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Apical root resorption during orthodontic treatment of patients with multiple aplasia: a study of maxillary incisors

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SUMMARY The aim of this study was to evaluate the risk of root resorption during orthodontic treatment of patients with aplasia, and to analyse the relative importance of some anamnestic and treatment variables. The subjects comprised 68 orthodontically treated patients with 1–16 congenitally missing teeth. The age of the patients was 11–20 years (mean 15 years). All patients were treated with fixed edgewise appliances. The purpose of the orthodontic treatment varied: to create optimal conditions for prosthetic restorations or osseointegrated implants, or to achieve aesthetic and functional alignment of teeth in less severe cases. The degree of root resorption was assessed before and after treatment from intra-oral radiographs of the maxillary incisors using a scale of 0–4. In all, 186 maxillary incisors were evaluated.

The degree of apical root resorption was significantly greater in cases of multiple aplasia (4–16 missing teeth) than in those with only one to three missing teeth. Root form, treatment time with rectangular wires and intermaxillary elastics, and total treatment time were significantly related to root resorption. Discriminant analysis disclosed that the following variables were the most important determinants of root resorption: number of missing teeth, root form, and time with rectangular archwires and intermaxillary elastics.

It is concluded that there is a high risk of apical root resorption during orthodontic treatment in patients with multiple aplasia (four or more teeth), in particular in teeth with an abnormal root form and lengthy treatment with elastics and rectangular archwires.

Introduction

The aetiology of root resorption associated with orthodontic therapy is complex: several factors, alone or in combination, may contribute. A frequency of severe apical root resorption of 5–18 per cent in adolescents has been reported (Malmgren *et al.*, 1982; Linge and Linge, 1983; Levander and Malmgren, 1988; Mirabella and Årtun, 1995a). In orthodontic treatment of patients with aplasia an inherent complication is the increased risk of apical root resorption (Kjær, 1995). The purpose of orthodontic treatment may be to upright teeth and close spaces, or to establish optimal conditions for prosthetic restorations, osseointegrated implants, autotransplantations or conventional bridgework. Apical root resorption is particularly unfavourable if the teeth are intended to be used as anchorage for prosthetic restorations. It is thus important to consider the risk of root resorption during treatment planning of patients with aplasia.

The aim of the study was primarily to evaluate the risk of root resorption of maxillary incisors during orthodontic treatment of patients with aplasia, and also to analyse the relative importance for the resorption of some anamnestic and treatment variables.

Table 1 Distribution of 186 orthodontically treated maxillary incisors in relation to the number of missing teeth in 68 patients.

Number of missing teeth	Number of patients	Maxillary incisors evaluated				Total
		Tooth number				
		12	11	21	22	
Group I						
1–3	33	8	33	31	3	75
Group II						
4–7	29	20	28	28	22	98
8–16	6		6	6	1	13
Total	68	28	67	65	26	186

Subjects and methods

The subjects comprised two groups of orthodontically treated patients: Group I, 33 patients, 9 boys and 24 girls; Group II, 35 patients, 14 boys and 21 girls. The age interval at the start of treatment was 11–20 years (mean 15 years).

Group I included all patients with one to three congenitally missing teeth, treated by one of the authors between 1986 and 1996. Group II comprised all orthodontically treated patients with aplasia of four or more teeth with complete records, including peri-apical radiographs of the maxillary incisors before and after treatment, referred to the Prosthodontic Department at the Eastmaninstitutet in Stockholm during the same period.

The aplasia in the 68 patients is presented in Table 1. Maxillary lateral incisors and premolars predominated. Fifteen patients had unilateral congenital absence of a lateral incisor and 32 bilateral. Two lower second premolars were absent in 23 patients and two upper premolars in 18 subjects.

The patients were treated with fixed edgewise appliances: in Group I, the duration ranged from 9 to 33 months (mean 18 months) and in Group II from 7 to 52 months (mean 20 months). Treatment mechanics included rectangular archwires in 22 patients in Group I for 3–15 months (mean 7 months) and in 24 patients for 1–24 months (mean 11 months) in Group II. Intermaxillary elastics were used in three patients in Group I for 2–5 months (mean 4 months) and in 13 boys and girls in Group II for 1–25 months (mean 9 months).

The aim of the orthodontic treatment was to provide optimal conditions for prosthetic restoration or osseointegrated implants (42 patients), or aesthetic and functional alignment of teeth and space closure in cases where prosthetic therapy was not essential (26 patients).

In all, 186 maxillary incisors in the 68 patients were included in the study; 75 in Group I and 111 in Group II (Table 1). Five teeth were excluded because the radiographs were of poor quality.

Analysis of radiographs

The root form was evaluated according to the radiographic appearance as normal (128 teeth), short (one tooth), blunt (26 teeth), apically bent (26 teeth), and pipette-shaped (five teeth) (Levander and Malmgren, 1988). Abnormal root forms were recorded for 34 roots in patients with multiple aplasia and 24 roots in subjects with one to three missing teeth.

The degree of root resorption which occurred during orthodontic treatment was evaluated by two experienced observers on intra-oral radiographs of the maxillary incisors before and after treatment. A modified parallel technique and long focus film distance were used. Signs of apical root resorption were registered with index scores from 0 to 4 (Figure 1) described earlier (Malmgren *et al.*, 1982; Levander and Malmgren, 1988) and a consensus decision was made. All evaluations were repeated after 1 month. A third evaluation was undertaken in cases with differences in the decisions.

Statistical methods

The root resorption index was described for the two groups, Group I with one to three missing teeth and Group II with multiple aplasia. The variation in resorption between the groups, and in relation to the following anamnestic and treatment variables was analysed with the chi-square

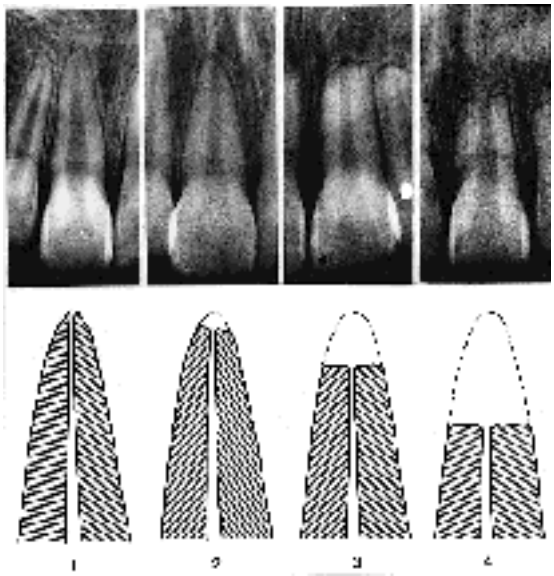

Figure 1 Index for assessment of root resorption. (1) Irregular root contour. (2) Root resorption apically, amounting to less than 2 mm. (3) Root resorption apically, from 2 mm to one-third of the original root length. (4) Root resorption exceeding one-third of the original root length.

test ($P < 0.05$): sex, age at the start of treatment, number of missing teeth, root form, treatment time with rectangular archwires, with intermaxillary elastics, and total treatment time.

Stepwise discriminant analysis was used to indicate the relative importance of the variables significantly related to root resorption. In the analysis root resorption was treated as the dependent variable, and the number of missing teeth, treatment and anamnestic variables as independent. The stepwise procedure was discontinued when the next F value for the variable to be included was not significant ($P > 0.05$).

Error of the method

The reproducibility of the evaluation of root resorption using the index scores was studied with double determinations of all radiographs. There was full agreement in 156 out of 186 duplicate determinations (84 per cent). A difference of one index score was found in 30 cases.

Results

The results are summarized in Table 2.

The degree of apical root resorption was significantly greater in Group II than in Group I. In patients with multiple aplasia (Group II) 35 of 111 incisors (32 per cent) had a resorption index score of 3, compared with four of 75 (5 per cent) in Group I, patients with one to three congenitally missing teeth (Figures 2 and 3).

The variables, root form, treatment time with rectangular archwires and intermaxillary elastics, and total treatment time were significantly related to the amount of root resorption.

Discriminant analysis disclosed that the following variables were of the greatest importance for root resorption: number of missing teeth, treatment time with rectangular archwires, root form and treatment time with intermaxillary elastics. In the analysis, the variables sex, age at the start of treatment, and the total treatment time were not included.

Discussion

Patients with multiple aplasia require extensive dental rehabilitation, which often includes a period of orthodontic treatment. The purpose of orthodontic therapy varies, e.g. correction of over-erupted teeth, positioning of abutment teeth, bite opening and space closure (Bergendal *et al.*, 1996).

Quantifying apical root resorption is technically difficult. A quantitative method has been described by Linge and Linge (1983). The length of the root from the cemento-enamel junction (CEJ) to the apex is measured on pre- and post-treatment radiographs. Change in root length is corrected for magnification differences with a ratio between crown lengths on the first and second radiograph. However, the method presumes correct location of the CEJ, and variation in X-ray beam angulation in relation to the tooth projects the CEJ differently. Mirabella and Årtun (1995a) found a mean error of 0.41 mm for crown length measurements using this method. Another approach to assess the amount of apical root resorption is calculation performed by subtraction of tooth lengths on

Table 2 Root resorption after orthodontic treatment of patients with aplasia in relation to the number of aplasia and anamnestic and treatment variables.*

Number of missing teeth	Total number of teeth	Number of teeth with root resorption index/(percentage)			
		0	1	2	3
Group I					
1–3	75	4 (5)	23 (31)	44 (59)	4 (5)
Group II					
4–7	98	5 (5)	7 (7)	52 (53)	34 (35)
8–16	13	0	2 (15)	10 (77)	1 (8)
Treatment time in months					
(1) Total					
≤12	37	4 (11)	9 (24)	24 (65)	0
≥13–≤24	114	5 (4)	20 (18)	60 (53)	29 (25)
≥25	35	0	3 (8)	22 (63)	10 (29)
(2) With rectangular archwire					
0	64	5 (8)	18 (28)	36 (56)	5 (8)
≤12	98	4 (4)	13 (13)	56 (57)	25 (26)
≥13	24	0	1 (4)	14 (58)	9 (38)
(3) With intermaxillary elastics					
0	129	9 (7)	30 (23)	75 (58)	15 (12)
≤12	45	0	2 (4)	26 (58)	17 (38)
≥13	12	0	0	5 (42)	7 (58)
Root form					
Normal	128	7 (6)	23 (18)	77 (60)	21 (16)
Short	1	0	1 (100)	0	0
Blunt	26	0	5 (19)	16 (62)	5 (19)
Apically bent	26	2	1 (19)	10 (39)	13 (50)
Pipette-shaped	5	0	2 (40)	3 (60)	0

*Only variables significantly related to root resorption included ($P < 0.05$).

radiographs before and after treatment. The precision in this procedure is dependent on a strictly standardized projection technique.

All patients in the present study were examined radiographically with a modified parallel long cone technique. In patients with multiple aplasia (Group II) several operators were involved, implying a risk of minor variations in the projection. Apical root resorption was therefore evaluated qualitatively and not quantitatively. The reproducibility using index scores was in accordance with earlier investigations (Goldson and Henrikson, 1975; Levander and Malmgren, 1988).

In the present study, 5 per cent of the roots in patients with aplasia of one to three teeth were resorbed 2 mm or more. This frequency is less than reported in earlier studies (Linge and Linge, 1983; Levander and Malmgren, 1988; Mirabella and Årtun, 1995a). Linge and Linge (1983) found a prevalence of apical root resorption of more than 2 mm in approximately 10 per cent, Levander and Malmgren (1988) in 18 per cent, and Mirabella and Årtun (1995a) registered resorption of 2.5 mm or more in 16.5 per cent of upper incisors. One explanation may be the high proportion of missing maxillary lateral incisors, which are more prone than central incisors to apical root resorption (Phillips, 1955; DeShields, 1969; Goldson and Henrikson, 1975; Kennedy *et al.*, 1983; Sharpe *et al.*, 1987). In patients with aplasia of four to seven teeth the degree of severe resorption was higher. This is in accordance with Kjær (1995) who reported one extensively resorbed tooth in 20 per cent of patients with aplasia. In the present study only one tooth

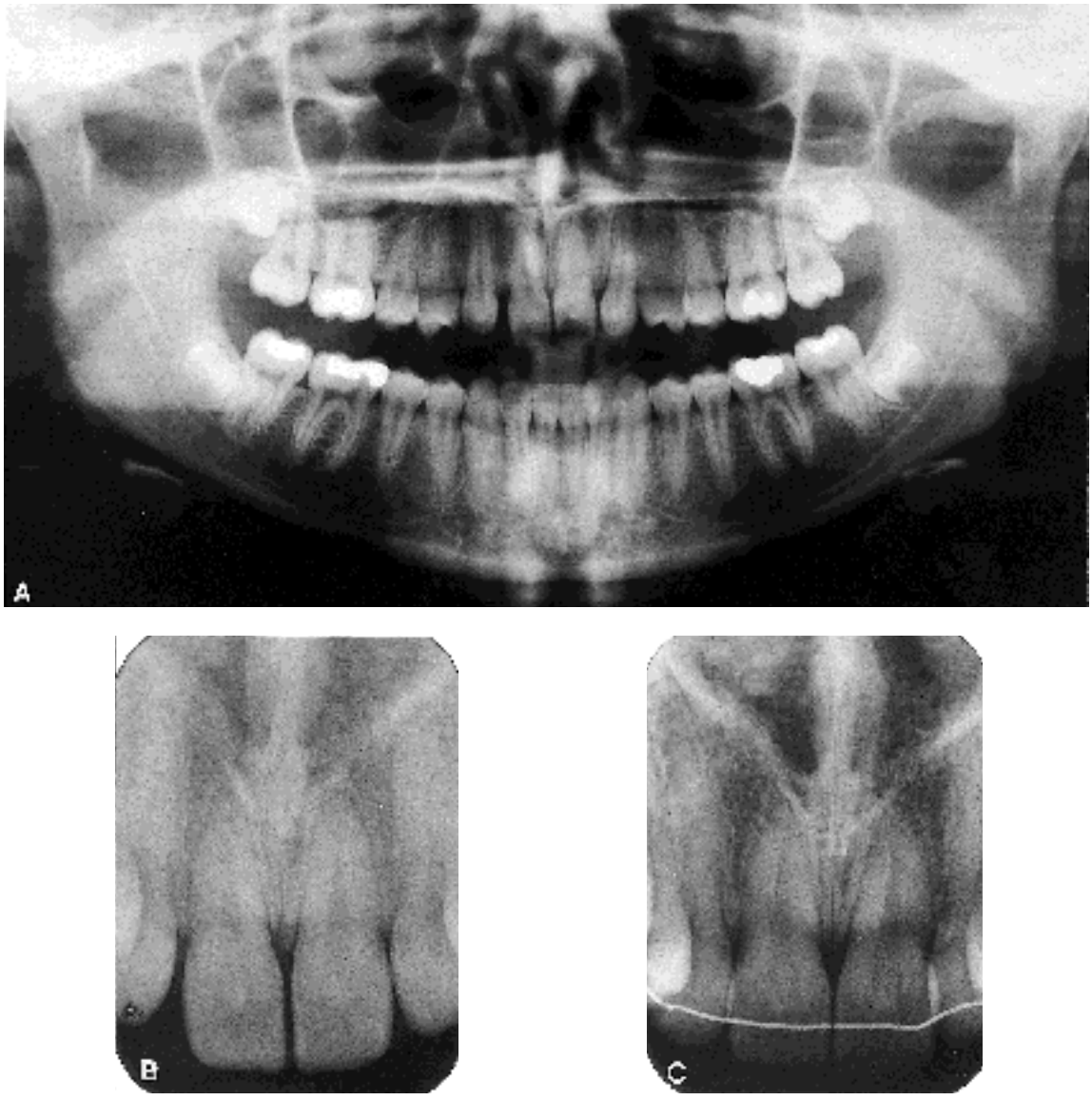

Figure 2 Radiographs of a girl with aplasia of the maxillary lateral incisors (Group I) before and after orthodontic treatment. Minimal resorption of central incisors after treatment. (A) Orthopantomogram before treatment. (B,C) Periapical radiographs of maxillary central incisors (B) before and (C) after treatment.

was severely resorbed in five patients with aplasia of eight to 16 teeth. The number of teeth in this group was only 13 and too small for statistical evaluation.

The study disclosed an association between root resorption and root form, as has been reported previously by Levander and Malmgren (1988), Kjær (1995), and Mirabella and Årtun (1995b). The highest incidence of root resorption was found in teeth with apical bends. Only five teeth had pipette-shaped roots, thus no statistical evaluation is relevant for these teeth.

The treatment variables related to root resorption were the total treatment time, treatment time

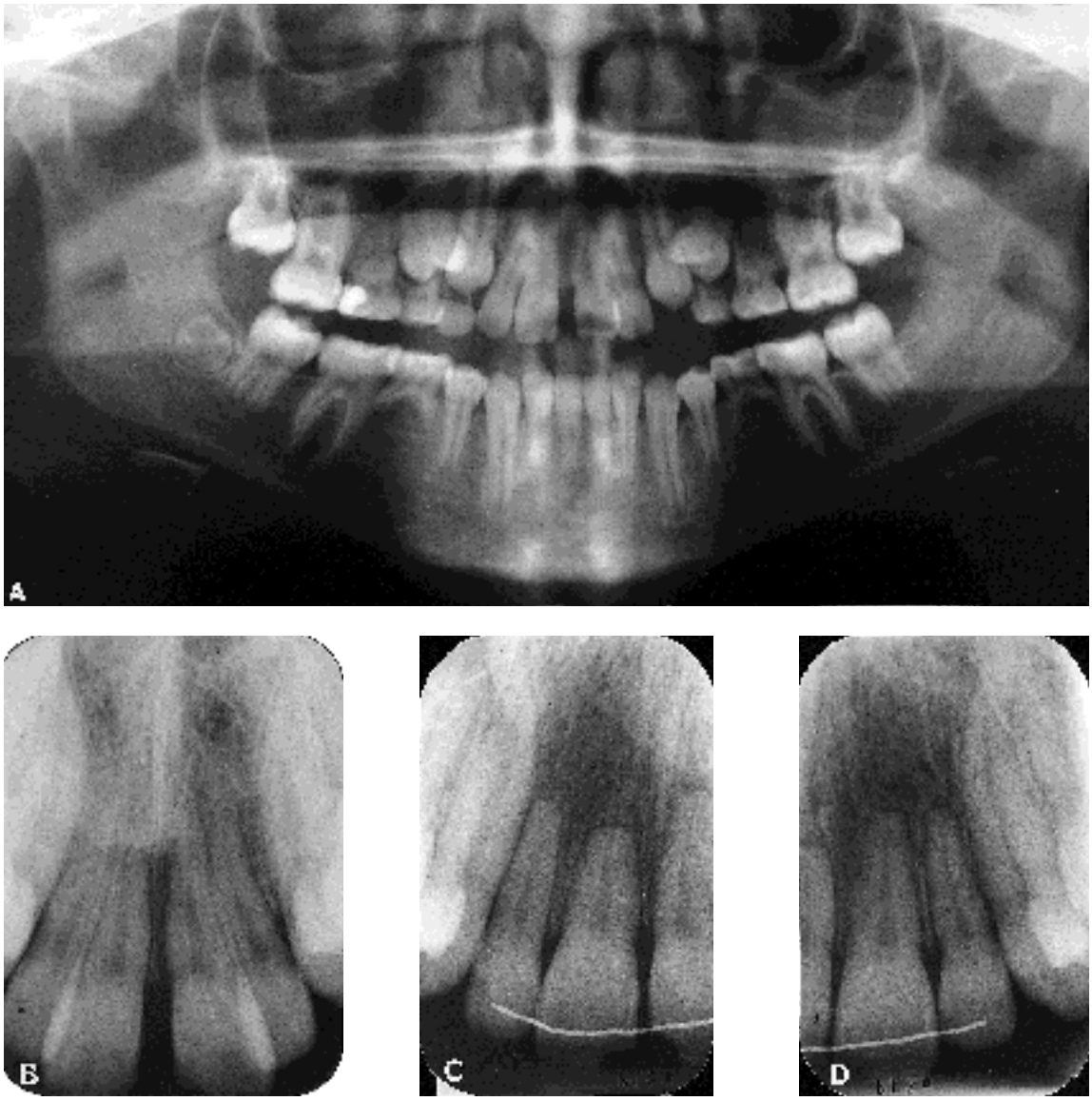

Figure 3 Radiographs of a girl with aplasia of four premolars (Group II) before and after orthodontic treatment. (A) Orthopantomogram before treatment. (B) Peri-apical radiographs of maxillary incisors before and (C,D) after treatment. Severe resorption of all four incisors after treatment.

with rectangular archwires, and intermaxillary elastics. A correlation between duration of treatment and apical root resorption has been reported by DeShields (1969), Stenvik and Mjör (1970), Goldson and Henrikson (1975), Linge and Linge (1983) and Goldin (1989).

In the discriminant analysis the total treatment time was not significant. This is probably due to an inter-relationship between the duration of treatment and the treatment variables. The orthodontic force delivered by different mechanics is considered to be of major importance for

root resorption. Thus, the treatment time with these mechanics is probably more important than the total treatment time and it seems to be of great importance that the orthodontic forces are equally controlled when less teeth are anchored. Linge and Linge (1983, 1991) reported a high incidence of root resorption during orthodontic treatment with rectangular archwires and intermaxillary elastics. However Owman-Moll (1995) reported contradictory findings, indicating poor correlation between root resorption and the magnitude of orthodontic forces.

No significant relationship between sex and root resorption was found in the present study. Reports in the literature on the relationship between root resorption and gender are conflicting. Studies by Massler and Malone (1954), Kennedy *et al.* (1983) and McFadden *et al.* (1989) found no correlation, whereas other studies indicate that females are more susceptible (Massler and Perreault, 1954; Newman, 1975). Neither was a positive relationship between root resorption and patient age found. This is in accordance with Phillips (1955), Goldin (1989) and McFadden *et al.* (1989).

Conclusions

Treatment planning of patients with multiple aplasia should take into consideration the risk of excessive apical root resorption during orthodontic therapy. The longevity of intended abutment teeth might be jeopardized by severe resorption, particularly in cases of teeth with abnormal root form, and/or lengthy treatment with elastics and rectangular archwires.

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