THE NOT-SO-HARMLESS MAXILLARY PRIMARY FIRST MOLAR EXTRACTION

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A B S T R A C T

Background. Premature loss of primary molars has been associated with space loss and eruptive difficulties, especially when the loss occurs to the primary second molars and when it occurs early. This has not been thought to be the case for primary first molars.

Methods. The author revisited 13 cases from an earlier study on the effects of premature loss of maxillary primary molars. These longitudinal cases were scrutinized, using serial panoramic radiographs, to explain the irregular response in terms of dental migration. The author presents two case reports.

Results. In the earlier study, the author used digitized study casts and the concept of D + E space—the space occupied by the primary first and second molars—to describe the dental migration that occurred after premature tooth loss. Using analysis of variance on data generated using an instrument capable of measuring in tenths of millimeters, the author produced findings regarding the amount of space loss, rate of space loss, effect of age at loss, amount of space regained at the time of replacement by the permanent tooth and effect on Angle's classification. Finally, the author created a simulation describing directional change; this revealed that the maxillary primary first molar loss resulted in a mesial displacement of the permanent canine during eruption.

Conclusions. When the maxillary primary first molar is lost prematurely, the first premolar erupts in a more mesial direction than normal, as a result of the mesial incline of the primary second molar, and consumes the space of the permanent canine, which becomes blocked out.

Clinical Implications. Rather than use a space maintainer after the premature loss of the maxillary primary first molar, the author suggests, clinicians can choose from a number of other options for preventing the first premolar from erupting too far in a mesial direction.

Most dental students are taught that the premature loss of primary teeth results in a loss of space that can compromise the eruptive opportunities of permanent teeth. It is taught that it is the primary second molar that is the culprit, and that the loss of the first primary molar is not detrimental to arch length. In hopes of providing a better understanding of the dynamics of the developing dentition, this article demonstrates how D loss—premature loss of the primary first molar—is profound and detrimental to arch circumference, and it describes the mechanism of space loss.

LITERATURE REVIEW

The concept of space loss resulting from early exfoliation of primary teeth was described as early as the 1880s by Davenport[1] and Hutchinson.[2] Early investigations were handicapped by the quality and size of study samples (a lack of longitudinally gathered data known as growth samples) and limitations in measurement technique.

The first known study that attempted to quantify space loss was performed by Liu[3] in 1949. She compared cross-sectional data on affected children with the available normative data of Lehman and Lewis,[4] Cohen[5] and Hellman,[6] and then she reported that the early loss of a maxillary primary second molar would result in a space loss of 2.49 millimeters. The loss of a maxillary primary first molar would result in a space loss of 2.2 mm, while the loss of both maxillary primary first and second molars would result in a space loss of 2.3 mm. In the mandibular arch, the loss of a primary second molar, primary first molar or both would be 1.38 mm, 1.42 mm and 1.93 mm, respectively.

In 1952, Jarvis[7] used early data from the growth sample collected in Burlington, Ontario, Canada, to measure quadrant lengths from the distal of the lateral incisor to the mesial contact point aspect of the permanent first molar. He calculated the amount of divergence from the mean quadrant length for a number of groups, including one that had unattended caries and groups in which subjects experienced premature loss of the primary canine, D loss or E loss—premature loss of primary second molars. He did this in both arches and for both sexes. The greatest divergence from the mean determined the status for any situation; he did not separate out those subjects who had lost both primary molars, but instead he included them in the primary second molar group.

His cross-sectional evaluation revealed that 20 male subjects experienced D loss in the maxilla and lost 0.13 mm of space. Ten of these subjects experienced D loss in the mandible and lost a mean of 1.86 mm. Among female subjects, three experienced D loss in the maxilla and lost 1.37 mm of space; Jarvis did not record the sole subject who experienced D loss in the mandible. Four male subjects experienced E loss in the maxilla and a mean reduction of 4.23 mm, while 16 male subjects experienced a mean loss of 2.69 mm. Fourteen female subjects experienced E loss in the maxilla and lost a mean of 2.08 mm, while 19 female subjects experienced a mean loss of 2.87 mm.

In 1951 and 1961, Breakspear[8,9] attempted to quantify space loss due to premature loss. He defined premature loss as the loss of one or two primary molars on one side of the mouth while the corresponding teeth on the opposite side of the mouth were retained. Using the unaffected side as a control, he examined schoolchildren in a cross-sectional fashion and reported on the divergence from the affected side.

Using a rather loose methodology and speculating a great deal, Breakspear reported that D loss in the maxillary or mandibular arches resulted in arch length reduction of 0.8 mm and 0.7 mm, respectively. When E loss occurred, the space loss was 2.2 mm in the maxilla and 1.7 mm in the mandible. If both primary molars were lost early, the arch length reduction was 2.0 mm in the maxilla and 1.3 mm in the mandible. His articles do not specify the number of subjects in his groups; the cases of D + E loss—premature loss of the primary first and second molars—were pooled as E loss cases.

While measured space loss was considerable during the initial stages of the study, graphic representation of this study group demonstrated a profound 'catch-up' in subjects at approximately 11 years of age.

Only Liu[3] demonstrated that arch length reduction after the loss of a primary first molar was similar to the reduction after the loss of a primary second molar. The primary second molar has been represented as the "cornerstone" of stability by many authors.[3,10-15] Some authors focused on the extraction of maxillary vs. mandibular primary teeth and the resultant space loss.[12,13] Seipel[14] concentrated on the age at which the extraction took place. Liu[3] and Richardson[13] related the amount of space lost to the proximity in time of the tooth lost. Davenport[1], Love[16] and Flint[17] resisted current thinking that teeth close space through mesial migration, and Clinch and Healy[11] first argued that this was a mandibular phenomenon.

In a 1998 article, Lin and Chang[18] measured D + E space—the space occupied by the primary first and second molars— arch width, arch length and arch perimeter. While they found that the D + E space on the extraction side was shorter than on the control side, they found that the D loss in the mandible did not result in changes in any of the constructed measurements.

In my 1977 master's thesis,[19] I extensively examined space lost after the premature loss of one or more primary molars. In that study, I found that the permanent first molar did not come very far forward after the loss of the maxillary primary first molar. While measured space loss was considerable during the initial stages of the study, graphic representation of this study group demonstrated a profound "catch-up" in subjects at approximately 11 years of age. While this was outside the scope of a dental cast morphometric study, further scrutiny revealed that these subjects suffered impaired eruption of the canine. The use of panoramic radiograph information allowed me to construct what impactions took place and how.

METHODS AND SUBJECTS

I began my research on the effects of premature loss of primary molars 28 years ago with Dr. Robert Wainwright. We used data from the growth sample of Dr. Arto Demirjian, a digitizing instrument of Dr. Frans van der Linden and the computing powers of Dr. Robert Moyers. The research was conducted in three planes of space.[19,20] Using an instrument capable of measuring in a digitized format with the precision of 0.2 mm, we mounted casts on a sliding stage under a dissection microscope to define points that were to be registered in the x and y planes. Casts then were inverted 90 degrees so that the z-axis could be recorded as well. The instrument was the same instrument that was used in digitizing and preparing the text, Standards of Human Occlusal Development.[21]

At its inception in 1966, the growth sample at the Centre de Recherche sur la Croissance Humaine at the Université de Montréal was to have consisted of 108 6-year-old boys, 101 6-year-old girls, 111 10-year-old boys and 113 10-year-old girls. To compensate for the inevitable attrition, 38 8-year-old girls and 21 8-year-old boys were added at the beginning of the third year of the collection process. The following year, 23 9-year-old girls and 20 9-year-old boys were added. In parallel, Dr. Demirjian gathered data regarding 162 siblings in a mixed longitudinal fashion; we selected 107 of these children for our study. Inclusion criteria required four consecutive years of intact dental casts; many of the subjects had seven consecutive years of intact dental casts. While the Montréal growth sample contains data collected annually on two sets of children, one starting at age 6 years and one starting at age 10 years, our study on premature loss used only the younger set. These data were collected during the 1960s and early 1970s. Our average observation period was 5.9 years. Most of the communities where growth samples were collected, such as Burlington, Ontario, Canada, and Ann Arbor, Mich., had fluoridated water supplies. Montréal did not, and the caries incidence was so high that we excluded many of the subjects from our study because they were totally edentulous during multiple years between the ages of 6 and 13 years. Several subjects ultimately lost all of their teeth during adolescence.

> ***Where previous studies have had to rely on caliper-determined constructed measurements, using our computer-aided measuring technique gave us the opportunity to observe the points as they move in space relative to one another.***

We divided our earlier study[20] into six parts:
- the dimension of space loss due to premature exfoliation;
- the direction from which space was lost;
- the influence of age on the rate of space loss;
- the regaining of space at the time of replacement by the permanent teeth;
- the effect on molar and canine relationships as described by Angle's classification;
- the use of schematic models to describe the combination of changes that took place.

We assigned the status of "prematurely exfoliated" if the tooth was missing from the dental study casts for two consecutive registrations (more than 12 months apart). The typical replacement interval between natural exfoliation and eruption of the permanent tooth is less than six months; therefore, we felt that a duration of more than 12 months would reflect an abnormal event.

The spatial dimension called D + E space was depicted by computer. The concept of D + E space is made possible by using computers to describe the movement of any given point relative to a reference plane, in this case the palatal rugae. Where previous studies have had to rely on caliper-determined constructed measurements, using our computer-aided measuring technique gave us the opportunity to observe the points as they move in space (in this case, on a dental cast) relative to one another.

For this article, I combined the panoramic radiographs

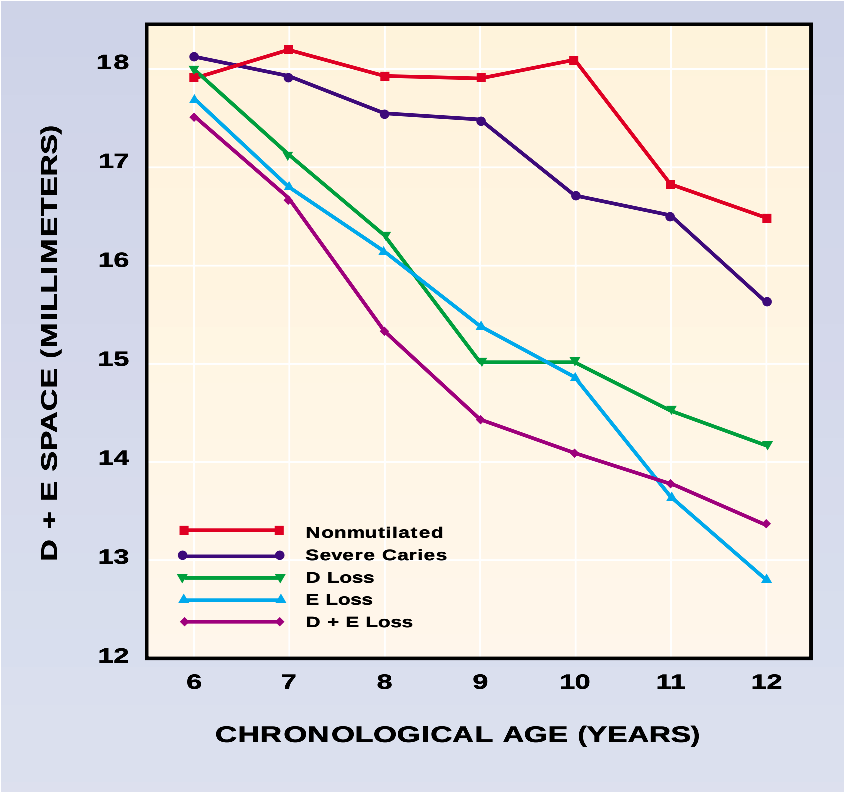

Figure 1. Mean changes in mandibular D + E space—the space occupied by the primary first and second molars—in millimeters by chronological age. (Reproduced with permission of the publisher of Angle Orthodontist from Northway and colleagues.[20])

taken of the same subjects for whom we studied dental casts alone in our earlier articles.[19,20] Thirteen maxillary quadrants from the Montréal data set experienced the premature loss of the primary first molar as their most severe event. Each was scrutinized for this article.

RESULTS

One or more primary molars were lost prematurely in 71 of the 107 subjects (66 percent). Eighteen subjects (17 percent) had primary molars that were decayed severely but not extracted, and only 18 subjects (17 percent) were free of unattended caries or did not experience premature extraction. Many of the subjects in the Montréal data set of 433 children, who were followed annually from 6 to 13 years of age, had so many teeth missing that they did not provide meaningful data and were not included in the study.

We found the amount of destruction in the mandibular arch from restorations, caries, D loss, E loss and D + E loss to be significantly greater than that in the maxillary arch for both sexes at all ages. The groups that were caries-free, had restorations or mild caries differed little in changes to D + E space, so we combined these groups into a new group designated as "nonmutilated." We compared this group with the extraction groups in this study. Further responses to unattended caries were discussed in another article.[22]

The computer-determined data for the subjects' mandibular arches are shown in Figure 1. They demonstrate the changes in D + E space as a function of chronological age for each of five groups: nonmutilated, severe caries, D loss, E loss, and D + E loss. We performed one-way analysis of variance, or ANOVA, among the groups at each age at which data were gathered. Two-way ANOVAs with age and group as factors were not applicable here because of small group size and the disabling effects of missing data.

Mandibular arch. From the first year of the study, there was a statistically significant reduction in arch length in each of the premature exfoliation groups (D loss, E loss and D + E loss). The response to unattended caries and premature loss of mandibular primary molars is represented in Figure 1. Using ANOVA for the differences among the groups, we found a statistically significant difference for each age after six years at $P \leq .001$. While the number changed slightly from year to year, there were approximately 39 for the nonmutilated group, 66 for the severe caries group, 15 for the D loss group, 26 for the E loss group and 30 for the D + E loss group. During each year of the study, a quadrant was counted in the group that reflected the worst condition that it attained at any given time during the entire study; for example, if a subject eventually experienced the premature loss of both primary molars, the quadrant was counted in the D + E loss group throughout the study. A steady decrease in space in subsequent years reflected continuing space closure. The severe caries group behaved much like the nonmutilated group, except for the 1-mm reduction that it experienced at age 10 years. On inspection, we found that the cariously involved teeth exfoliated one year earlier than those in the nonmutilated group, experiencing the leeway reduction described by Moorrees[23] earlier than those in the nonmutilated group.

For all extraction groups, the mean space loss was 0.9 mm for the first year and 1.9 mm for the first two years. The most dramatic space loss occurred during the first three years of the study; the average space loss was 1 mm per year. Thereafter, the rate of space loss slowed to about 0.5 mm per year. In the E loss and D + E loss groups, the ranges for space closure were between 0.3 mm and 1.6 mm per year with averages of 0.9 mm and 0.7 mm per year, respectively. The D loss group showed an increase in D + E space for one year, age 10; otherwise, there was an average annual loss of 0.6 mm, ranging from 0.3 mm to 1.0 mm.

The maximum divergence from the nonmutilated group was 4.0 mm in the D + E loss group at age 10 years. The greatest divergence from the nonmutilated group at the end of the study was in the E loss group in which the space was 3.7 mm shorter.

Maxillary arch. The changes in arch length, as represented by D + E space, for the maxillary arch are seen in Figure 2. The statistical treatment is the same as for the mandibular arch data. Again, the differences between the premature exfoliation groups and the nonmutilated group are dramatic from the outset. By age 7 years, the D + E space in each

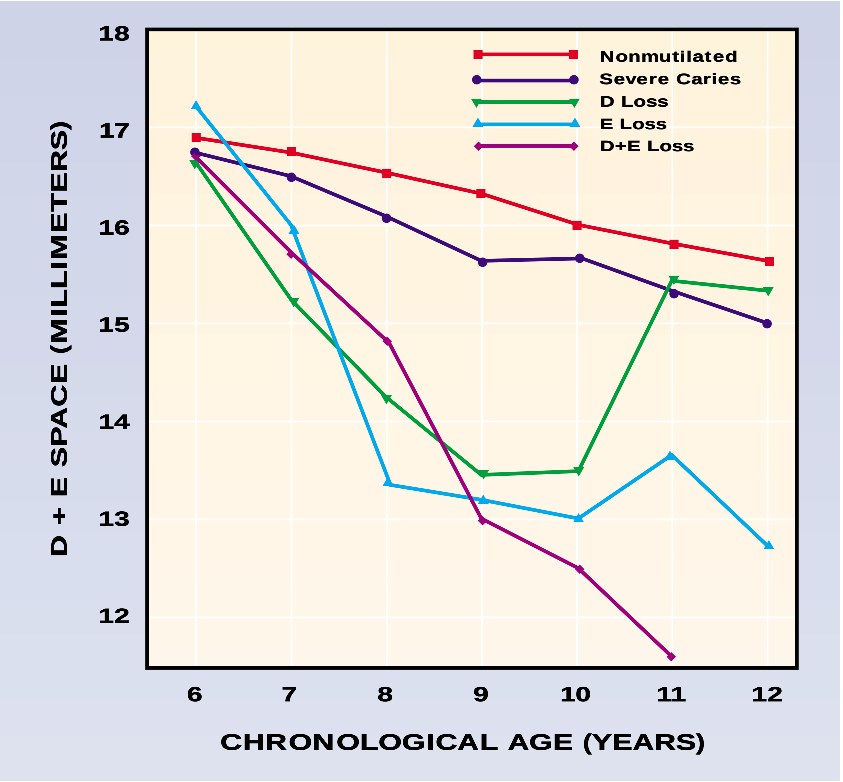

Figure 2. Mean changes in maxillary D + E space—the space occupied by the primary first and second molars—in millimeters by chronological age. (Reproduced with permission of the publisher of Angle Orthodontist from Northway and colleagues.[20])

of the premature exfoliation groups was significantly smaller than that of the nonmutilated group; this trend continued through age 10 years. The attained *P* value for significance was .0011 for age seven years and .000 for each age thereafter. The numbers for the groups were approximately 72 for the nonmutilated group, 72 for the severe caries group, 13 for the D loss group, 20 for the E loss group and 11 for the D + E loss group. Between ages 10 and 11 years, D + E space for the D loss group increased and nearly returned to the length of the nonmutilated; the other premature exfoliation groups did not. The arch circumference in the severe caries group was reduced by about 1 mm at age 9 years as the result of an early transition to permanent dentition.

Rates of space loss comparison. Initially, the space loss rate was more dramatic in the maxillary arch than in the mandibular arch. In the first two years, the mean loss in the maxillary extraction groups was 2.8 mm. The annual space loss for the first three years averaged 1.2 mm. But from ages 8 through 10 years, the E loss and D loss groups began to level off in terms of annual increments. Maxillary space loss ceased being as dramatic as that in the mandible where, for the same three years, there had been an average of only 0.9 mm space loss per year for the subjects who experienced premature extraction.

In the mandible, the mean space loss for each of the

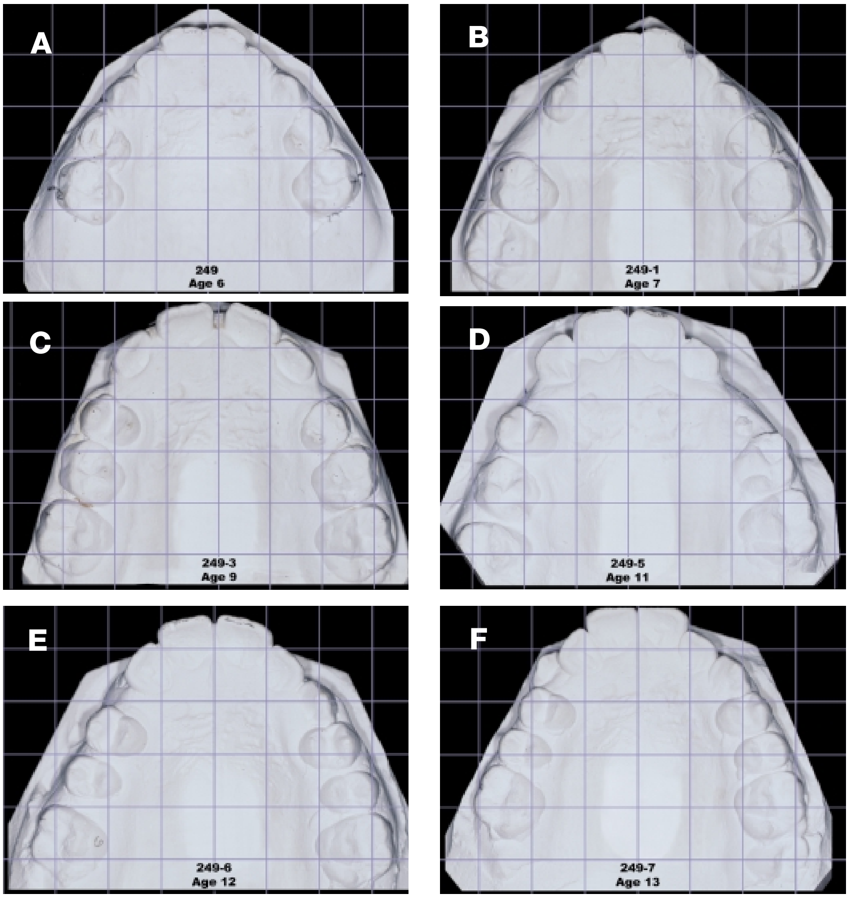

Figure 3. Case 1 occlusal views at ages 6 years (A), 7 years (B), 9 years (C), 11 years (D), 12 years (E) and 13 years (F).

extraction groups began to decrease during the next three years; in the maxilla, however, both of the groups that experienced the loss of a primary first molar showed an increase in D + E space between the ages of 10 and 11 years. There was little space lost in the maxilla after age 9 years. While the total space lost in the maxillary arch was 4.7 mm and 4.8 mm for the E loss and D + E loss groups, respectively, the D loss group experienced a net reduction of less than 1 mm.

Because of the timing, it might appear that the eruption of the premolar accounts for the increase in D + E space. Previous research, however, showed little recovery in the lost D + E space that was associated with the emergence of the premolar.[17] The remarkable increase in D + E space for the D loss group between ages 9 and 11 years coincided with the replacement of the missing primary molar by the first premolar. This typically was as a result of the mesial and often labial displacement of the maxillary canine.

CASE REPORTS

I present two of the 13 cases of maxillary primary first molar loss that occurred in the Montréal growth sample, as they are representative of the response to this phenomenon.

Case 1. In Case 1 (number 249 in our study), the maxillary primary right first molar was lost between ages 6 and 7 years (Figure 3A and B). By age 9 years (Figure 3C), the first premolar had erupted mesial to where one might expect it compared with the left side. It should be noted that even the left side did not show an abundance of space for the eventual eruption of the canine. By age 11 years (Figure 3D), the pending eruption of the canines had begun to close the spacing among the anterior teeth; the maxillary primary left first molar had been lost recently, as can be seen by the granulation tissue in its site. The maxillary right first premolar appears to have moved even more in a mesial direction; note the space on either side of the primary second molar. By age 12 years (Figure 3E), the maxillary left premolar had erupted in a rather normal fashion, and the maxillary right side showed even more space between the premolars after the eruption of the primary second molar. Much of this is due to the mesial placement of the first premolar. During the next year (Figure 3F), the maxillary right canine erupted into a “blocked-out” position, toward the labial aspect and out of proper arch alignment. The mesial rotation of the maxillary permanent maxillary right first molar should be noted.

Case 2. Case 2 (number 106 in our study) shows the loss of the maxillary primary left first molar before its first registration at age 6 years (Figure 4). The view at age 7 years (Figure 4A) demonstrates how the left primary second molar erupted nearly 2 mm in a more mesial direction than the right primary second molar did. Comparisons with the palatal rugae and the molar on the contralateral side reveal that this forward displacement did not worsen appreciably during the course of the study. At age 11 years (Figure 4C), when the first premolars erupt, the premolar on the left was not profoundly mesial to the one on the right. While the maxillary right canine erupted relatively normally at age 12 years (Figure 4D), the maxillary left canine was significantly blocked out of the arch and was even more so at age 13 years (Figure 4E). As in Case 1, the spacing on either side of the second premolar on the right side allowed for more adjustment than did the spacing on the left side, where the first premolar was so far toward the mesial aspect. By age 15 years (Figure 4F), the right side had become acceptable, but the affected left side was in trouble. Again, note the rotation of the molars, especially on the left.

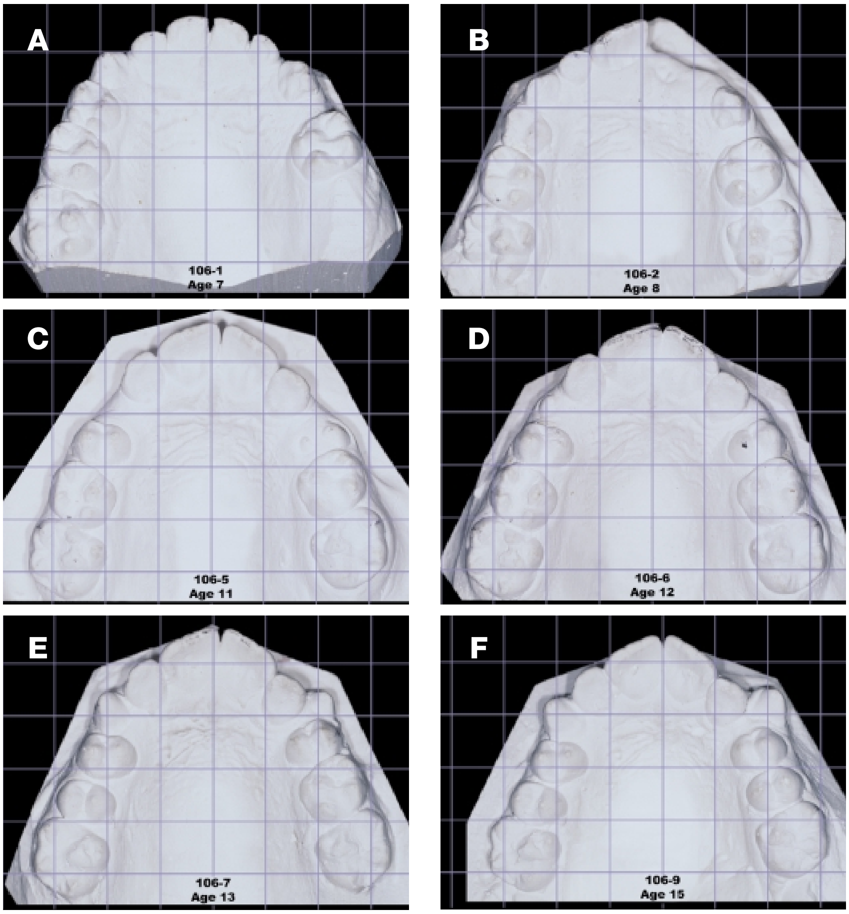

Figure 4. Case 2 occlusal views at ages 7 years (A), 8 years (B), 11 years (C), 12 years (D), 13 years (E) and 15 years (F).

In Figure 5, I provide a corrected sketch of the progressive dental development; that is, I used the dental casts to calculate the actual distance between teeth and then accordingly corrected the radiographs, which are highly susceptible to distortion. Apart from the immediate forward shift of the primary second molar that took place after the loss of the primary first molar, not much happened until the interval between the ninth and 10th year, when the first premolar was erupting actively. As it descended, it shifted forward conspicuously, glancing off of the mesial surface of the primary second molar. This so sufficiently consumed the space for the canine that it was prevented from erupting normally.

DISCUSSION

Most studies of the changes in arch depth resulting from premature loss of primary teeth have used constructed measurements, usually involving the incisors, but some researchers have demonstrated that these are of limited usefulness.[18,24] Changes in incisor position can account for tremendous variation in arch depth, especially during the incisor emergence period. To avoid such distractions, I restricted my observations to the boundaries of the primary molar sites—the D + E space—an approach first used by Seipel.[14]

The majority of earlier investigators reported far greater sagittal alteration in the maxilla than in the mandible after premature exfoliation.[3,6,8,9,11,12,15,25,26] Ronnerman and Thilander,[27] who were unable to demonstrate sufficient dental change to create an impact on facial profile, reported that “a significant difference for space was found only in the maxilla, which reflects a greater migratory tendency after early losses in this jaw than in the mandible.”

As stated in the Methods and Subjects section, the changes that occur in D + E space are demonstrable because of the three-dimensional digitized data that can be

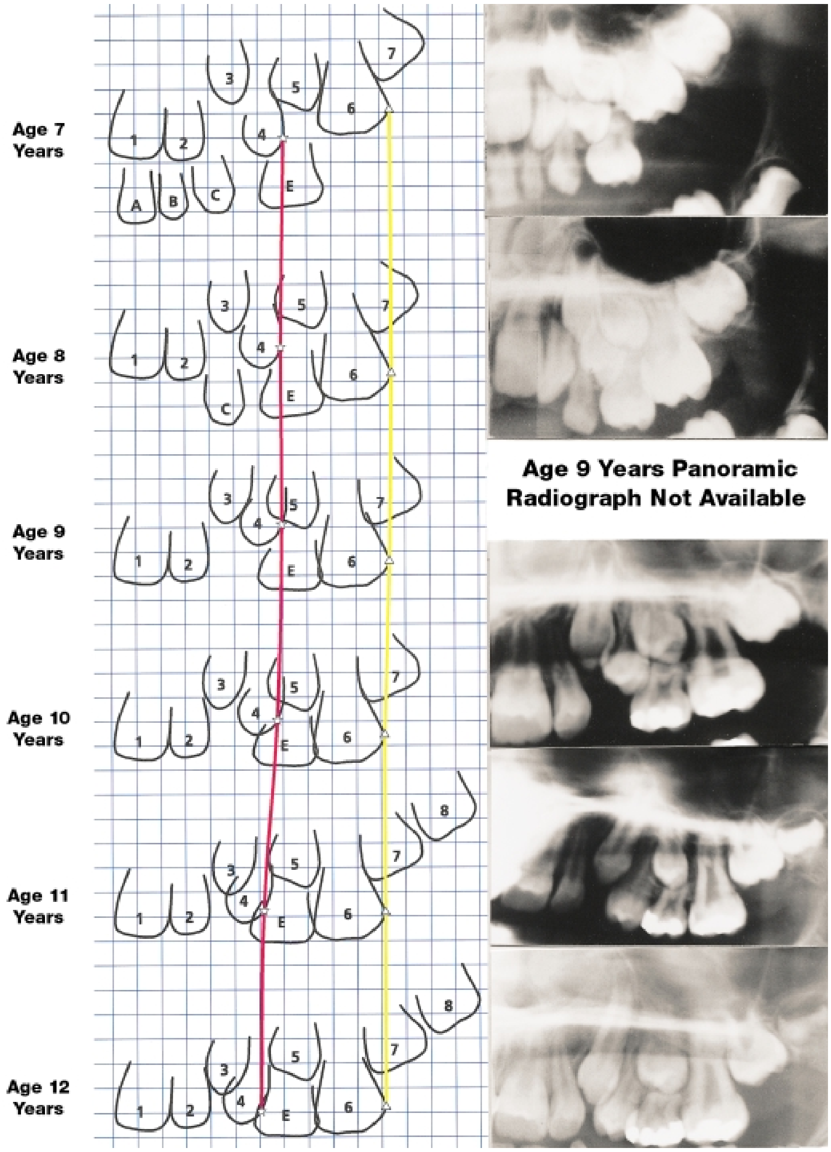

Figure 5. Case 2 composite from panoramic radiograph and dental cast data.

rendered using a computer-aided instrument. Movement then can be monitored, using a central reference point, to reveal migration relative to that reference point. By schematically assuming that the position of the nonmutilated molar and canine positions are constant and plotting the difference between their movement and that of any of the experimental groups, we can examine the relative anterior and posterior movements that any one of these groups makes during development. Figure 6 is a schematic representation of D + E space, assuming that D + E space for a control is a fixed length, which it is not. Starting with a constant, one-year annual incremental values have been plotted in a cumulative fashion. In this way, we are able to construct what would happen to “the mean subject,” assuming that all groups are identical at the beginning, which they are not. This construct allows us to formulate what should happen to “the mean subject” who might experience the loss of one or more primary molars in the maxilla.

What becomes clear and what the individualized scenario of the D loss cases reveal is that the permanent molar migrates very little in a mesial direction. When the first premolar erupts, it comes in so much more to the mesial than it should (as a result of its reaction to the mesial incline of the primary second molar) that the canine has insufficient space for proper eruption. When it does erupt, it is forced to do so in a more mesial placement than normal and usually to the labial aspect. This is different from the E loss, in which the permanent molar does move an average of 3 mm in a mesial direction. Owing to the sequence of eruption in which the permanent first premolar typically erupts before the second premolar, the second premolar often is trapped vertically between the first premolar and the permanent first molar. Likewise, the forward erupted permanent first molar in the D + E loss group often traps the second premolar.

The case reports in this article are all the more persuasive for their longitudinal nature. While Ronnerman and Thilander[27] were able to look at the aftermath of premature loss and speculate as to what had contributed to subsequent malocclusion, longitudinal data allow practitioners to watch specific situations develop. These data nicely illustrate the palatal eruption of the maxillary premolars trapped by E loss or D + E loss.

The findings from our data also reveal valuable information on a simplified approach to the treatment of D loss in the maxilla. Often, the placement of a space maintainer is a futile exercise, as the amount of space lost to mesial movement of the molar will be nominal. The band and loop retainer often demonstrated in the pediatric dental literature is rendered useless as soon as the primary canine or primary second molar exfoliate. Instead, it would seem more prudent to slice the mesial aspect of the primary second molar to such an extent that the first premolar would not be guided in a mesial direction. Any costs that might be expended on a space maintainer might be better applied later to the construction of a space regainer. Some alternatives worth considering include, but are not limited to, an upper Hawley retainer with an active component to move the molar in a distal direction, an acrylic-cervical-occipital appliance with improved retention on the anteriors or a transpalatal arch with or without activation, especially if the mesial aspect of the first molar has been allowed to rotate inward toward the palate. A space regainer would be used best at the time the first premolar is actively erupting and would reestablish the correct position of the permanent first molar and often the primary second molar. In this way, the erupting premolar then should follow the backward-moving molar into corrected position. Finally, the extraction of the primary second molar with the simultaneous application of a slight distal force to the permanent first molar, which should be scheduled to be performed at the same time as the first premolar erupts, might be considered. This would remove completely the deleterious effect of the incline of this tooth and would be an excellent treatment decision in the compliant patient.

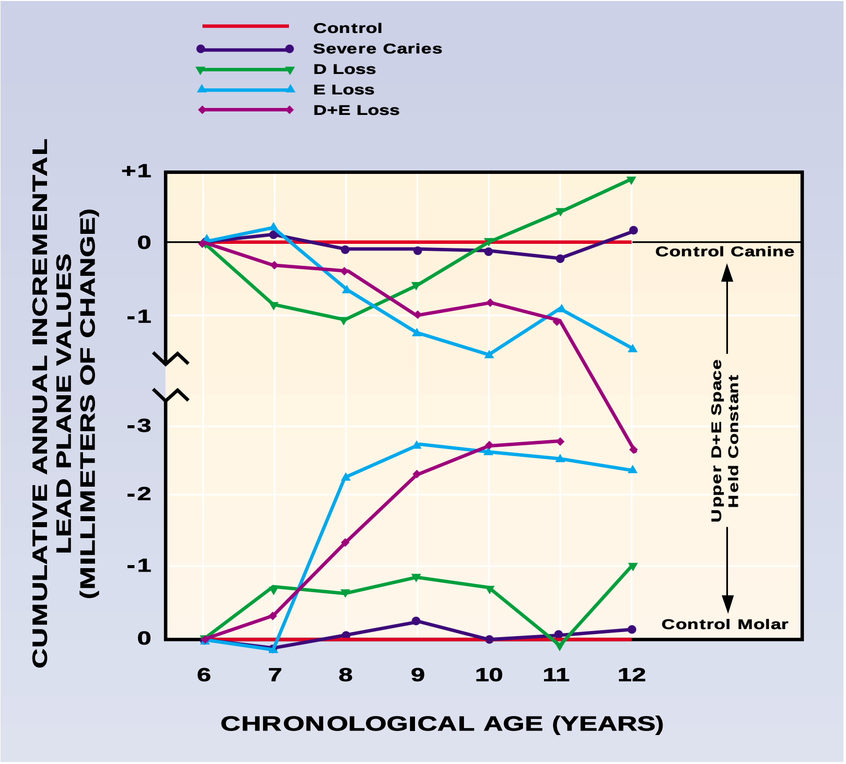

Figure 6. Mean divergences from control of maxillary canines and molars. (Reproduced with permission of the publisher from Northway and colleagues.[20])

With increased fluoride application, we see fewer clear-cut cases of prematurely extracted primary molars, but they still do occur. Dentists should explore the dental histories of patients who have a permanent maxillary canine blocked out. Except in the obvious case of exaggerated mesial eruption of the posterior teeth (as in an Angle's Class II relationship, especially when it occurs on one side only), dentists often will find that the presence of a blocked-out canine often will accompany the D loss in the maxilla in the patient's history.

In this article I in no way endeavor to overlook the peripheral affects of the developing dentition; I view the quadrants as if the extraction event is the only thing happening. I am aware of the influences of aberrant malocclusions, good or poor interdigitation, the affect of variations in facial musculature on the proclination or retroclination of anterior teeth, functional habits, lateral tongue thrust or posture, or the vertical component of growth and its bearing on space closure. In focusing on these data, I am attempting to explore exclusively the response to a simple human event: the premature loss of a primary tooth.

CONCLUSION

Premature loss of primary molars causes a reduction in arch length. While studies have failed to show that D loss in the maxilla results in a significant mesial migration of the permanent molars, careful scrutiny of the migration of the remaining teeth reveals a consistent, predictable deleterious effect: the maxillary permanent canine will be blocked out of the arch. Of 13 cases with D loss in the maxilla, only two eventually failed to develop blocked-out canines; one had a palatally impacted canine, and the other had microdontic teeth. This article reveals the phenomenon of, explains the mechanism of and provides cases to demonstrate the response. ■

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