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Agenesis of mandibular second premolars with retained primary molars. A longitudinal radiographic study of 99 subjects from 12 years of age to adulthood

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SUMMARY In subjects with agenesis of the second mandibular premolar teeth, the primary molar may be left *in situ*. The long-term prognosis of a retained primary molar has not been established in any study that included large number of patients. The aim of this investigation was to monitor the survival of retained mandibular second primary molars, from 12–13 years of age to adulthood. The material comprised the radiographs of 99 subjects, 37 males and 62 females, with retained primary molars and agenesis of 149 mandibular second premolars. In subjects with bilateral agenesis, only one randomly selected primary molar was included to ensure that all primary molars were statistically independent units. Three variables were recorded on intraoral radiographs at 11 registration stages starting at 12–13 years of age: the distance between the permanent molar and the premolar abutting the retained primary molar, infraocclusion of the primary molar, and resorption of the primary molar roots. The mean age at the final registration was 24 years 7 months, [standard deviation (SD) 5.3 3 years, range 18.25–45.44 years]. Paired *t*-tests were used to analyse changes in the variables and intraclass correlation coefficient (ICC) to determine whether all primary molars could be included in the analyses.

During the observation period, only seven of the 99 primary molars were lost due to extensive root resorption, infraocclusion, or caries. Long-term survival may be expected in more than 90 per cent of patients with retained primary molars with agenesis of mandibular second premolars.

Introduction

In Scandinavian children, the prevalence of agenesis in the permanent dentition is reported to be 6–8 per cent (Grahnén, 1956, Thilander and Myrberg, 1973). Excluding third molars, the most commonly missing teeth are the mandibular second premolars, which are absent in 2.4–4.3 per cent of the population (Grahnén, 1956; Ravn and Nielsen, 1973; Thilander and Myrberg, 1973; Bergström, 1977; Locht, 1980).

The time of the diagnosis of agenesis is of importance. Although treatment should be started early, it should be borne in mind that the condition may be diagnosed as late as 9–10 years (Wisth *et al.*, 1974; Steffensen, 1981).

From 3 to 19 years, Swedish children undergo an oral examination carried out at Public Dental Service every 1 or 2 years. Occlusal abnormalities are monitored and, where necessary, the child may be referred to an orthodontist.

A correlation between hypodontia and other anomalies has been hypothesized. Hoffmeister (1977) and Pfeiffer (1974) suggested that developmental anomalies such as hypodontia, supernumerary teeth, peg-shaped lateral incisors, and ectopic eruption of maxillary first permanent molars are all microsymptoms of an hereditary disturbance due to a general disturbance of the tooth developmental structures.

Bjerklin *et al*. (1992) found a reciprocal association between infraocclusion of the primary molars and aplasia of the premolars. The children with premolar aplasia also exhibited a higher prevalence of ectopic eruption of maxillary canines than that found in the general population. In an untreated orthodontic population aged 7–14 years, Baccetti (1998) reported association patterns for seven anomalies (aplasia of second premolars, small maxillary lateral incisors, infraocclusion of primary molars, enamel hypoplasia, ectopic eruption of the first molar, supernumerary teeth, and palatal displacement of maxillary canines). That author concluded that the group with second premolar aplasia demonstrated significant associations not only with infraocclusion of primary molars but also with small maxillary lateral incisors, enamel hypoplasia, and palatal displacement of the maxillary canines.

When agenesis of mandibular second premolars is diagnosed, there are a number of treatment options. The primary molar may be left *in situ* or extracted. In some cases, the contralateral premolar and the maxillary premolars are also extracted, with spontaneous space closure or closure with a fixed orthodontic appliance. The maxillary third molar may be autotransplanted. Other options are implant-supported prosthetic replacement or a tooth-supported bridge and pontic.

Many factors must be considered in the orthodontic treatment plan. The skeletal and dentoalveolar classifications are of importance. To extract the mandibular second primary molars to try to close the spaces in a low angle subject, may be contraindicated, especially in uncrowded cases. The condition of the second primary molar is another factor. Retention of the tooth may be contraindicated because of caries or large restorations or when there is progressive root resorption and infraocclusion.

Several methods of managing agenesis of mandibular second premolars have been described (Kokich and Kokich, 2006).

Joondeph and McNeill (1971) suggested that in subjects with hypodontia, the primary mandibular molar should be extracted early, before 11 years of age, to allow spontaneous space closure.

In a 4 year follow-up after extraction of the primary molar in subjects with agenesis of the second premolar, Mamopoulou *et al.* (1996) showed that 80 per cent of the extraction space was closed, leaving a mean residual space of 2 mm. Lindqvist (1980) reported similar findings. In 84 per cent of selected cases, the space was closed by mesial drift and tipping of the first molar and distal drift and tipping of the first premolar. Extraction of the primary molar after completed root development of the second molar and first premolar often leads to more tipping of these teeth. Lindqvist (1980) also reported a significant mandibular dental midline shift to the extraction site.

A simple technique can be used in extraction therapy, namely hemisection or controlled slicing. The method is based on slicing the second primary molar and removing the distal half. This will allow mesial drift of the first permanent molar. As soon as the movements slow, the residual mesial root half is removed. If the mechanisms are carefully designed and supported, the mandibular molar can be moved mesially with less anterior tipping and loss of anchorage (Northway, 2004; Valencia *et al.*, 2004).

In an uncrowded arch in which the second primary molar is at risk of progressive root resorption or pronounced infraocclusion and mesial movement of the first permanent molar is considered difficult or undesirable, autotransplantation may be the treatment of choice. Transplantation preserves alveolar bone volume and replaces a missing tooth without involvement of adjacent teeth, as, e.g. in tooth-supported prosthetic treatment. The tooth that can be used for such transplantation is a maxillary third molar, which has approximately the same crown size as a mandibular second primary molar. The success rates for autotransplantation range from 82 to 94 per cent (Lundberg and Isaksson, 1996).

Fixed orthodontic appliance therapy can achieve space closure if the decision to extract the second primary molar is made late, i.e. after 11–12 years of age, or if spontaneous space closure has not occurred (Kokich and Kokich, 2006). Mandibular anterior crowding can be relieved in this manner.

Extraction of the mandibular second primary molar is contraindicated in subjects with no crowding, with a pronounced deep bite and a hypodivergent vertical skeletal pattern, or with mandibular retrusion or generalized spacing of teeth. It is difficult to close space in these cases without detrimental effects, e.g. on the facial profile.

In these circumstances, leaving the primary molar *in situ* would be an option. There are, however, few long-term studies with a large number of patients followed to adulthood that have investigated retained mandibular second primary molars.

Rune and Sarnäs (1984) studied 77 subjects with retained second primary molars, up to a mean age of 17 years: only 5 per cent of the primary molars were extracted because of infraocclusion and in almost 50 per cent root resorption levels remained unchanged. No correlation between root resorption and infraocclusion was observed. Similar findings were reported by Ith-Hansen and Kjær (2000). In a sample of 26 second primary molars, root resorption remained unchanged in 23. Bjerklin and Bennett (2000) studied 59 retained mandibular second primary molars in 41 subjects. The mean age at the final registration was 20 years and 6 months. Almost 35 per cent had unchanged root resorption levels from the first to the third registration (11–16 years). In several cases, root resorption ≥50 per cent was recorded at the initial registration, but the second primary molars still remained *in situ* 19–20 years or later. There are two studies of adult subjects (Sletten *et al.*, 2003; Nordqvist *et al.*, 2005).

Sletten *et al.* (2003) evaluated root resorption and submergence of retained second primary molars in 20 adult patients selected from more than 6000 subjects.

Nordqvist *et al.* (2005) undertook a cross-sectional study in Sweden. All 170 dentists in one county were requested by letter to submit intraoral radiographs of patients aged 18 years or older with retained primary teeth. Twenty per cent responded to the request and provided radiographs from 65 patients with 89 primary teeth. With respect to mandibular second primary molars, the study supported the opinion that these teeth have a good long-term prognosis despite a significant correlation between root resorption and age. More root resorption was recorded in the older subjects.

In cases of premolar agenesis, there are no long-term follow-up studies of retained mandibular second primary molars from 12 years of age to adulthood with a large number of subjects.

The aim of the study was primarily to follow the long-term survival of retained primary molars and also to monitor any changes in infraocclusion and root resorption or changes in the mesiodistal arch width between the first permanent molar and the first premolar.

Subjects and methods

The material comprised the radiographs of 99 subjects, 37 males and 62 females, diagnosed with retained second

Table 1 Distribution of the 99 patients with agenesis of the mandibular second premolars and persisting second primary molars at the different registration stages and the age at registration. One tooth from each patient.

Age (years)	12–13	14–15	16–17	18–19	20–21	22–23	24–25	26–27	28–29	30–33	34–45
Registration	1	2	3	4	5	6	7	8	9	10	11
Number of patients	99	92	95	96	82	60	50	32	22	13	6

primary molars and agenesis of 149 mandibular second premolars. The subjects underwent regular dental check-ups by general dental practitioners at intervals of 1–2 years that included the taking of intraoral, periapical, and bitewing radiographs obtained using the same technique which were sent to the institute. In all, there were 11 sets of registrations, from the initial registration at 12–13 years of age to the final registration at 18 years of age or older.

Intraoral radiographs were not available or possible to register at each of the 11 registration stages for every patient. Eighty-two patients had reached 20–21 years of age and 60, 22–23 years of age at their last registration (Table 1).

The mandibular second primary molars with congenitally missing successors were *in situ* because, e.g. there was negligible crowding in the lower arch, the children or their parents refused extractions and/or orthodontic treatment, or closing spaces would have been contraindicated, and the primary molars were in good condition.

The intraoral radiographs were examined by three of the authors (KB, MAN, HK) after calibration in the registration methods.

The distance between the first permanent molar and the first premolar was measured using a digital calliper in tenths of a millimetre. The width of the second primary molar was used as the baseline distance. A reduction in this measurement indicated tipping of the adjacent teeth (Figure 1).

Infraocclusion was recorded if the tooth had lost its vertical position relative to the neighbouring teeth (Kurol, 1981). It was measured in tenths of a millimetre from the occlusal plane to the occlusal surface of the primary molar (Figure 1).

Root resorption was assessed subjectively and scored on a six-point scale of severity according to Bjerklin and Bennett (2000). Each root was registered separately (Figure 2).

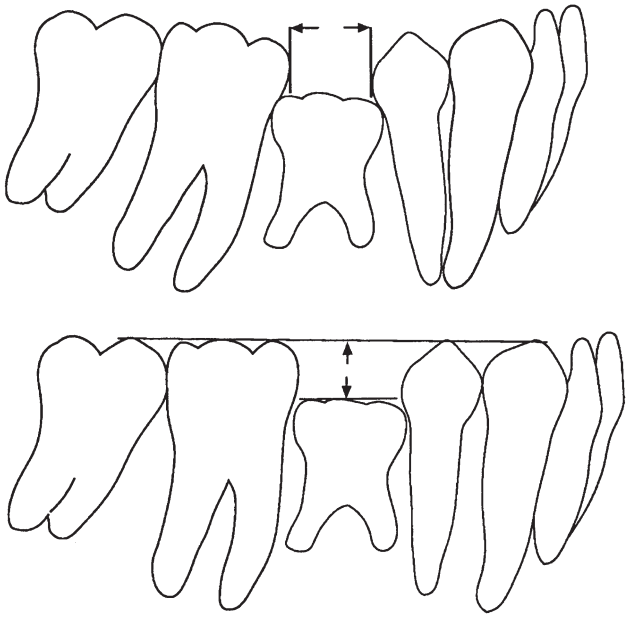

Figure 1 Measurement of the distance between the mandibular first molar and first premolar with the width of the primary molar as baseline and the measurement of infraocclusion.

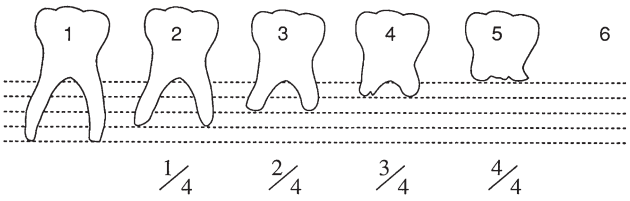

Figure 2 The different resorption stages, measuring quarters of each root (Bjerklin and Bennett, 2000).

Statistical analysis

All statistical analyses were undertaken using the Statistical Package for Social Sciences (Windows 2000 version 13.0; SPSS Inc., Chicago, Illinois, USA).

Paired *t*-tests were used to analyse whether changes in the same variables between different registration stages were statistically significant: the distance between the first permanent molar and the first premolar and infraocclusion. Intraclass correlation coefficient (ICC) analyses were used to determine whether all primary molars could be used in the analyses, i.e. whether in cases of bilateral agenesis two primary molars in the same patient could be treated as independent units. ICCs were also used in the error study (Kirkwood, 1996).

Error of the method

The errors of the measurements were estimated by duplicate determination after an interval of 1–2 months. The three examiners repeated all measurements on 10 teeth. The differences between the two measurements were negligible. ICC analyses showed no significant differences ($P > 0.05$)

between the measurements recorded either at the two sessions or between the examiners.

Results

General results

ICC showed greater similarity between bilateral primary molars than the overall average of the group of primary molars. Thus, in cases of bilateral agenesis, the two primary molars were not independent. Statistical analyses were therefore made on 99 second primary molars, one from each of the 99 patients. In cases of bilateral agenesis, the primary molar to be included in the study was randomly selected. The final material comprised 55 left and 44 right mandibular primary molars. The distribution of the subjects at the different registrations is presented in Table 1.

At the final registration, in 11 subjects (five males and six females) the mandibular second primary molar had been lost: seven on the left and four on the right side (Table 2).

Distance between the mandibular first molar and first premolar

The mean distance from the mesial of the mandibular first permanent molar to the distal of the first premolar did not change markedly from registration to registration. At baseline, the mean width of the primary molar was 10.56 mm [standard deviation (SD) 0.60]. At registration point 5 (20–21 years of age), the distance between the first molar and first premolar was 10.08 mm (SD 0.82), measured on 81 of the cases (Table 3). At registration point 9 (28–29 years of age), the figures were very similar (mean 10.08 mm, SD 0.83).

When comparing this distance for 81 of the subjects at the first and fifth registrations, the mean change was significantly reduced (0.50 mm, SD 0.75; Table 4). The maximum change between two successive registrations was less than 0.2 mm.

In eight patients, the distance between the first premolar and the first molar was less than 9 mm at each of the registrations. One measured 7.6 mm at the initial registration, decreasing to 2.7 mm at registration 4 (18–19 years of age). This tooth was extracted at 21 years of age. In another subject in whom the width of the primary molar was 10.6 mm, the distance between the first molar and first premolar was 9.6 mm at the first registration, decreasing to 8.9, 8.6, 8.6, 8.6, and 8.6 mm through the subsequent five registrations.

Table 2 The 11 patients (five males, six females) who had lost mandibular second primary molars (four on the right side and seven on the left side).

Number of lost primary molars	Age (years)	Cause
4	19–20	Replaced by two implants and two transplanted maxillary third molars
1	21	Root resorption and infraocclusion
2	22–23	Progressive infraocclusion
1	24	Caries
2	33	Root resorption
1	35	Caries

Infraocclusion

The greatest mean infraocclusion of the primary molar was 1.62 mm, recorded at registration stage 9, with an SD of 1.33 mm (Table 5). The maximum infraocclusion was 10 mm, registered in one patient. Infraocclusion of more than 5 mm was observed in four patients.

Infraocclusion was recorded for a total of 18 (21 per cent) of the 86 teeth at the initial registration, 41 (50 per cent) of the 82 registered at 20–21 years and 11 (52 per cent) of the 21 primary molars registered at the age of 28–29 years.

Six subjects presented with infraocclusion of more than 2 mm at the initial registration: 2.2, 2.4, 3.4, 3.6, 3.7, and 5.2 mm, respectively. Infraocclusion progressed to 3.4, 5.2,

Table 3 The distance (mm) between the first molar and first premolar, and the width of the primary molar.

	Primary molar width	Distance between the first molar and first premolar										
		Age (years)—registration stage										
		12–13	14–15	16–17	18–19	20–21	22–23	24–25	26–27	28–29	30–33	34–45
	0	1	2	3	4	5	6	7	8	9	10	11
Mean (mm)	10.56	10.52	10.35	10.19	10.08	10.08	9.98	9.97	9.89	10.08	10.10	9.90
SD	0.60	0.75	0.82	0.97	1.19	0.82	0.87	0.82	1.11	0.83	0.96	0.84
Range	9.3–12.0	7.6–12.8	6.6–12.8	5.1–12.7	2.7–12.0	8.0–12.0	7.5–11.9	7.4–11.4	6.1–11.4	8.2–11.4	8.2–11.4	8.6–10.5
Number	99	85	92	92	92	81	60	50	30	21	13	5

SD, standard deviation.

5.3, 6.9, 5.8, and 6.1 mm, respectively, at the final registrations at 24–25 and 26–27 years of age. In two subjects, the teeth were extracted at 19 and 21 years of age. In one patient, infraocclusion of 4.3 mm at registration 2 (14–15 years) progressed to 6.2 mm at the next registration and 10 mm at the two following registrations. The tooth had been extracted at the 24–25 year registration.

The mean changes in infraocclusion between registrations 1 and 5 (0.83 mm) and registrations 1 and 7 (0.99 mm) were statistically significant (Table 6). The mean changes from registration 5 to 7 and 5 to 9 were less pronounced.

Root resorption of the mandibular second primary molars

At all 11 registrations, some patients exhibited no root resorption (level 1). At the initial registration (age 12–13), there were 20 such cases: 17.6 per cent of the mesial roots and 23.5 per cent of the distal roots. At the initial registration, level 5 root resorption was recorded on the mesial roots in two patients and on the distal root in one patient. In these subjects, level 5 root resorption was also recorded at the final registration at 24–25 years of age (Table 7).

From 12–13 to 20–21 years of age (registration stages 1–5), almost 50 per cent of the 74 primary molars which could be monitored did not change resorption levels; 45 per cent of both roots. One-third had changed one resorption stage: 31 per cent of the mesial roots and 30 per cent of the distal roots. From 12–13 to 24–25 years of age, 44 per cent, did not change resorption stage (Table 8).

Table 4 The mean changes (mm) and standard deviations (SD) in the distance between the first molar and first premolar at registrations 5 and 7 in the comparison with the primary molar width (0) and between registrations 5 and 7 and 5 and 9. Registration stages: 5, 20–21 years; 7, 24–25 years; and 9, 28–29 years.

Registration stage	0–5	0–7	5–7	5–9
Mean (mm)	−0.50	−0.67	−0.18	−0.23
SD	0.75	0.77	0.27	0.44
Number	81	50	49	21
P	***	***	***	*

*$P < 0.05$, ***$P < 0.001$.

Discussion

This is the first long-term follow-up study, through adolescence to adulthood, of a large number of subjects with agenesis of the mandibular second premolars and retained second primary molars. The aim was to have a large number of subjects aged 18 years or more at the final registration. Of the 99 subjects, 96 could be registered at 18–19 years of age. It was not possible to follow all subjects to the registration at 34 years of age or more because only six had reached that age. Fifty subjects had reached 24–25 years of age (Table 1). The gender ratio, i.e. 37 males and 62 females, cannot be explained by different prevalences between males and females; it may be that more females than males had previously refused extraction of the primary molars.

In subjects with bilateral agenesis, only one primary molar from each patient was included to ensure that all primary molars were independent units for statistical analyses using *t*-tests.

The mean age at final registration was 24 years 7 months (range 18.25–45.44 years). The initial registration was set at 12–13 years of age because this is the upper age limit at which extraction of the primary molars, in selected cases, can result in spontaneous spaces reduction. Such space reduction is probably mainly due to tipping of the first permanent molar and first premolar but can also be caused by rotation of these teeth.

The measurements were made with a sliding calliper on intraoral radiographs taken by general practioners using a similar technique. The validity is of course not 100 per cent when the registrations are not carried out in a standardized manner. That is why the registrations were made in tenths of a millimetre.

Bjerklin and Bennett (2000) showed that up to 20 years of age, the prognosis for survival of the second primary molars was good. However, the number of subjects in that study was limited. Rune and Sarnäs (1984) concluded that

Table 5 Infraocclusion (mm) and the number of mandibular second primary molars measured at the different registrations.

	Age (years)—registration stage										
	12–13	14–15	16–17	18–19	20–21	22–23	24–25	26–27	28–29	30–33	34–45
	1	2	3	4	5	6	7	8	9	10	11
Mean (mm)	0.51	0.95	1.28	1.26	1.43	1.49	1.51	1.43	1.62	1.09	1.28
SD	1.07	1.52	1.70	1.94	1.86	1.90	1.60	1.83	1.33	1.44	0.65
Range	0–5.0	0–6.9	0–6.9	0–10.0	0–10.0	0–10.0	0–6.0	0–6.9	0–4.0	0–4.0	0–1.5
Number	86	92	94	94	82	59	50	32	21	12	5

the primary molars may be retained as substitutes for developmentally absent premolars until adulthood, when surgical or prosthetic replacement may be undertaken or when residual space may be accepted. They found that the level of root resorption remained unchanged for approximately 50 per cent of the retained primary molars. The present study confirmed that finding: from 12–13 to 20–21 years of age, there was no progression of resorption for 45 per cent of the roots (Table 8).

Rune and Sarnäs (1984) found no correlation with dental decay or submergence and no relationship between any particular root resorption stage and submergence. However, the mean age at the final registration was approximately 17 years of age.

Ith-Hansen and Kjær (2000) showed, in 18 subjects in the permanent dentition without morphological deviations, that a considerable number of primary molars persisted unaltered up to 15 years after the time for normal exfoliation. Follow-up studies are, however, necessary to determine the long-term outcome of these retained teeth.

It is difficult to extrapolate the results of the three studies cited because the subjects were relatively young at the final registration or the number of subjects was limited. From the present research, it may be concluded that for the three variables studied there was only minor deterioration from registration stage 5 (20–21 years of age) to registration stage 7 (24–25 years of age) and from registration stage 5 to registration stage 9 (28–29 years of age; Tables 4, 6, and 8 and Figure 3).

Sletten *et al.* (2003) evaluated root resorption and submergence in a sample of 20 patients selected from more than 6000 subjects. The mean age at initial registration was 36.1 (SD 12.9) and 48.5 (SD 12.6) years at the final registration. Those investigators concluded that retaining a healthy primary mandibular second molar is a viable treatment alternative. However, the sample represented only those with surviving primary molars: the number of cases with agenesis of mandibular second molars in which the

Table 6 The mean changes (mm) and standard deviations (SD) in infraocclusion between the first registration (1) and registrations 5 and 7, and between registration 5 and registrations 7 and 9, respectively. The age at the first registration is 12–13 years, at registration 5, 20–21 years, at registration 7, 24–25 years, and at registration 9, 28–29 years of age.

Registration stage	Infraocclusion changes between the different registration stages			
	1–5	1–7	5–7	5–9
Mean (mm)	0.83	0.99	0.11	0.03
SD	0.99	1.18	0.47	0.48
Number	70	46	49	21
P	***	***	ns	ns

ns: $P > 0.05$, ***$P < 0.001$.

Table 7 Number of mandibular second primary molars (percentage) in the different resorption levels at the different registrations. The mesial (M) and distal (D) roots are evaluated separately.

Resorption level	Age (years)—registration stage																					
	12–13		14–15		16–17		18–19		20–21		22–23		24–25		26–27		28–29		30–33		34–45	
	1		2		3		4		5		6		7		8		8		10		11	
	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D
1	17.6	23.5	11.0	14.3	8.7	8.6	6.3	7.4	7.0	7.0	8.1	8.2	7.8	9.8	9.1	12.1	13.0	8.7	7.1	6.7	16.7	16.7
2	38.8	32.9	28.6	31.9	21.7	28.0	17.9	23.2	15.1	18.6	19.4	19.7	17.6	15.7	21.2	18.2	13.0	8.7	21.4	13.3	33.3	16.7
3	31.8	31.8	36.3	28.6	42.4	33.3	38.9	35.8	32.6	33.7	30.6	27.9	31.4	27.5	30.3	21.2	30.4	30.4	21.4	31.3	16.7	33.3
4	9.4	10.6	19.8	32.0	18.5	25.8	26.3	24.2	30.0	26.6	32.3	34.4	33.3	37.3	36.4	39.4	39.1	39.1	21.4	20.0	16.7	16.7
5	2.4	1.2	4.4	3.3	8.7	4.3	9.5	8.4	10.5	9.3	6.5	6.6	7.8	7.8	3.0	9.1	4.3	13.0	14.3	13.3	—	—
6	—	—	—	—	—	—	1.1	1.1	4.8	4.8	3.3	3.3	2.0	2.0	—	—	—	—	15.3	15.3	16.7	16.7

Table 8 Percentage of primary molars that showed no change or changed one, two, three, or four stages in resorption level from registration 1 to 5, 1 to 7, 5 to 7, and 5 to 9. The age at the first registration is 12–13 years, at registration 5 20–21 years, at registration 7, 24–25 years, and at registration 9, 28–29 years of age.

	Change in resorption level							
	Age (years)—registration stage							
	12–13 to 20–21		12–13 to 24–25		20–21 to 24–25		20–21 to 28–29	
	1–5		1–7		5–7		5–9	
	M	D	M	D	M	D	M	D
No change	45	45	44	44	90	82	91	77
One stage	31	30	31	31	10	18	9	23
Two stages	18	15	20	18	—	—	—	—
Three stages	5	8	5	7	—	—	—	—
Four stages	1	—	—	—	—	—	—	—
Five stages	—	1	—	—	—	—	—	—
Six stages	—	—	—	—	—	—	—	—
Number of primary molars	74		45		50		22	

M, mesial root; D, distal root.

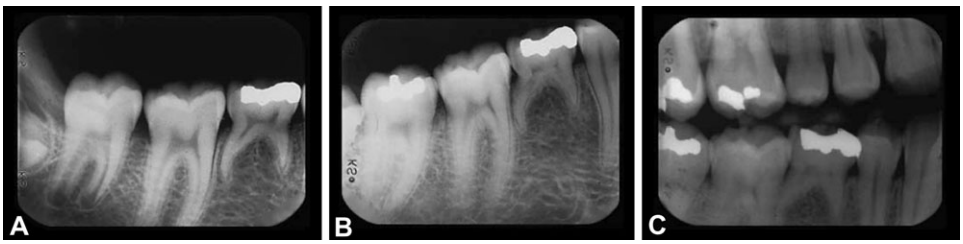

Figure 3 A female with root resorption and restoration of the right second primary molar at 12 years of age (A) and negligible progression of resorption at ages 20 (B) and 26 (C) years.

primary molar had been extracted or otherwise lost is not known. It is therefore difficult to draw comparisons with the present long-term follow-up study. However, in the present investigation, only very small increases in root resorption and submergence in the oldest patients after 20 years of age were found. Approximately 90 per cent of the roots did not change resorption levels from 20–21 to 24–25 years of age or from 20–21 to 28–29 years of age (Table 8). Infraocclusion increased by a mean of only 0.1 mm (SD 0.47) from 20–21 to 24–25 years of age and by mean of 0.0 mm (SD 0.48) from 20–21 to 28–29 years of age. In the 20–21 to 28–29 age groups, only 21 primary molars were available for comparison (Table 6).

Nordqvist *et al.* (2005) studied primary teeth in adults. They reported a good long-term prognosis for mandibular second primary molars in their cross-sectional study from one county of Sweden. In that study, only 20 per cent of the 170 dentists responded to the request, providing radiographs from 65 patients with 89 primary teeth, 53 of which were mandibular second primary molars. Those authors found no relationship between the severity of root resorption and gender, fillings/caries, or infraocclusion. There was, however, a significant correlation between root resorption and age.

In the present investigation, with very few lost primary molars, some cases with resorption and shortened roots of the primary molar at the initial registration were almost unchanged 15 years later (Figure 3).

A relationship between root resorption and gender has not previously been reported.

Four of the 11 extracted or exfoliated primary molars were lost at 19–20 years of age. Two were extracted and replaced with implants and two by autotransplantation of the maxillary third molars. This treatment plan had been decided several years previously. This is an appropriate age for transplantation of maxillary third molars.

When the second primary molar is lost early or is infraoccluded, tipping of the adjacent first permanent molar and sometimes also of the first premolar will occur (Lindqvist, 1980; Mamopoulou *et al.*, 1996). The mean

reduction in the distance between the first molar and first premolar was less than 1 mm and the mean infraocclusion was a maximum 1.62 mm. In a few cases, however, the distance between the first molar and first premolar was 2.7 mm and infraocclusion 10.0 mm. In one subject where the primary molar width was 10.6 mm, the distance between the adjacent permanent teeth was 9.6 mm at the first registration (12–13 years) and at the final registration (22–23 years) this distance had further decreased by only 1 mm. Infraocclusion changed from 4.1 to 4.2 mm. The root resorption level was 4 (3/4 of the root resorbed) for both roots at all six registrations. This indicates that it is not possible to predict the probability of survival for a single primary molar at an early age. However, the overall probability for a long-term survival can be estimated to be more than 90 per cent.

Conclusions

The results show that in the 99 subjects in this investigation with retained second primary molars, seven primary molars (7 per cent) were extracted or exfoliated because of extensive root resorption, infraocclusion, or caries.

In almost half the subjects (44–45 per cent), root resorption levels of the primary molars were unchanged up to 24–25 years of age. After this age, there was even less change in the resorption level.

In subjects with agenesis of mandibular second premolars, long-term survival of the primary molars can be expected, on average, to be more than 90 per cent.

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