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Twelve-month space changes after premature loss of a primary maxillary first molar

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Background. Many early investigations concerning space changes following premature extraction of primary molars had a cross-sectional design, a small sample size, and a somewhat crude methodology, which may have led to misunderstandings.
Aim. The aim of this study was to use established longitudinal data to investigate ongoing (12-month) dental-arch space problems arising as a result of premature loss of a primary maxillary first molar.
Design. Thirteen children (mean ± SD age at time of tooth extraction, 6.0 ± 0.74 years) with unilateral premature loss of a primary maxillary first molar were selected for this study. Maxillary dental study casts were obtained from participants 2 or 3 days after the tooth was removed, as well as at a follow-up appointment 12 months later. Six reference lines were measured on the study cast: D + E space, arch width, arch length, intercanine width, intercanine length, and arch perimeter. For each participant, the D + E space of the contralateral intact primary molar served as a control. A paired *t*-test was used to compare the cast measurements between initial examination and 12-month follow-up. A *t*-test was used to compare D + E space changes with those of the control group.
Results. The D + E space of the extraction side after 12 months was significantly smaller than that of the control side ($P < 0.05$) and the initial D + E space ($P < 0.05$). A significantly greater arch perimeter, intercanine width, and intercanine length were found after 12 months compared with the initial parameters. No significant differences were found, however, in arch width or arch length between the initial examination and the 12-month follow-up examination ($P > 0.05$).
Conclusions. The 12-month space changes in the maxillary dental arch after premature loss of a primary maxillary first molar consist mainly of distal drift of the primary canine toward the extraction site. Mesial movement of permanent molars or tilting of the primary molars did not occur. An increased arch dimension was found especially in the anterior segment (intercanine width and length). There is no need for the use of space maintainers from the results in this study in cases of premature loss of a primary first molar.

Introduction

Clinical investigations of space changes following premature extraction of primary molars have reached a wide range of conclusions[1]. Previous studies have emphasized harmful effects, such as tipping of the permanent first molar, crowding of the dental arch, and impaction of the permanent tooth[2–5]. Many early investigations had a cross-sectional design and a somewhat crude methodology, which may have led to misunderstandings[6]. Regarding the small sample size of study dealing with space changes, it seems inevitably to face further extraction problems of qualified cases due to high caries rate, which will reduce the number of samples[7]. Tunison *et al.* performed a systematic review of dental-arch space changes following premature loss of primary first molars

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through a search of electronic databases and found that only 3 of 79 studies had sufficiently high methodological quality to be considered for the review[7–10].

Although there is little controversy regarding the need for a space maintainer after the loss of a primary second molar, opinions differ about the need for space management following premature loss of a primary first molar. Well-designed studies providing clear evidence from which to draw meaningful conclusions are still lacking. In 1998, we used a strict sampling regimen and longitudinal data to study space changes after premature loss of a primary mandibular first molar. The results showed that early space change of the mandibular dental arch consisted primarily of distal movement of the primary canine toward the extraction space[7]. In 2007, in a related study of premature loss of a primary maxillary first molar, we found a similar distal drift of the primary canine and approximately 1 mm of space loss within 6 months after extraction, which was not likely to be of sufficient clinical significance to warrant use of a space maintainer[9]. We wanted to further explore dental-space problems and observe space changes of the entire dentition, especially in the maxillary arch. The aim of this study, therefore, was to use established longitudinal data to investigate ongoing (12-month) space problems arising as a result of premature loss of a primary maxillary first molar.

Material and methods

Thirteen children (five boys and eight girls) with premature loss of a primary maxillary first molar were recruited from the Children's Dental Clinic of the Chang Gung Memorial Hospital–Kaohsiung Medical Center, Taiwan. Six of 19 original participants were excluded because of extensive decay or loss to follow-up. All participants met the inclusion criteria specified by the protocol described in our previous study[9], as follows:

1. No major craniofacial disease was apparent.
2. The permanent first molars were about to erupt or had just erupted.
3. The patient was cooperative in finishing dental treatment before impressions were obtained.
4. The maxillary dentition featured unilateral premature loss of a primary first molar due to extensive caries but had intact contralateral primary molars.
5. Premature loss of the primary molar was defined as the absence of a permanent tooth after extraction of the primary molar; however, the permanent tooth eventually would erupt into the space.
6. Parents or guardians must not have wanted their child to receive dental treatment involving the use of a space maintainer.
7. All parents of the children included in the study signed a consent form. Ethical approval for the study was granted by the institutional review board of Chang Gung Memorial Hospital.

A research assistant made maxillary study casts from alginate impressions that were obtained 2 or 3 days after one of us (Y.-T. L. or W.-H. L.) extracted the tooth. None of the study participants received any type of space maintainer during the entire follow-up period. All patients had a recall appointment 1 year after the tooth was extracted, and we obtained longitudinal study casts to compare with the initial study casts.

Cast measurements

The researchers measured six reference lines pertaining to dental-arch development: the primary molar (D + E) space[6], arch width, arch length, intercanine width, intercanine length, and arch perimeter. We defined these parameters as follows:

1. D + E space: the distance between the mesial midpoint of the permanent first molar (or the distal midpoint of the primary second molar if the permanent molar was missing) and the distal midpoint of the primary canine[6] (Fig. 1).
2. Arch width: the distance between the central fossae on the occlusal surfaces of the two primary second molars (Fig. 2).
3. Arch length: the perpendicular distance from the contact point of the central incisors to the arch width (Fig. 2).

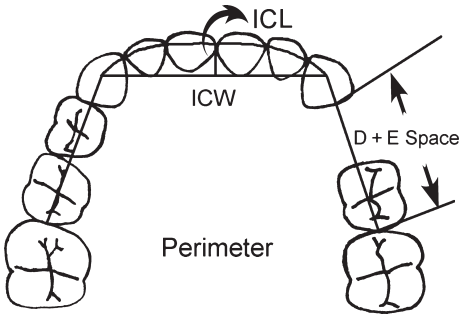

Fig. 1. Measurements of the primary molar (D + E) space, arch perimeter, intercanine width and intercanine length.

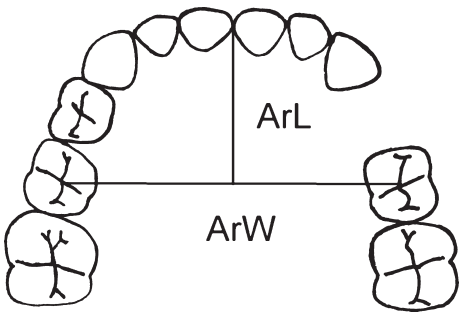

Fig. 2. Measurements of the arch width and the arch length.

4. Intercanine width: the distance between the cusp tips of the two primary canine teeth (Fig. 1).
5. Intercanine length: the perpendicular distance from the contact point of the central incisors to the intercanine width (Fig. 1).
6. Arch perimeter: the arc measured from the mesial midpoint of the permanent first molar (or the distal midpoint of the primary second molar if the permanent molar was missing) through the cusp tip of the canine and the incisal edges of the incisors to the opposite mesial midpoint of the permanent first molar (or the distal midpoint of the primary second molar if the permanent molar was missing), as measured with the aid of a brass wire (Fig. 1).

Table 1. Reliability coefficients for intraexaminer and interexaminer.

	Intraexaminer's group (n = 20)	Interexaminers' groups (n = 20)
D + E	0.954	0.947
Arch width	0.983	0.985
Arch length	0.995	0.994
Arch perimeter	0.997	0.996
Intercanine width	0.984	0.983
Intercanine length	0.994	0.992

Indices of reliability >0.900 exhibit high consistency and reliability.
D + E space: primary molar space.

Statistical analysis

Interexaminer and intraexaminer reliability testing. We used reliability coefficients to compare the consistency and reliability between the intraexaminer and interexaminer groups using an electronic digital caliper for each cast. We defined a statistically significant difference as $P < 0.05$. The two examiners (Y.-T.L. or W.-H.L.) performed and recorded the measurements for 20 casts obtained from 10 subjects for the purpose of reliability testing; they repeated the measurements 3 weeks later.

The means and standard deviations of six measurements for each of the 20 casts were the parameters used to compare the interexaminer and intraexaminer groups. Table 1 shows the results of reliability coefficient testing for the interexaminer and intraexaminer groups with regard to the D + E space, arch width, arch length, arch perimeter, intercanine length, and intercanine width. Indexes of reliability greater than 0.900 for the interexaminer and intraexaminer groups denote measurements that were highly consistent and reliable.

Statistical testing. For each participant, the initial D + E space of the contralateral intact primary molar served as a control. We used a paired *t*-test to compare the two sets of longitudinal cast measurements. In addition, we used a *t*-test to compare the D + E space changes with those of the control group. The level of significance (α) was 0.05.

Results

The age of the 13 subjects at the time of tooth extraction ranged from 5 years 1 month to 7 years 7 months, with a mean (±SD) age of 6.0 ± 0.74 years. Table 2 shows the D + E space changes between the initial examination and the 12-month follow-up

Table 2. Comparisons of the D + E space between the initial examination and 12-month follow-up examination on control and extraction sides.

Side of mouth	D + E space (Mean ± SD)(mm) Initial examination (n = 13)	12-month examination (n = 13)	P-value
Control	16.93 ± 1.03	16.92 ± 1.11	0.975
Extraction	16.66 ± 0.94	15.84 ± 0.97	0.025*
P-value	0.488	0.015*	–

*Statistically significant at $\alpha < 0.05$.

examination. As the table shows, the D + E space on the extraction side did not differ from the space on the control side at the initial examination. At the twelfth month examination, however, the D + E space on the extraction side was significantly smaller than the space on the control side, as well as smaller than the initial D + E space on the extraction side.

Table 3 presents the measurements for the five other parameters at the initial and after 12-month examinations. Intercanine width, intercanine length, and arch perimeter were significantly greater after 12 months tooth extraction than at the initial examination, with about 1 mm of space gained for each parameter. We found no significant differences in arch width and arch length between the initial examination and the 12-month follow-up examination. The difference in arch length approached statistical significance, however, with a P-value of 0.081 (Table 3).

Table 3. Changes in arch width, arch length, arch perimeter, intercanine width and intercanine length between initial examination and 12-month follow-up.

	Measurement (Mean ± SD) (mm) Initial examination (n = 13)	12-month examination (n = 13)	P-value
Arch width	41.85 ± 2.44	41.73 ± 2.07	0.757
Arch length	22.35 ± 2.04	23.10 ± 2.42	0.081
Arch perimeter	80.74 ± 3.47	81.75 ± 3.89	0.043*
Intercanine width	30.83 ± 2.07	31.92 ± 1.81	0.000*
Intercanine length	8.06 ± 2.01	9.35 ± 2.30	0.001*

*Statistically significant at $\alpha < 0.05$.

Discussion

Many factors may be involved in the consequences of premature extraction of primary teeth[2–5]. These include age at the time of tooth loss, facial and dental growth potential, status of dental interdigitation, oral habits, and study methodology. Our serial studies focused on individuals who underwent unilateral extraction of a primary first molar in either the maxillary or mandibular arch during a certain period of arch development[7,9]. This study continued our previous research on 6-month space changes after premature loss of a primary maxillary first molar, in order to achieve a better understanding of ongoing (12-month) space changes. Six of 19 original participants were excluded because of four cases with extensive decay leading to significant errors of case measurement, and loss to follow-up of two cases. Individuals with unilateral loss of one primary molar, as in this study, can be difficult to involve in a longitudinal study because they have a high rate of caries, leading to additional extraction of adjacent teeth and reducing the number of participants.

This study found significant space loss on the extraction side as measured by D + E space 12 months after extraction compared with the control side and with the initial D + E space (Table 2). We found no significant differences in arch width and arch length, indicating that 12-month space changes in the extraction side consisted primarily of distal movement of the primary canine toward the site of the extracted tooth. Similar to the conclusion in our 6-month study, these changes were responsible for the reduction in D + E space. Mesial movement of permanent molars or tilting of primary molars did not occur. Similarly, Northway observed cases of premature loss of a primary maxillary first molar and found no apparent mesial migration of the permanent molar. He recommended mesial slicing of the primary second molar in order to prevent the first premolar from erupting in a more mesial direction, causing permanent canine blockout[11].

Comparison with the control side showed that the amount of space loss 6 or 12 months after extraction of a primary first molar was

approximately 1 mm, the same amount found in premature loss of a primary mandibular first molar[7]. It appears that most of the space loss after extraction of a primary first molar in either arch occurs within the first 6 months. Richardson found the same tendency of a slowing space-closure rate after the first 6 months[12].

With regard to arch dimension, the intercanine width, intercanine length, and arch perimeter 12 months after tooth extraction were significantly greater than corresponding values at the initial examination. The overall picture is somewhat different from the 6-month results, which revealed no significant differences for arch perimeter and intercanine length, but significant increases in both intercanine width and arch length. The explanation for the 6-month results is that the increased intercanine width (gained from distal drifting of the primary canine) after premature loss of the first molar compensated for the extraction-associated reduction in arch length[9]. In this study, the increase in arch length approached statistical significance; however, we found no significant difference in arch width, suggesting that the increased arch dimension was gained during the second 6 months follow-up, especially in the anterior segment (intercanine width and intercanine length). This likely indicates that the permanent incisors will erupt in a more labial position, leading to an increased arch dimension, especially in the anterior segment.

The findings of our serial studies reveal only part of the scenario concerning premature loss of primary teeth. We found that mesial movement of permanent molars or tilting of the primary molars after premature removal of the primary first molars did not occur during the 12-month follow-up period. Park *et al.* used a three-dimensional laser scanner to investigate space changes associated with premature loss of a primary maxillary first molar and found a similar limited influence on the space in the permanent dentition[13]. Surprisingly, an increase in the arch dimension was seen in the anterior segment 12 months after tooth extraction. Ronnerman and Thilander used longitudinal data and found differences between the extraction side and control side in the lateral segment (cuspid-premolar segment) at 9 and 11 years of age[14]. These differences were reduced, and however, no longer significant at 13 years of age. It seemed that the increase of lateral segment could also be expected from their observation. Therefore, the results of our serial studies challenge the use of space maintainers, either the band-and-loop or palatal arch type, for preserving the extraction space after premature loss of a primary maxillary first molar. In addition, clinicians must give more consideration to individual clinical situations and factors, as described above, before deciding to use space maintainers. Terlaje and Donly expressed the same idea in their review of treatment planning for space maintenance, suggesting that no treatment be administered for unilateral loss of a primary first molar in patients in whom the permanent first molar had erupted, unless leeway space was to be preserved[15].

Although this study found statistically significant space changes, their clinical significance is limited given the change of only 1 mm from the initial examination to the 12-month follow-up examination. To preserve space loss as possible as we can during the transition of mixed dentition to permanent dentition is still important in order to prevent further space loss related consequences such as crowding of successors and protrusion of anterior teeth. Further, longitudinal studies or other risk-factor assessments are needed in order to provide a more complete picture regarding premature loss of the primary molars.

Conclusions

The 12-month space changes after premature loss of a primary maxillary first molar consist mainly of distal drift of the primary canine toward the extraction site around the time the permanent first molar is about to erupt or has just erupted. Mesial movement of permanent molars or tilting of the primary molars did not occur. An increased arch dimension was found especially in the anterior segment (intercanine width and length), suggesting that there is no need for the use of space maintainers in cases of premature loss of a

primary first molar around the time the permanent first molar is about to erupt or has just erupted.

What this paper adds

- The 12-month space changes after premature loss of a primary maxillary first molar present a different picture compared with immediate and 6-month results and with premature loss of a primary mandibular first molar.
- The 12-month space changes consist mainly of distal drift of the primary canine toward the extraction site around the time the permanent first molar is about to erupt or has just erupted.
- An increased arch dimension was found especially in the anterior segment (intercanine width and length).

Why this paper is important to paediatric dentists

- The results of this paper suggest that there is no need for the use of space maintainers after premature loss of a primary maxillary first molar around the time the permanent first molar is about to erupt or has just erupted.
- Clinicians must give more consideration to individual clinical situations before deciding to use space maintainers.

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