Effect of Extraction in the *Early* Mixed Dentition on the Eruption of the First Premolar in *Macaca Nemestrina*

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Serial extraction procedures are begun in the mixed dentition with the objective of guiding the eruption of the permanent dentition toward a more favorable alignment. Deciduous teeth are often extracted with the hope of accelerating the eruption of the permanent successors.

REVIEW OF LITERATURE

The effects of extracting deciduous teeth on the eruption of their permanent successors have been studied in both human[1-6] and nonhuman[7] subjects. The most recent investigation of the effects of premature loss of deciduous molars on eruption of the premolars was done on pigtail macaques (*Macaca nemestrina*) that were 27 to 33 months old at the time of extractions.[7] At this age, premolar root formation has begun and is roughly equivalent to that of a 10- to 12-year-old human, late mixed dentition. Their results showed that in all 19 extractions, ten in the lower arch and nine in the upper, all of the premolars on the extraction sides erupted before their antimeres regardless of sex, arch, chronological or dental ages.

The present study attempted to simulate the initial phases of serial extraction to permit an assessment of the effects of extracting the deciduous first molars of M. nemestrina during the *early* mixed dentition on the eruption of the first premolars.

METHODS

Subjects were 12 *M. nemestrina* (six males, six females) from the Primate Field Station of the Regional Primate Research Center at the University of Washington. All were known to be 15 to 16 months old at the time of extraction. Dental development at this age is similar to that of five- to six-year-old humans. The deciduous first molars were extracted unilaterally in all twelve animals.

To document the growth and development changes, 45-degree oblique head films were taken initially at the time of extractions and subsequently at periodic intervals until all first premolars had erupted. A modified orthodontic ear rod headholder[8] with a custom nasion rest[9] was used for all radiographs. The 45-degree oblique head film was chosen over the standard lateral head film because it provided a more distinct view of the first premolar region[10] (Figs. 1A and B). When the first premolars appeared to be nearing eruption into the oral cavity, visual intraoral examinations were made at three-week intervals to document clinical emergence. Clinical

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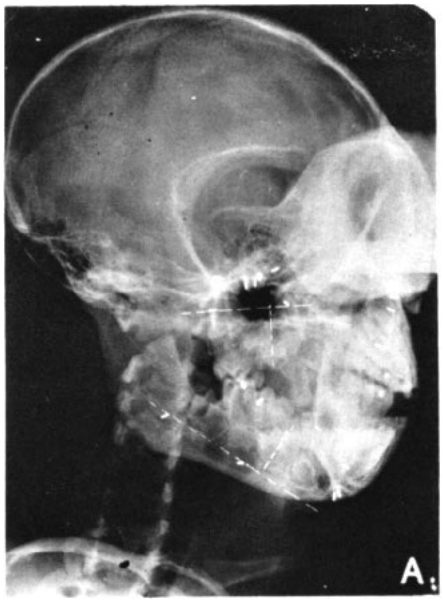

Fig. 1A Forty-five degree oblique head film of left premolar area. To determine the level of preclinical eruption a base line was established through the most occlusal aspect of two implants in each quadrant. A perpendicular was drawn from the base line to the most occlusal portion of the dental sac. The length of the perpendicular represented the relative level of eruption of the first premolar at that age.

Fig. 1B Standard lateral head film. The radiographs shown in Figs. 1A and B were taken on the same animal on the same day. Note the increased clarity of both the maxillary and mandibular first premolar regions on the 45-degree oblique head film (Fig. 1A).

eruption of the first premolars was defined as the penetration of any portion of the crown through the gingiva into the oral cavity.

Before extraction of the deciduous teeth, tantalum implants were placed in the cranial base, maxilla and mandible as described by Garfinkle[11] and Van Ness.[12] The implants were used to evaluate the position of the first premolars during the preclinical eruption phase of this study. To accomplish this, a baseline was traced through the most occlusal aspect of two implants in each quadrant on the head film. From this baseline a perpendicular was drawn to the most occlusal portion of the dental sac of the developing first premolar (Fig. 1A). The length of this perpendicular represented the relative level of eruption of the first premolar. Measurements were made with Helios calipers accurate to the nearest 0.05 mm. The measurements were repeated on the longitudinal radiographs to document and compare the eruption rates between the extraction and control sides. Eruption rates (mm/month) were calculated by determining the difference in the level of eruption on successional head films and dividing this by the number of months in the interval.

To evaluate the error in radiographic and measurement techniques, five head films were taken on the same animal on the same day. Before each radiograph the monkey was completely removed from the headholder and repositioned. The distance from

TABLE I

Eruption measurements (to nearest 0.05 mm) of mandibular first premolars made from five head films of one animal, all taken on the same day.

Film	*Right*	*Left*
1	2.35	4.45
2	2.40	4.70
3	2.40	4.45
4	2.25	4.50
5	2.35	4.45
Mean	2.35	4.51
S.D.	0.06	.0.11

the most occlusal portion of the dental sac to the implant reference line was measured on both right and left sides in each of the exposures. The measurements are shown in Table I. On both the right and left, four of the five measurements are within 1 S.D. For the most part this variation is 0.05 mm. The standard deviations, 0.06 and 0.11 mm, represent the error attributable to measurement technique. The uniformity of the figures indicates the accuracy of this technique and the minimal potential for error.

Results

During the course of this study, six of the original twelve animals died of causes unrelated to experimental procedures. This high mortality rate reduced the final sample size to a point that hypothesis testing was not feasible.

The preclinical eruption phase of this study, ages 450 to 1020 days, was relatively uneventful. The eruption information accumulated during this period is shown in Tables II and III.

Table II shows the averaged eruption rates of the first premolars for the entire sample and male and female groups. Regarding the entire

TABLE II

Average eruption dates (mm/month) of first premolars during preclinical eruption phase.

Age	Maxilla				Mandible			
	Extraction		Control		Extraction		Control	
(months)	mean	range	mean	range	mean	range	mean	range
Total Sample								
15.5-19.5	0.38	(0.30-0.60)	0.28	(0.09-0.56)	0.22	(0.15-0.35)	0.27	(0.19-0.46)
19.5-22.0	0.41	(0.10-1.0)	0.35	(0.20-0.70)	0.23	(0.00-0.50)	0.28	(0.04-0.66)
22.0-25.5	0.14	(0.06-0.26)	0.17	(0.11-0.21)	0.24	(0.11-0.39)	0.18	(0.00-0.37)
25.5-33.5	0.16	(0.03-0.26)	0.20	(0.13-0.29)	0.11	(0.00-0.20)	0.15	(0.06-0.24)
15.5-33.5	0.28		0.25		0.20		0.22	
Males								
15.5-19.5	0.32	(0.30-0.34)	0.27	(0.22-0.29)	0.20	(0.15-0.24)	0.35	(0.23-0.46)
19.5-22.0	0.29	(0.10-0.40)	0.23	(0.20-0.26)	0.20	(0.18-0.22)	0.20	(0.10-0.30)
22.0-25.5	0.08	(0.06-0.10)	0.17	(0.11-0.21)	0.18	(0.11-0.24)	0.08	(0.00-0.16)
25.5-33.5	0.12	(0.03-0.21)	0.26	(0.23-0.29)	0.13	(0.08-0.17)	0.19	(0.14-0.24)
15.5-33.5	0.20		0.23		0.17		0.21	
Females								
15.5-19.5	0.45	(0.36-0.60)	0.31	(0.09-0.56)	0.25	(0.15-0.35)	0.19	(0.19-0.19)
19.5-22.0	0.55	(0.24-1.0)	0.48	(0.36-0.70)	0.25	(0.00-0.50)	0.35	(0.04-0.66)
22.0-25.5	0.20	(0.13-0.26)	0.16	(0.13-0.18)	0.30	(0.20-0.39)	0.25	(0.14-0.37)
25.5-33.5	0.23	(0.19-0.26)	0.16	(0.13-0.18)	0.10	(0.00-0.20)	0.06	
15.5-33.5	0.37		0.27		0.22		0.24	

sample, the maxillary first premolars on the extraction side erupted at a slightly greater rate than the controls (0.28 mm/month vs. 0.25 mm/month). The mandibular first premolars on the extraction side erupted at a slightly slower rate than the controls (0.20 mm/month vs. 0.22 mm/month). In all four quadrants the eruption rates prior to age 22 months were generally higher than in the later stages (Fig. 2). This was substantially so on the extraction and control sides in the maxillary arch, and slightly greater in both quadrants of the mandibular arch. Dividing the sample into male and female groups, a sexually dimorphic pattern is evident. The eruption rates of the first premolars were faster in the females than in the males for both the extraction and control sides. As a group, the females exhibited a higher average eruption rate on the extraction side in the maxillary arch, but a slightly lower eruption rate on the extraction side in the mandibular arch. The males showed a higher average eruption rate in the control quadrants of both arches.

Table III shows the timing of clinical eruption of the first premolars in days of age, with male, female and overall means. Overall means indicate maxillary eruption is accelerated, whereas in the mandible it is delayed. Male and female means indicate a sexually dimorphic response. Extraction in females resulted in earlier eruption in both maxillary and mandibular arches. In males, extraction of first deciduous molars delayed the clinical emergence of the first premolar in both arches. However, the variability of the individual responses is significant.

TABLE III

Timing of clinical eruption* of the first premolars (all ages in days)

		Age at Eruption			
		Maxilla		*Mandible*	
Animal	*Age at Extraction*	*Extraction*	*Control*	*Extraction*	*Control*
Male					
73026	477	1470	1395	1635	1620
73048	452	1170	1170	1470	1110
73063	445	1320	1260	1650	1620
Mean		1320	1275	1590	1455
Female					
73019	466	1275	1230	1230	1275
73039	461	780	1275	1215	1260
73046	462	1125	1320	1140	1260
Mean		1059	1275	1194	1260
Overall mean		1191	1275	1389	1359

* Penetration of gingiva into oral cavity.

Discussion

The high mortality rate of this sample so reduced its size that hypothesis testing was not possible. Nevertheless, we did observe trends that may complement the findings from other studies, as well as indicate directions for future research.

In the literature on human subjects there is a lack of agreement regarding the effects of extracting the deciduous first molars during the early mixed dentition stage on the eruption of their successors. Pankova and Hajek[4] and Butler[1] found that early loss of deciduous teeth played no major role in altering the eruption of their permanent successors, whereas others have concluded that early loss of the deciduous first molar did affect the eruption of the first premolar to varying degrees. Sleichter[6] found a general acceleration in first premolar eruption; so did Fanning,[13] except that in four to four and a half year olds, an initial spurt in eruption was followed by a dormant period allowing the non-extraction side first premolars to erupt earlier. Carr,[2] Hargreaves,[3] and Posen[5] found that loss of the first deciduous molar accelerated the first premolar eruption in the maxilla, but delayed first premolar eruption in the mandi-

ble when the loss of the primary tooth occurred before ages seven, six, or eight years, respectively.

The results of this investigation indicate that extraction of the deciduous first molars during the *early* mixed dentition stage results in alterations in the eruption rate and timing of the first premolars. On the average our findings were in agreement with those of Hargreaves[3] and showed that extraction of the deciduous first molars in *M. nemestrina,* equivalent in dental development to that of five or six year old humans, caused an accelerated eruption in the maxillary first premolars and a delayed eruption in the mandibular first premolars.

When this sample was segregated into male and female groups, the observations presented a different picture of first premolar eruption (Table III). In female *M. nemestrina,* clinical eruption of the first premolars on the extraction side was accelerated in both the maxillary and mandibular arches whereas in the males, clinical eruption of the first premolars on the extraction side was delayed in both the maxillary and mandibular arches.

However, more significant than the mean response was the high degree of variability in the alteration of eruption timing. Although the maxillary first premolars on the extraction side erupted an average of 84 days before controls, in three animals the maxillary first premolar on the control side actually erupted first; the variability was also demonstrated in mandibular first premolar eruption. When the results were evaluated for males and females separately, individual variation was still evident. These findings point to the difficulty of predicting the effects of extracting the deciduous first molar during the early mixed dentition stage on the eruption of the first premolar.

Garfinkle et al.[7] reported that in *M. nemestrina* 27 to 33 months old at the time of extraction of the deciduous first molars, an accelerated eruption of the first premolars on the extraction sides occurred without exception, regardless of sex. Contrasting this with our findings, it appears that the importance of sexual dimorphism and individual variation in the prediction of premolar eruption apparently decreases with the increasing age of the animal at the time of extraction. This is in agreement with Posen[5] who found that extraction of the deciduous first molars in five year old humans delayed both maxillary and mandibular premolar eruption, in five to eight year olds caused variable eruption patterns, and after eight years of age, accelerated the eruption of the first premolar.

As might be expected, increased eruption rates on the average resulted in earlier clinical emergence of the succedaneous tooth. Conversely, delayed emergence generally resulted from decreased eruption rate (Tables II and III). It is interesting to note that, for the most part, the eruption rates of the maxillary and mandibular first premolars in both the extraction and control quadrants were higher before age 22 months. Since this pattern occurred on the experimental side as well as the control side, it indicates that this characteristic in the eruption of the first premolar is unaffected by the extraction of the deciduous first molar (Fig. 2). The significance of this finding is questionable owing to the small sample size. However, it does suggest that alterations in eruption timing occur in the later stages of preclinical eruption.

Summary and Conclusions

The effects of extracting deciduous first molars during the early mixed dentition stage on the eruption of the

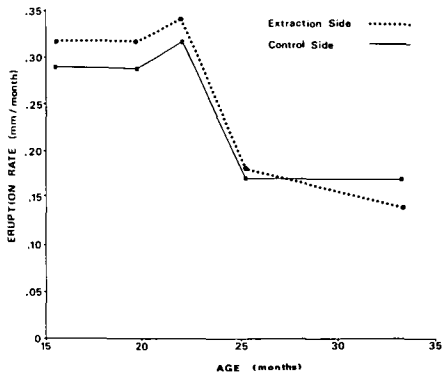

Fig. 2 Graph illustrating the average eruption rates for all six *M. nemestrina* from ages 15.5 to 33.5 months. The data for both the maxillary and mandibular arches are averaged together to give one curve for all extraction side first premolars and one for all control side first premolars. The curves show that on both the extraction and control sides the average eruption rates are considerably higher prior to age 22 months. The uniformity of this pattern on both extraction and control quadrants indicates that it is unaffected by extraction of the deciduous first molars during the early mixed dentition stage.

first premolars were studied in six *M. nemestrina,* three males and three females, age 15 to 16 months at the time of extraction. Their dental development was comparable to that in five to six year old humans. Preclinical eruption rates were determined from measurements made on 45-degree oblique head films and the age at clinical emergence of the first premolars.

On the basis of the findings of this study, the following trends were established:

1. Extraction of the deciduous first molars during the early mixed dentition stages appears to alter the clinical eruption rate and timing of the first premolars.
2. Early extraction of first deciduous molars showed a sexually dimorphic response. In females, clinical eruption was accelerated in both maxillary and mandibular arches whereas males exhibited a delayed eruption in the extraction quadrants. However, this is an observation based on means. Individual variation compromises the predictability of the effects of early deciduous extraction.
3. Female *M. nemestrina* apparently exhibit a higher preclinical eruption rate as well as an earlier clinical eruption of the first premolars on both the extraction and control sides than do males.

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