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

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Serial extraction has been defined in the literature as the extraction of deciduous and permanent dental units for the purpose of harmonizing the amount of tooth material with the available supporting tissues. In many instances the deciduous teeth are extracted in mixed dentition patients in an attempt to alter the eruption of their successors. The idea of extracting a primary tooth to affect the eruption of the permanent successor is not a new one. Ambroise Pare, a French surgeon during the 16th century, observed that in some instances the retention of a deciduous tooth would lead to a deformity in the permanent dentition. In these cases he advocated removal of the primary tooth to allow the permanent dentition to "assume its natural position" in the arch. The rationale for serial extraction in modern orthodontics was first defined by Kjellgren in 1929 and since then the importance of serial extraction has become widely recognized and studied.

REVIEW OF LITERATURE

There is a lack of agreement among reports with regard to the effect of extraction of deciduous teeth on the eruption of their permanent successors. Studies involving humans have been complicated by arch length loss,[1,2] or unilateral extractions required by caries or its complications[3,4] rather than being elective.

The clinical impression of Kjellgren[5] and others[6,7] has been that correct timing of deciduous tooth extraction would hasten eruption of the permanent successors. Butler[2] found that premature extraction of deciduous molars at any age was not associated with significant earlier eruption of premolars. Brandt[8] noted that selective extraction of deciduous teeth did not always accelerate eruption of the successional teeth. Sleichter[4] concluded that removal of a deciduous tooth usually expedited eruption of its successor, but in some cases eruption was retarded. Posen[9] found that following early loss of a deciduous molar at four to five years of age, eruption of premolars was delayed, but from age six through ten years, a progressive increase in the percentage of accelerated premolar eruption occurred.

Bodegom[10] performed early and late extractions of deciduous teeth in miniature pigs and found in the former no systematic effect on clinical emergence of the successional teeth, while in the latter significantly earlier clinical emergence of the successors occurred.

The purpose of this study was to assess the effect of elective deciduous tooth extraction in the *late* mixed dentition on eruption of successional teeth in *Macaca nemestrina*. This

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primate is a good experimental model since mandibular arch length does not decrease as in humans, but actually increases.[11]

Materials and Methods

Ten *Macaca nemestrina* monkeys born and reared in the breeding colony of the Regional Primate Center of the University of Washington at Medical Lake, Washington were selected for the study. Dental development at the time of selection ranged from the presence of loose deciduous mandibular central incisors to the early clinical emergence of the permanent mandibular central incisors, and corresponded to a dental age of 27-33 months.[12]

The animals were all similarly prepared by the placement of dental, skeletal, and cranial base implants[13] as well as implanted head positioners.[14] Each animal had left maxillary and mandibular deciduous first molars extracted with surgical forceps; no tissue flaps were reflected nor was bone removed. The above surgical procedures were performed under general anesthesia.[15] Serial cephalometric radiographs were taken at three month intervals.

The ten monkeys used in this study had a chronologic age range of 33.5 to 44.7 months at the time of extraction. Dental developmental age was derived from an evaluation of a lateral cephalometric radiograph of each animal taken on the day of extraction, based on Merrill's[12] data on dental development and eruption in *Macaca nemestrina*. Dental age ranged from 31 to 42 months and is compared to chronologic age in Table I.

The time interval between the date of extraction of the deciduous left first molars and the date of eruption of the experimental and control succedaneous teeth was calculated for each arch in each animal. Eruption was defined as the earliest visual emergence of a tooth into the oral cavity.

TABLE I

COMPARISON OF CHRONOLOGIC AGE AND DENTAL AGE (MONTHS) AT TIME OF EXTRACTION OF LEFT PRIMARY FIRST MOLARS

Monkey Number	*Sex*	*Chronologic Age*	*Dental Age**
M6922	M	44.7 (1360)†	42
M6999	F	39.3 (1180)	31
M69109	F	39.1 (1174)	36
M702	F	35.8 (1075)	33
M704	M	36 (1079)	33
M7012	M	35.1 (1054)	33
M7043	M	33.8 (1014)	35
M7044	F	33.8 (1014)	31
M7049	M	33.7 (1010)	35
M7064	M	33.5 (1005)	33

† Chronologic age in days
* Determined by Merrill's method

Results

The mean difference between the first premolar eruption time on the experimental and control sides of both arches was evaluated utilizing the paired "t" test ($\alpha = .05$) (Table II).

In all cases the first premolar on the experimental side erupted before that on the control side, regardless of the differences in sex, chronologic and dental age. The range of difference in eruption time was 91 to 375 days in the maxilla with a mean of 183.9 days, and 26 to 175 days in the mandible with a mean of 105 days.

Paired "t" tests revealed that the mean difference in eruption times of first premolars between the experimental and control sides of both arches was significant at .001 level of confidence.

On the extraction side the general

TABLE II

MONKEY NUMBER	MAXILLA					MANDIBLE				
	Experimental Side		*Control Side*			*Experimental Side*		*Control Side*		
	Age	*Time Elapsed*	*Age*	*Time Elapsed*	*Difference*	*Age*	*Time Elapsed*	*Age*	*Time Elapsed*	*Difference*
M6922	X	X	X	X	X	1465	105	1640	280	175
M6999	1270	90	1376	196	106	1359	179	1418	238	59
M69109	1275	101	1366	192	91	1239	65	1394	220	155
M702	1221	146	1596	521	375	1354	279	1515	440	161
M704	1140	61	1330	251	190	1400	321	1477	398	77
M7012	1143	89	1305	251	162	1527	473	1575	521	48
M7043	1101	86	1305	291	204	1471	457	1497	483	26
M7044	1157	143	XX	XX	XX	1189	175	XX	XX	XX
M7049	1083	73	1270	260	187	1286	276	1356	346	70
M7064	1183	178	1339	334	156	1165	160	1339	334	174
		107.4		287.0	183.9		249.0		362.2	105.0

Chronologic age (days) at the time of eruption of the first premolars and time elapsed (days) from the extraction of the primary first molars and eruption of the first premolars.

Paired "t" test: Experimental side vs. control side in both arches: $n = 17$, $t = 7.12$, $d = 142.2$, $S\bar{d} = 82.3$, $S\bar{d} = 19.9$, d.f. $= 16$, and $P < .001$.

X Maxillary first premolars had already erupted at initiation of the experiment.

XX Observations terminated due to accidental death.

pattern was for the maxillary first premolar to erupt before the mandibular; two of the ten mandibular first premolars erupted before their antagonists (in M69109 and M7064). The same pattern was observed on the control side with only one mandibular first premolar erupting before its antagonist (M702), and one at the same time (M7064).

Observations were prematurely terminated in M7044 because of accidental death. In the maxillary arch of M6922 there were no observations because at the time of extraction this animal had already erupted the maxillary first premolars.

Discussion

The evidence gained from this investigation is fairly conclusive, namely, that extraction of deciduous first molars in the late mixed dentition is seen to accelerate eruption of succedaneous teeth in *Macaca nemestrina*. This approximately coincides with the time when deciduous first molar extraction in a serial extraction sequence would normally be performed in the human child.

No data indicating a statistically significant difference in the eruption time of the right and left homologous teeth in *Macaca nemestrina* have been reported in the literature. Hurme and Van Wagenen[16] found some variation in the eruption times of pairs of teeth in *Macaca mulatta*, but these were not quantified. There is considerable documentation to show that no difference exists in humans.[17-20] Sturdivant et al.[21] found that the mean times of gingival emergence of homologous teeth of the same dental arch were practically alike. No significant variation between right and left sides in a control group of 25 patients was found by Posen.[9] Lysell et al.[22] reported that the teeth of Swedish children did not show any tendency to erupt earlier on one side of the jaw than the other.

Fanning,[3] Sleichter,[4] and Brandt[8] agreed that conditions such as trauma and apical pathology were important factors in hastening eruption of permanent successors. In this study the only trauma introduced was during the extraction procedure.

Merrill[12] found that the average age of *Macaca nemestrina* at the time of eruption of mandibular first premolars was 46 months with a range of 42 to 48 months; and of the maxillary first premolar, 43 months with a range of 40 to 46 months. The results of this study corroborate Merrill's findings that the first premolar erupts in the maxilla before the mandible in *Macaca nemestrina*.

Numerous histologic studies of tooth movement indicate that cementum and dentin are in general more resistant to resorption than surrounding alveolar bone. It seems logical that resorption of tooth material is a slower process and that once the permanent tooth is actively erupting, additional time is required for resorption of the primary tooth roots. This study supports the suggestion by Carr[1] that, with timed extraction of the primary tooth, this requirement is eliminated and the eruption process is accelerated, at least as far as emergence through the bone is concerned.

Conclusions

The effect of deciduous tooth extraction in the late mixed dentition on the eruption of succedaneous teeth was studied in ten *Macaca nemestrina*. Nineteen deciduous teeth were extracted: nine maxillary and ten mandibular left deciduous first molars. Regardless of sex, arch, chronologic or dental age, all first premolars on the experimental side erupted before those on the control

side and this pattern was statistically significant. Extraction of deciduous molars in the late mixed dentition is seen to accelerate eruption of first premolars in *Macaca nemestrina*. This could be the result of eliminating the need for deciduous tooth root resorption during the normal process of eruption.

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