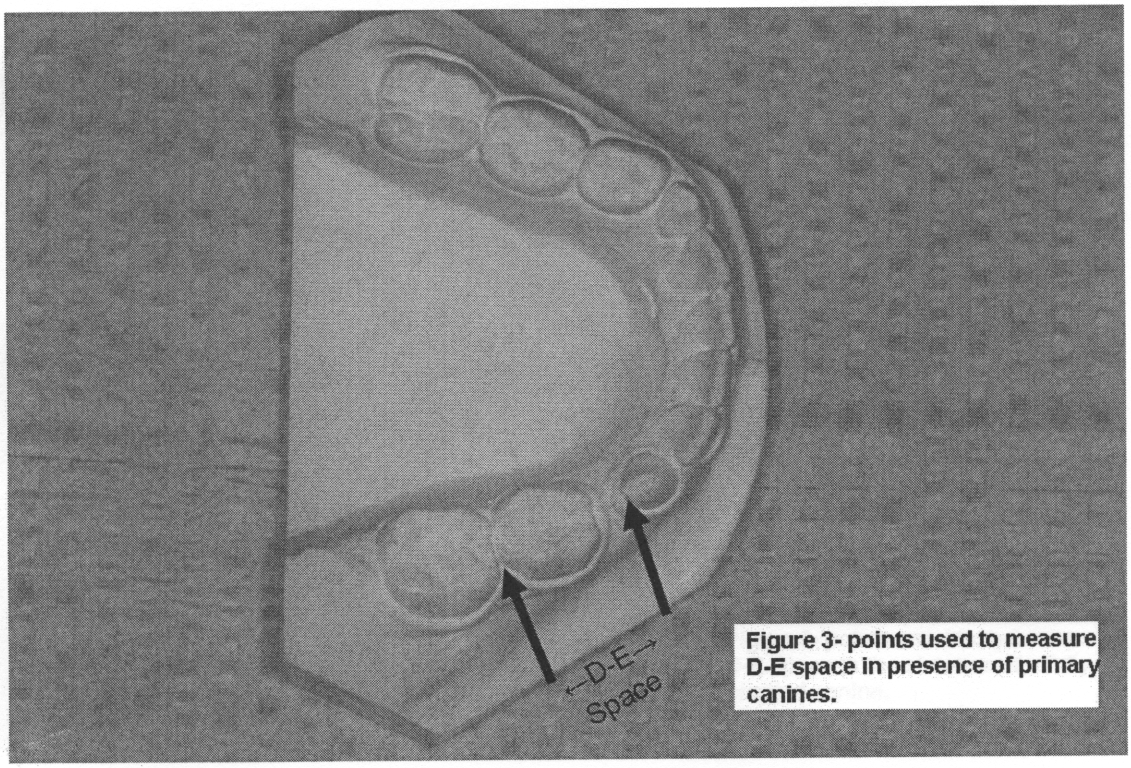


Figure 3- points used to measure D-E space in presence of primary canines.

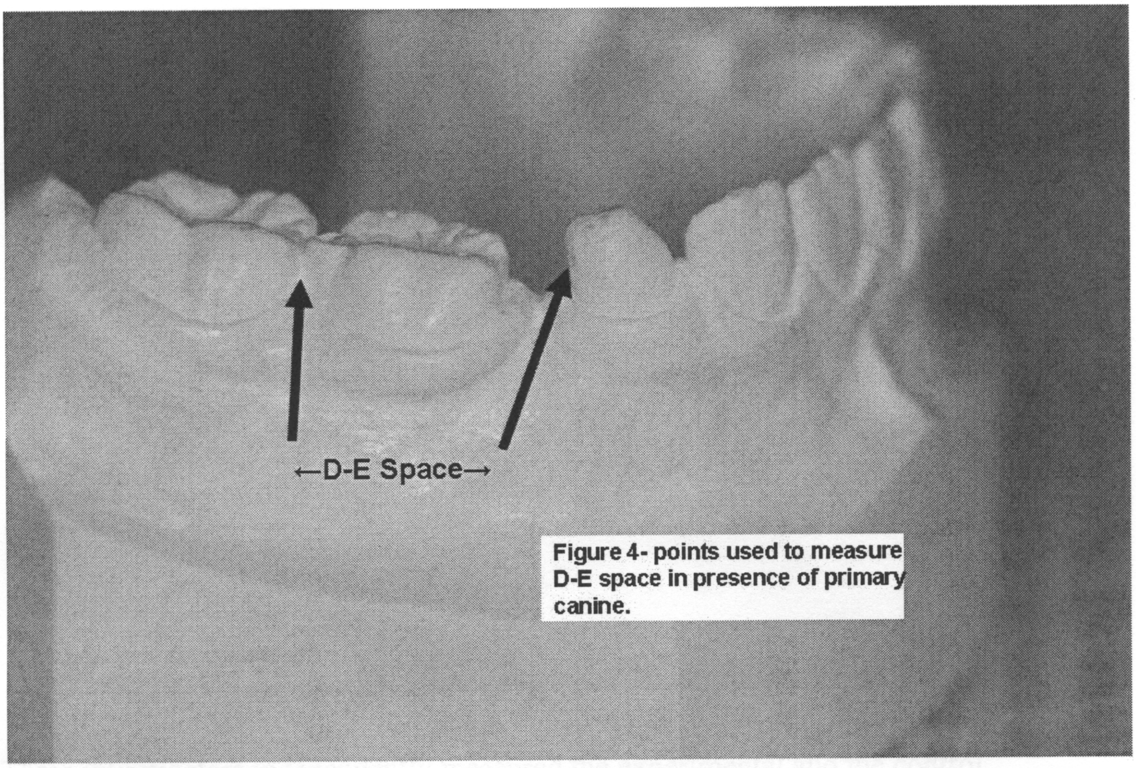


Figure 4- points used to measure D-E space in presence of primary canine.

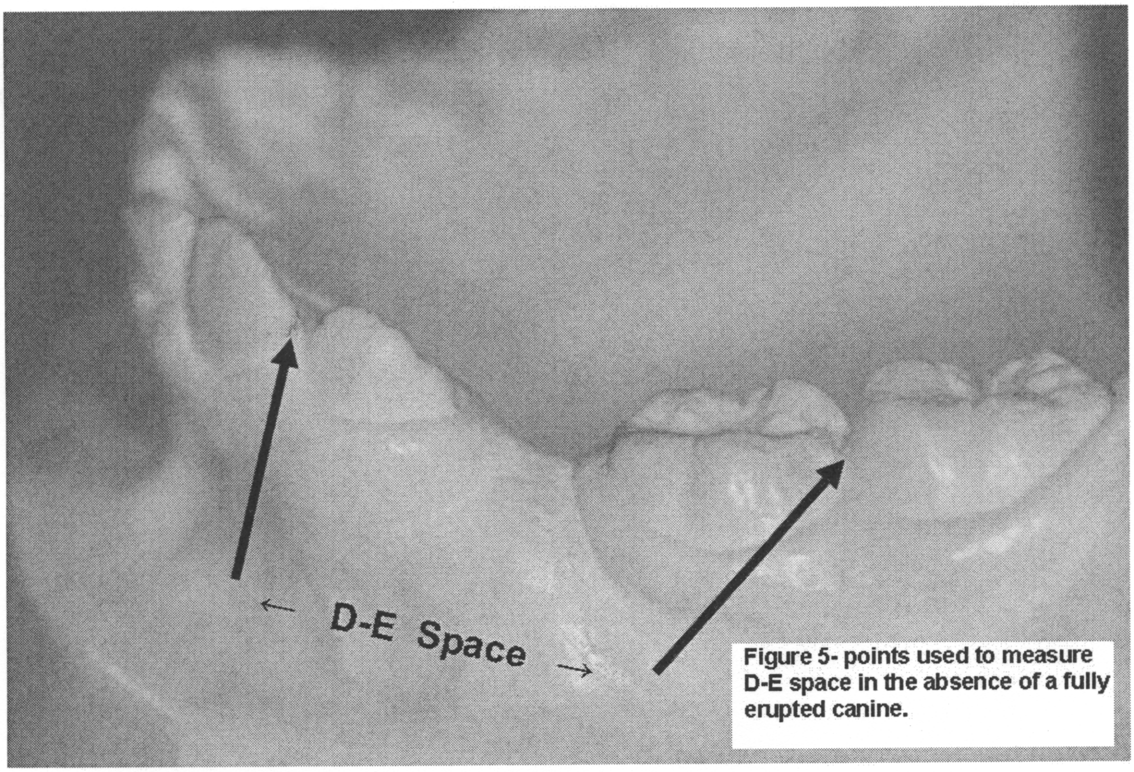


Figure 5- points used to measure D-E space in the absence of a fully erupted canine.

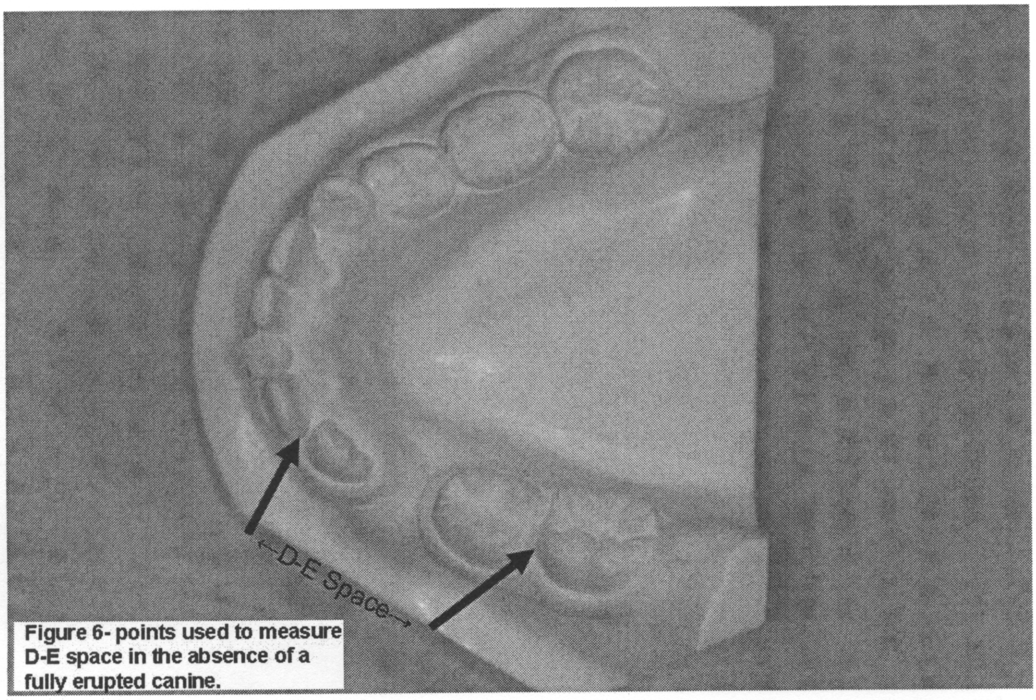


Figure 6- points used to measure D-E space in the absence of a fully erupted canine.

Three investigators independently measured the experimental and the control sides of each cast with an electronic caliper placed at the reference points indicated via access through the interproximal embrasures on the facial side of the teeth (Figures 8 and 9). Each investigator was also required to me asure the D/E space of five casts, without knowledge or their original measurements in order to evaluate rater reliability.

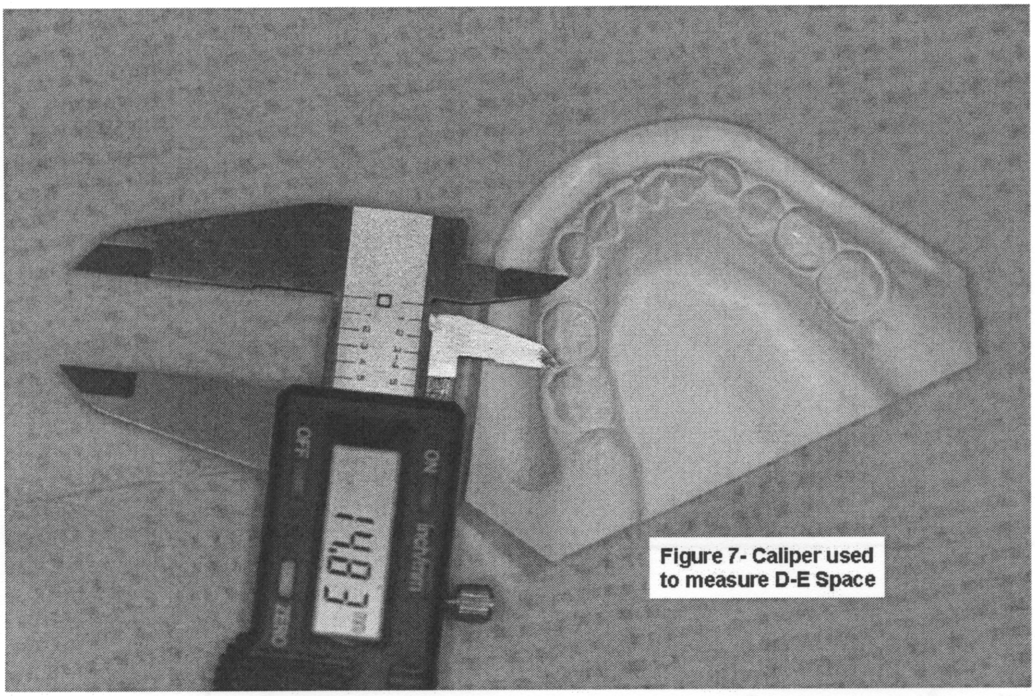


Figure 7- Caliper used to measure D-E Space

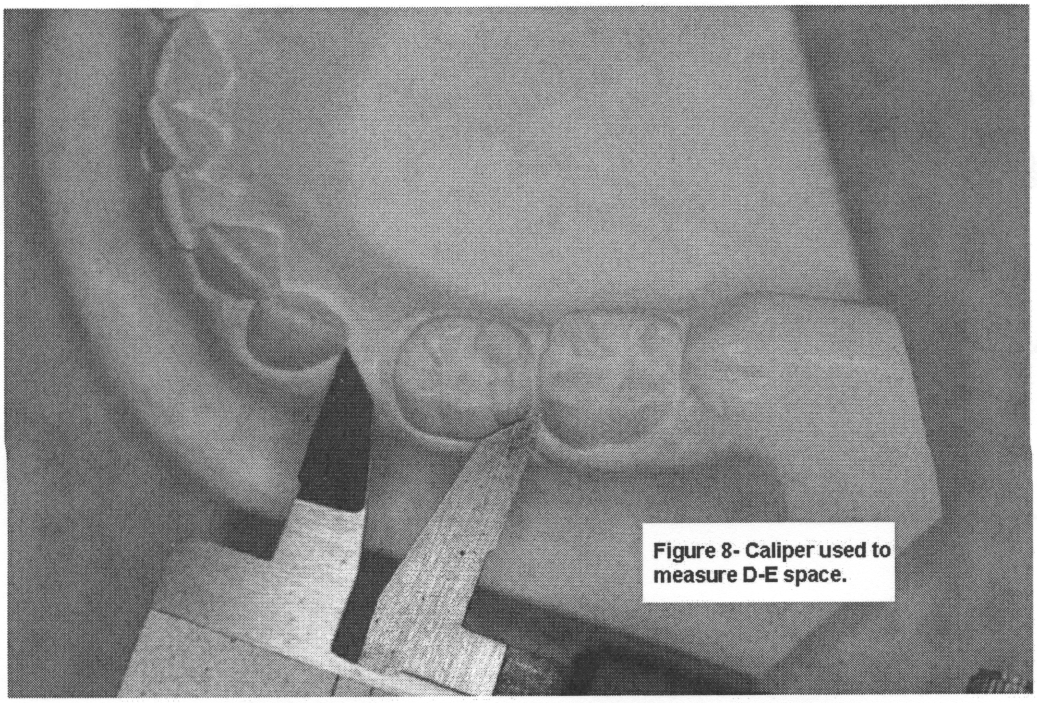


Figure 8- Caliper used to measure D-E space.

An average of the three readings was the final value used for analysis.

Siriwat conducted an epidemiologic study in 1985 regarding the relationship of malocclusion and facial morphology. He determined that the mandibular plane angle is an excellent indicator of facial type, thus this measurement was used as the method of facial typing for this project.[10] Cephalometric films were used to determine the mandibular plane angle. One investigator completed the tracings and determined the mandibular plane angle. The mandibular plane angle was measured as the intersection angle between the mandibular plane and the Frankfort horizontal (Sella to Orbitale). Figure 8. The subjects were then categorized as either flat (<22°), average (22° -27°), or steep (>27 °).

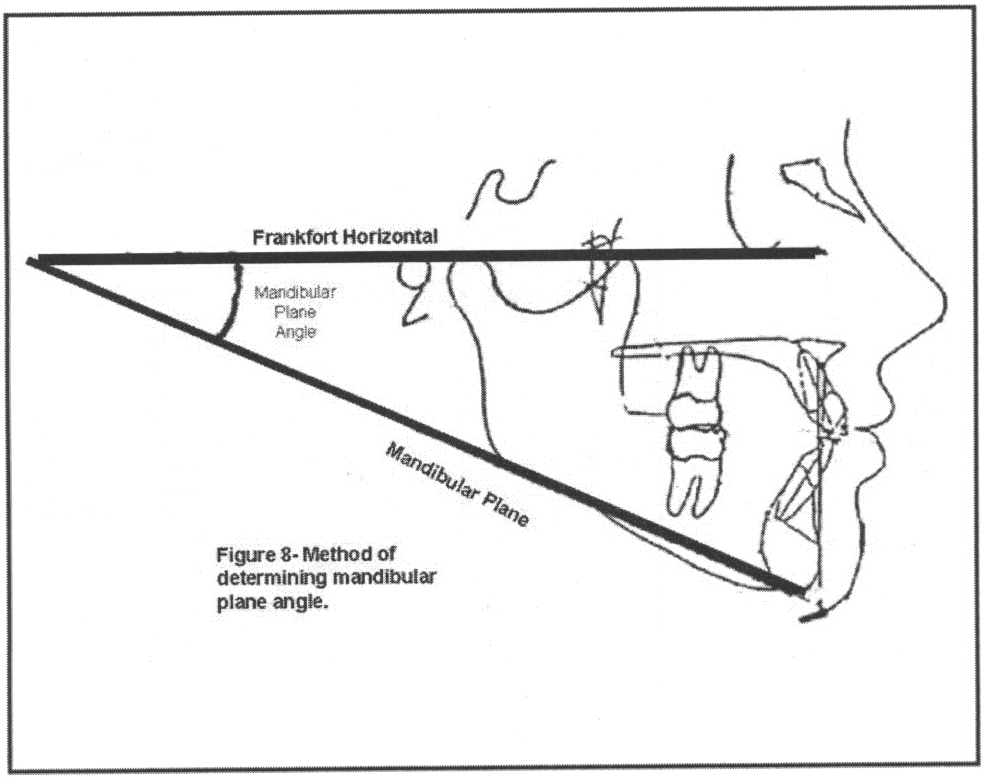


Figure 8- Method of determining mandibular plane angle.

Statistics

SPSS was used to perform statistical analysis on the collected data. The student T-test, ANOVA, and the Tukey post hoc analysis were completed.

Results

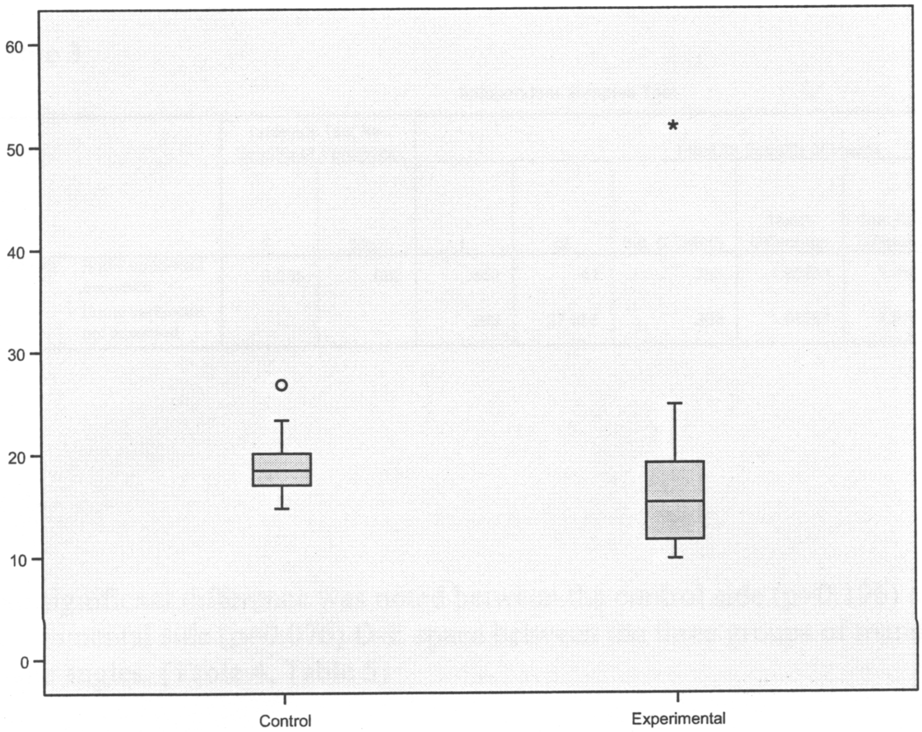
A total of 23 subjects were included in the final analysis. There were 13 male and 10 female subjects with an age range of 6 to 17 years. The mean age was 11 years and 6 months. The mean D-E space length was 18.90mm for the control side and 17.24mm for the experimental side, rounded to the nearest tenth. (Table 1) The data was normally distributed, although skewed to the left. Both the control and experimental group had one outlier. (Figure 9)

Table 1

Descriptives

			Statistic	Std. Error
Control	Mean		18.8961	.65167
	95% Confidence Interval for Mean	Lower Bound	17.5446	
		Upper Bound	20.2476	
	5% Trimmed Mean		18.7148	
	Median		18.4500	
	Variance		9.768	
	Std. Deviation		3.12532	
	Minimum		14.73	
	Maximum		26.77	
	Range		12.04	
	Interquartile Range		3.60	
	Skewness		.752	.481
	Kurtosis		.355	.935
Experimental	Mean		17.2435	1.80192
	95% Confidence Interval for Mean	Lower Bound	13.5065	
		Upper Bound	20.9804	
	5% Trimmed Mean		15.9210	
	Median		15.2700	
	Variance		74.679	
	Std. Deviation		8.64171	
	Minimum		9.81	
	Maximum		51.89	
	Range		42.08	
	Interquartile Range		8.26	
	Skewness		3.117	.481
	Kurtosis		12.150	.935

Figure 10



The mean D-E space values (in mm) are presented in Table 2. At a 95% confidence interval there was no significant difference detected between the mean D-E space measurements (p=0.062). (Table 3)

Table 2

Alldatacontrol

Tukey HSD[a,b]

MNDBLPLN	N	Subset for alpha = .05 1
Steep	7	17.5786
Flat	10	18.7260
Average	6	20.7167
Sig.		.141

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 7.326.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Alldataexp

Tukey HSD[a,b]

MNDBLPLN	N	Subset for alpha = .05 1
Steep	7	13.8443
Flat	10	15.6230
Average	6	23.9100
Sig.		.063

Means for groups in homogeneous subsets are displaye

a. Uses Harmonic Mean Sample Size = 7.326.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 3

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Alldata	Equal variances assumed	3.659	.062	.862	44	.393	1.65261	1.91614	-2.20912	5.51434
	Equal variances not assumed			.862	27.658	.396	1.65261	1.91614	-2.27462	5.57984

No significant difference was noted between the control side (p=0.196) or experimental side (p=0.076) D-E space between the three groups of mandibular plane angles. (Table 4, Table 5)

Table 4

Multiple Comparisons

Dependent Variable: Alldatacontrol
Tukey HSD

(I) MNDBLPLN	(J) MNDBLPLN	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Flat	Average	-1.99067	1.56017	.425	-5.9379	1.9565
	Steep	1.14743	1.48889	.725	-2.6194	4.9143
Average	Flat	1.99067	1.56017	.425	-1.9565	5.9379
	Steep	3.13810	1.68088	.174	-1.1145	7.3907
Steep	Flat	-1.14743	1.48889	.725	-4.9143	2.6194
	Average	-3.13810	1.68088	.174	-7.3907	1.1145

Table 5

Multiple Comparisons

Dependent Variable: Alldataexp
Tukey HSD

(I) MNDBLPLN	(J) MNDBLPLN	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Flat	Average	-8.28700	4.11363	.135	-18.6944	2.1204
	Steep	1.77871	3.92569	.894	-8.1532	11.7106
Average	Flat	8.28700	4.11363	.135	-2.1204	18.6944
	Steep	10.06571	4.43188	.083	-1.1469	21.2783
Steep	Flat	-1.77871	3.92569	.894	-11.7106	8.1532
	Average	-10.06571	4.43188	.083	-21.2783	1.1469

Inter-rater reliability was also assessed. There were no statistical differences in measurements made by an individual evaluator on the same case at different times (Table 6, Table 7), nor was there a significant difference in the measurement made between the three evaluators for the control or the experimental groups. (Table 8, Table 9)

Table 6

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									90% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Test1Exp	Equal variances assumed	1.101	.325	-.285	8	.783	-.42600	1.49230	-3.20100	2.34900
	Equal variances not assumed			-.285	7.456	.783	-.42600	1.49230	-3.22750	2.37550
Test2Exp	Equal variances assumed	.114	.744	.191	8	.853	.30400	1.58772	-2.64844	3.25644
	Equal variances not assumed			.191	7.969	.853	.30400	1.58772	-2.64995	3.25795

Table 7

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									90% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Test1Exp	Equal variances assumed	.627	.451	.256	8	.805	.39200	1.53375	-2.46008	3.24408
	Equal variances not assumed			.256	7.685	.805	.39200	1.53375	-2.47531	3.25931
Test2Exp	Equal variances assumed	.005	.946	.092	8	.929	.14200	1.54388	-2.72892	3.01292
	Equal variances not assumed			.092	7.999	.929	.14200	1.54388	-2.72894	3.01294

Table 8

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Evaluator	(J) Evaluator	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Test1Exp	Stephen	Hanna	-.42600	1.45257	.954	-4.3013	3.4493
		Engle	-.03400	1.45257	1.000	-3.9093	3.8413
	Hanna	Stephen	.42600	1.45257	.954	-3.4493	4.3013
		Engle	.39200	1.45257	.961	-3.4833	4.2673
	Engle	Stephen	.03400	1.45257	1.000	-3.8413	3.9093
		Hanna	-.39200	1.45257	.961	-4.2673	3.4833
Test2Exp	Stephen	Hanna	.30400	1.57548	.980	-3.8992	4.5072
		Engle	.44600	1.57548	.957	-3.7572	4.6492
	Hanna	Stephen	-.30400	1.57548	.980	-4.5072	3.8992
		Engle	.14200	1.57548	.996	-4.0612	4.3452
	Engle	Stephen	-.44600	1.57548	.957	-4.6492	3.7572
		Hanna	-.14200	1.57548	.996	-4.3452	4.0612

Table 9

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Evaluator	(J) Evaluator	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Test1Cntl	Stephen	Hanna	-.35200	1.01086	.936	-3.0488	2.3448
		Engle	.26200	1.01086	.964	-2.4348	2.9588
	Hanna	Stephen	.35200	1.01086	.936	-2.3448	3.0488
		Engle	.61400	1.01086	.819	-2.0828	3.3108
	Engle	Stephen	-.26200	1.01086	.964	-2.9588	2.4348
		Hanna	-.61400	1.01086	.819	-3.3108	2.0828
Test2Cntl	Stephen	Hanna	.19600	1.15045	.984	-2.8732	3.2652
		Engle	.63800	1.15045	.846	-2.4312	3.7072
	Hanna	Stephen	-.19600	1.15045	.984	-3.2652	2.8732
		Engle	.44200	1.15045	.922	-2.6272	3.5112
	Engle	Stephen	-.63800	1.15045	.846	-3.7072	2.4312
		Hanna	-.44200	1.15045	.922	-3.5112	2.6272

Discussion

The results of this research failed to show any statistical difference between the D-E spaces present in the control sides when compared to the experimental sides (the side with the premature loss of a primary molar). The results of this study are contrary to those obtained by both Rönnerman and Lin which demonstrated the presence of significantly less D-E space on the experimental side than the control side when premature tooth loss occurred unilaterally.[11,2] Rönnerman and Lin's studies were well conducted studies with valid results. One reason that the results of this study differ from their results could be the effect of the small sample size used in this study. Although over 3,000 models were evaluated, only 23 cases met the inclusion criteria. Rönnerman's study, on the other hand, had more than twice as many subjects. Another reason is that this was a retrospective study and the age at the time of extraction and how long the tooth had been missing was unknown. Lin's study was prospective with a known patient age and dental history at the time of extraction. In his research, Northrup noted that although there did not appear to be a relation between the age at extraction and the amount of space loss when evaluating the mandible, how long the tooth had been missing was an important factor in the development of space loss.[5] Research by Cuoghi indicated that 75% of the space loss occurs in the first six months following the extraction.[6] Hence, time since the extraction appears to be a crucial element when evaluating space loss. There was no account of the subjects dental history in the charts, thus I was unable to determine when extractions were completed, and how long the teeth had been absent for this study. As a result, my comparisons could have been between subjects that lost the tooth only a couple of weeks prior to the fabrication of their initial orthodontic casts, whereas others may have been missing the tooth for years prior to the fabrication of the study casts. In his research, Owen stated that, "all of the experiments demonstrate conclusively that the longer the extraction space is present, the greater the space closure will be."[4]

The use of plaster models also has its limitations because there are distortions inherent in the making of the model. In addition, the impressions and models were made by many different individuals ranging from pre-doctoral dental students to practicing orthodontists, which would inevitably result in the introduction of more variation in the consistency of cast accuracy.

Another source of error that Owen noted in his research is that it must be taken into consideration that the amount of closure determined by comparing mesio-distal dimensions for the premature extraction space when compared to the intact contralateral side experiments tend to show less closure than what actually occurs.[4] This is most likely a result of caries experience on the "control" side. A patient with decay severe enough to result in a tooth extraction would likely also have space loss on the contralateral side (the control in this study) due to caries. Breakspear states that a true reading of the space loss by a prematurely extracted tooth can only be obtained when there is had been no caries on the control side of the dental arch.[1] This was not the circumstance in the majority of the cases utilized in this study.

Although the control and experimental D/E space values did not have a statistically significant difference, there were trends that could be observed. As Table 1 indicates, there is only a 1.65mm difference in the mean D-E spaces between the control and experimental sides. If, however, we evaluate the data in Figure 2 which separates the mean D-E space measurements based on mandibular plane angle, the mean differences are increased. When the means for the control and experimental flat mandibular plane angle groups are compared, a difference of 3.10mm was noted between the groups. For a steep mandibular plane angle, there was a difference of 3.7mm between the control and experimental groups. Thus, on average, there was 0.63mm more space loss in an individual with a steep mandibular plane compared to an individual with a flat mandibular plane. Breakspear noted, there is a certain amount of space that can safely be loss by the forward migration of the permanent teeth, but this cannot be exceeded or crowding of the permanent dentition can result.[1] While the value of 0.63mm may not be statistically significant, it could mean the difference between an impacted premolar and normal eruption. The current study suggests that individuals with a steep mandibular plane angle may be at risk for an increased amount of space loss in the presence of a prematurely lost primary molar and hence more likely to exceed the amount of space loss tolerated before dental crowding or impactions occur.

In order to obtain more significant data a larger number of subjects would be beneficial. Also a thorough dental history including the age of extraction, any history of space maintenance, and length of time since the since the tooth loss would be helpful.

Conclusion:

Based on the results of the statistical analysis of the data, the null hypothesis could not be rejected. Children who have a steep mandibular plane angle are no more likely to lose space following a premature loss of a primary molar than an individual with an average or flat mandibular plane angle.

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The Effect of Mandibular Plane Angle on Space Loss Following Premature Loss of a Primary Mandibular Molar.

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The effect of mandibular plane angle on space loss following unilateral premature loss of a mandibular primary molar was evaluated in this study. Models and bitewing and cephalometric radiographs created for initial orthodontic records were utilized for data gathering. The models were divided into a control and experimental side. The control side was defined as the side of the mandible without premature tooth loss. The experimental side was the side of the mandible with premature tooth loss. D/E space was defined as the distance between the most mesial point of the mandibular permanent first molar to the most distal midpoint of the primary or permanent canine. In the absence of a fully erupted permanent canine and exfoliated primary canines, the most distal point of the lateral incisor was used as the reference point. 23 cases met the inclusion criteria. The cephalometric films were traced and the mandibular plane angle was determined. Subjects were divided into three groups based upon their mandibular plane angle. The subjects were then categorized as either flat (<22°), average (22° -27°), or steep (>27 °). The mean D-E space length was 18.90mm for the control side and 17.24mm for the experimental side, rounded to the nearest tenth. Using the student t-test, ANOVA, and a Tukey's post-hoc statistical analysis was completed. No statistical difference was noted between mean D/E space of the control versus the experimental side. Nor was there a significant difference between the control side or experimental side D-E space between the three groups of mandibular plane angles. A trend of more space loss in the steep mandibular plane angle groups was noted. Although the value of 0.63mm may not be statistically significant, it may be clinically relevant. The conclusion reached as a result of this study was that, children who have a steep mandibular plane angle are no more likely to lose space following a premature loss of a primary molar than an individual with an average or flat mandibular plane angle.

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