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# Anomalous dental morphology and root resorption during orthodontic treatment: a pilot study

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The present study investigated the relation between anomalous dental morphology and root resorption during orthodontic treatment. One hundred and eleven sets of orthodontic records (a total of 1,630 teeth) were examined. Root resorption was determined from post-treatment panoramic radiographs using a five-grade quantitative measurement. It was found that patients with short or blunt roots before treatment underwent significant root shortening during orthodontic treatment. Patients with any one dental anomaly had a significantly higher degree of root resorption compared with patients with no dental anomaly. Invaginated teeth, teeth with thin or pipette-shaped roots and teeth with short or blunt roots were likely to be more susceptible to root resorption than those without such anomalies. Possible linkages between the aetiological factors of dental anomalies and the susceptibility to root resorption were discussed. The presence of anomalous dental morphology should be taken into account in orthodontic treatment planning.

Key words: Tooth-abnormalities, Dental anomalies, Root resorption, Orthodontics-complication

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## *Introduction*

Apical root resorption is a complication commonly associated with orthodontic treatment. De Shields[1] concluded that some degree of root resorption occurs in almost every patient. Loss of apical root material as a result of orthodontic treatment is unpredictable.[2] In most patients, root resorption is minor and insignificant.[3] However, 10 to 20 per cent of cases have been reported to have severe root resorption (> 3 mm).[3,4]

Several factors may contribute to the occurrence of orthodontic root resorption. Individual susceptibility is considered a major factor,[5] but seems to vary among persons and within the same person at different times.[6] It is believed that there will be more frequent root resorption in adults than in younger patients.[7] Reitan[8] suggested that changes in the periodontium with age are the main cause of a higher susceptibility to root resorption in adult patients.

Some previous studies[9,10] have shown no relation between gender and root resorption, although others have suggested that females are more susceptible.[11,12] Newman[12] found that the idiopathic root resorption ratio of females to males was 3.7:1. This ratio may be partly explained by the fact that there was a higher frequency of female patients. Linge and Linge[13] found that apical root loss was greater in treated females compared with treated males.

Different teeth have different tendencies to root resorption.[14] Several studies have reported that maxillary teeth are more sensitive than mandibular teeth.[15,16] Maxillary incisors are most often affected by root resorption.[1,8] Oppenheim[17] explained that this may be because the extent of movement of these teeth is usually greater than other teeth and their root structure and relation to bone and periodontal membrane tend to transfer the forces mainly to the apex. Two other studies found the mandibular incisors to be more affected.[18,19] It is believed that in the absence of apical root resorption of the maxillary or mandibular incisors, significant apical resorption of other teeth is less likely to occur.[1,19]

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Types of tooth movement[8,13,18,20] and the appliance used[13,21] are suggested as critical factors. It is also claimed that the severity of root resorption is directly related to treatment duration.[3,13] Goldin[10] reported the average amount of root loss during treatment is 0.9 mm per year. Levander and Malmgren[3] found that 34 per cent of teeth showed root resorption after six to nine months of treatment; whereas at the end of treatment that lasted nineteen months the rate increased to 56 per cent. The duration of force has been regarded as a more critical factor than the magnitude.[22] Nevertheless, some investigations have not been able to verify the association between treatment time and root resorption.[20,23]

Anomalous dental morphology may be an indicator of a predisposition to root resorption. It has been found that the degree of root resorption in teeth with blunt or pipette-shaped roots is significantly higher than in teeth with normal root form.[3,12,13,24] It was explained that the pipette-shaped form of the root means that the apical part of the root is thin and even minor root resorption may have a great effect on root length.[3] Recently, Kjær[24] found a strong association between some dental morphological characteristics, such as invagination and taurodontic root shape, and the tendency to root resorption during orthodontic treatment. He also found an association between ectopic eruption, agenesis and the tendency to orthodontic root resorption. However, the radiographic materials available for his study were collected from various sources and the study was done without a control group of subjects.

## *Aims and methods*

The aim of this study was to investigate the association between anomalous crown and root morphology and root resorption during orthodontic treatment. Records of 111 completed orthodontic cases (46 males, 65 females) were selected. The mean age of the patients at treatment initiation was 13.2±2.2 years (range 10.2 to 26.4 years). The mean treatment duration was 19.7±7.1 months (range 4 to 49 months). The distribution of malocclusions was: 31 with Angle Class I, 64 with Angle Class II division 1, 13 with Angle Class II division 2, and three with Angle Class III. Treatment was performed with extraction in 41 cases and without extraction in 70 cases. Edgewise appliances were used on 76 patients and Begg appliances on the remaining thirty-five.

Selection of records was based on the following criteria: a) no significant medical history; b) pre-treatment and post-treatment panoramic radiographs available; c) no history of endodontic treatment, or trauma to any tooth before the completion of orthodontic treatment; d) the presence of complete records for each patient, including pre-treatment study models; e) all radiographs taken on the same panoramic machine at the Dental School of the University of Queensland. Since this study was conducted retrospectively, it was not possible to control variation resulting from radiographic procedures. However, there was no reason to believe that the selection of radiographs was biased in any way.

Anomalous dental morphology was evaluated as agenesis, impaction, dilaceration, ectopic eruption, invagination, peg-shaped lateral incisor, thin or pipette-shaped root, short or blunt root and taurodontism. The diagnosis was based on the descriptions by Levander and Malmgren,[3] Lind,[25] Jorgenson,[26] and Langlais *et al.*[27]

Evidence of root resorption in each subject was observed from post-treatment radiographs, compared with pre-treatment radiographs. A good quality panoramic radiograph is considered to be an acceptable diagnostic aid for the detection of abnormal findings.[28,29] Additionally, in order to minimise radiographic misinterpretation, teeth with incomplete root formation seen in pre-treatment or post-

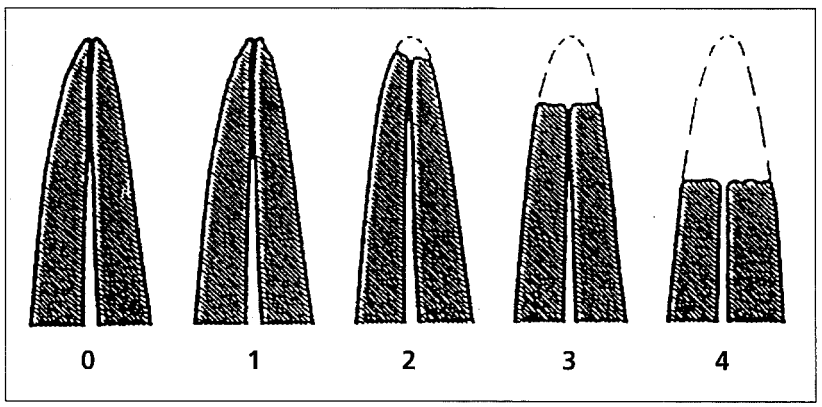



**Figure 1.**
Five ordinal scales for quantitative assessment of root resorption.
0 = No root resorption.
1 = Irregular root contour.
2 = Root resorption apically, amounting to less than 2mm (minor resorption).
3 = Root resorption apically, from 2mm to one third of the original root length (severe resorption).
4 = Root resorption exceeding one third of the original root length (extreme resorption).

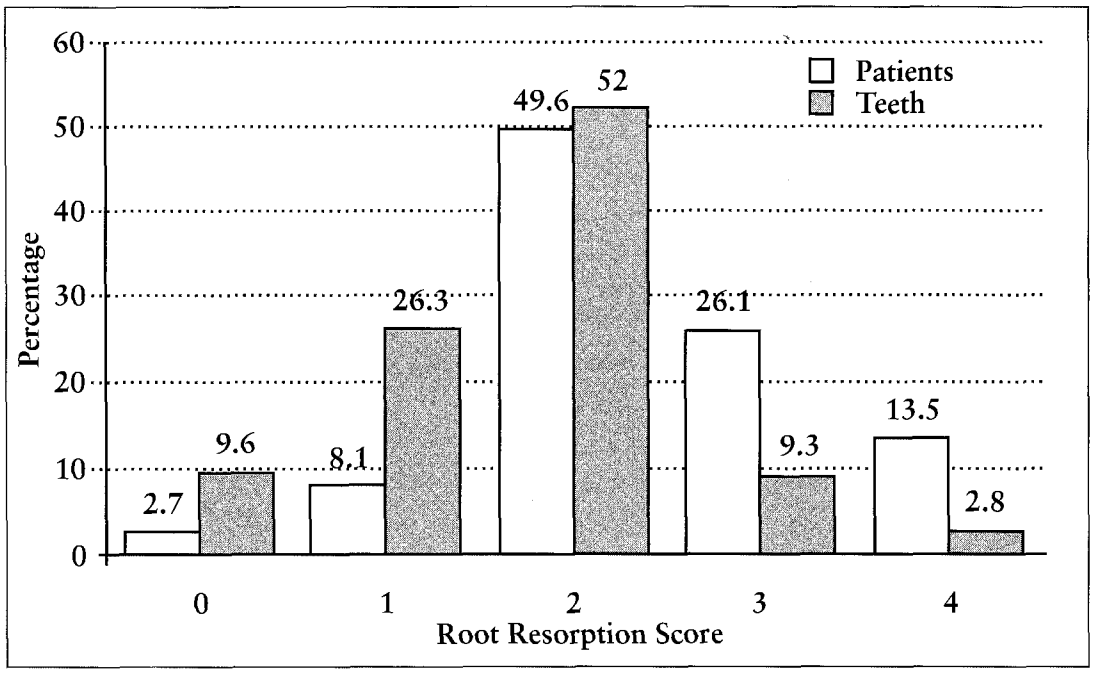



**Figure 2.** Percentage distribution of root resorption score by patients and by teeth.

treatment radiographs were not included in the study. Blurred image teeth were also excluded. All maxillary premolars and molars were excluded because the floor of the nose and antrum are projected onto these teeth and cause difficulty in identifying their root anatomy. The degree of root resorption is measured using a five-grade ordinal scale described by Beck and Harris[30] (Figure 1). A total of 1,630 teeth were investigated in the present study. The chi-square test was used to determine the association between each type of anomalous dental morphology and degree of root resorption. The male and female groups were pooled.

The reproducibility of the evaluation of anomalous dental morphology and root resorption measurement was tested by investigating pre-treatment and post-treatment panoramic radiographs of 16 randomly selected cases. These radiographs were examined on two separate occasions with a two-week interval between the examinations.

**Table I.** Occurrence of anomalous dental morphology in 111 patients.

| Type of anomalous morphology | n | % |
|---|---|---|
| None | 28 | 25.2 |
| Invagination | 29 | 26.1 |
| Short, blunt root | 26 | 23.4 |
| Thin, pipette-shaped root | 23 | 20.7 |
| Ectopic eruption | 16 | 14.4 |
| Impaction | 11 | 9.9 |
| Peg-shaped lateral incisor | 11 | 9.9 |
| Taurodontism | 11 | 9.9 |
| Agenesis | 9 | 8.1 |
| Dilaceration | 2 | 1.8 |

## *Results*

Duplicate determinations of anomalous dental morphology in pre-treatment panoramic radiographs showed 99.9 per cent agreement. Duplicate measurements of root resorption scores demonstrated 87.9 per cent agreement. The accuracy of the measurement methods for assessment of anomalous dental morphology and the degree of root resorption were considered to be acceptable.

The frequencies of dental anomalies are shown in Table I. Of the 111 individuals in the present study, 28 (25.2 per cent) showed absence of anomalous dental morphology. Invagination of upper incisors was the most prevalent (26.1 per cent), followed by short or blunt root (23.4 per cent), thin or pipette-shaped root (20.7 per cent), ectopic eruption (14.4 per cent), impaction (9.9 per cent), peg-shaped lateral incisor (9.91 per cent), taurodontism (9.9 per cent), agenesis (8.1 per cent) and dilaceration (1.8 per cent).

Figure 2 shows the distribution of root resorption severity for the whole sample. It can be seen that all cases except three (97.3 per cent) had undergone some degree of root resorption. In nearly half of the patients the worst root resorption was 2 (55 individuals, 49.6 per cent), while 29 (26.1 per cent) and 15 (13.5 per cent) had worst scores of 3 and 4 respectively.

Of the 1,630 teeth analysed, 9.6 per cent (156 teeth) had shown no signs of root resorption. Seventy-eight point three per cent (1,277 teeth) had mild to moderate root resorption (score 1 and 2); 197 teeth (12.1 per cent) suffered from

**Table II.** Chi-square test for duration of treatment (d) and root resorption (RR).

| Duration of treatment | RR score ≤ 2n | | RR score >2 | | |
|---|---|---|---|---|---|
| (d) (month) | n | % | n | % | $x^2$ |
| d ≤ 12 | 16 | 14.4 | 3 | 2.7 | |
| 12 < d ≤ 18 | 22 | 19.8 | 11 | 9.9 | 6.55* |
| 18 < d ≤ 24 | 18 | 16.2 | 18 | 16.2 | |
| d > 24 | 15 | 13.5 | 8 | 7.2 | |

* p > 0.1

**Table III.** Chi-square test for patients with short of blunt roots and root resorption (RR).

| Short or blunt root | RR score ≤ 2 | | RR score >2 | | |
|---|---|---|---|---|---|
| | n | % | n | % | $x^2$ |
| Present | 12 | 10.8 | 14 | 12.6 | 4.67* |
| Absent | 59 | 53.2 | 26 | 23.4 | |

*p < 0.5

**Table IV.** Chi-square test for differences in root resorption (RR) between patients with at least one and with no dental anomaly.

| Short or blunt root | RR score ≤ 2n | | RR score >2 | | |
|---|---|---|---|---|---|
| | n | % | n | % | $x^2$ |
| Patients without any dental anomaly | 22 | 19.82 | 6 | 5.41 | 3.47* |
| Patients with at least one dental anomaly | 49 | 44.14 | 34 | 30.63 | |

*p < 0.01

**Table V.** Chi-square test for teeth with different types of dental anomaly and root resorption (RR).

| Short or blunt root | RR score ≤ 2n | | RR score >2 | | |
|---|---|---|---|---|---|
| | n | % | n | % | $x^2$ |
| Invagination | | | | | |
| Present | 40 | 9.3 | 28 | 6.5 | 5.16* |
| Absent | 264 | 61.1 | 100 | 23.2 | |
| Thin pipette-shaped root | | | | | |
| Present | 62 | 4.2 | 16 | 1.1 | 7.5** |
| Absent | 1,258 | 84.8 | 148 | 10.0 | |
| Short, blunt root | | | | | |
| Present | 37 | 2.5 | 33 | 2.2 | 83.1** |
| Absent | 1,258 | 84.8 | 148 | 10.0 | |

* p < 0.05
** p < 0.01

severe root resorption (score 3 and 4). The most prevalent root resorption score was 2 (848 teeth, 52.0 per cent) (Figure 2).

In order to examine the association between selected variables and the degree of root resorption, the root resorption scale was divided into two categories: "no obvious resorption" (score 0 to 2), and "obvious resorption" (score 3 and 4). The chi-square test for association between duration of treatment and root resorption score was not statistically significant although suggestive (p<0.1) (Table II). Patients with short or blunt roots were more likely to show obvious root resorption (p<0.05) (Table III). Interestingly, patients with at least one form of anomalous dental morphology and patients with no anomalous dental morphology exhibited a significantly different frequency of severe root resorption (p<0.01) (Table IV). The severity of root resorption of teeth with anomalous morphology and teeth with no anomalous morphology were compared. Significant differences were seen for teeth with invagination (p<0.05), teeth with thin or pipette-shaped roots (p<0.01), and teeth with short or blunt roots (p<0.01) (Table V).

## Discussion

A total of 1,630 teeth were examined for the presence of anomalous morphology and the degree of root resorption after orthodontic treatment by means of standardised panoramic radiographs taken by the same machine. A good quality panoramic radiograph has been accepted as an adequate diagnostic aid for the detection of most abnormal findings.[28,29] In an attempt to eliminate the influence of residual root growth and distorted measurement. maxillary posterior teeth, teeth with incomplete root formation, and poor image teeth were excluded from the study.

All of the patients selected for this study were orthodontic patients. The expected rates of occurrence of dental anomalies in such a group are unknown. It is at least possible that the rates of occurrence of some anomalies in this sample are different from the rates of occurrence in a random sample.

The result revealing that 97.3 per cent of the patients had undergone some degree of root resorption was not a surprising finding. In fact, it has been known since 1969 that root resorption occurs in almost every orthodontic patient.[1] Approximately 40 per cent of the patients in the present study suffered from severe root resorption (score 3 and 4). This percentage was higher than that found by Linge and Linge,[13] who reported that only 16.5 per cent of their patients had root shortening of more than 2.5 mm.

Of the 1,630 teeth examined in the present study, the frequency of those with severe root resorption (score 3 and 4) was 12.1 per cent. This compares to the prevalence rates of 6.0-16.5 per cent outlined by previous studies.[3,4] Differences in root resorption measurement methods may account for such a wide range of percentages.

In the present study, the association between length of treatment time and root resorption was not significant. This finding was not consistent with the findings of earlier studies.[13,16] In concordance with previous studies,[13,18] age at the start of treatment and type of malocclusion were not significantly related to the amount of root resorption. It is interesting to note that patients with any one dental anomaly had a higher degree of root resorption than patients with no dental anomaly. However, it must be remembered that not all teeth were examined for every patient and the morphologies of teeth excluded from the study are unknown.

It was found that the degrees of root resorption in teeth with invagination, teeth with thin or pipette-shaped roots, and teeth with short or blunt roots were significantly higher than in teeth with normal root form. This is in agreement with earlier studies.[3,12] Kjær[24] found an association between taurodontism, as well as ectopic eruption, and the tendency to root resorption following orthodontic treatment. However, such relations were not found in the present study.

Several aetiological factors have been proposed as the cause of anomalous morphology. Newman[12] strongly suggested a genetic component for shortened roots. Disturbance during the development of the root caused by trauma or non-physiological forces, such as nail-biting, may be the cause of short or blunt roots.[31] Linge and Linge[6] found a relation between trauma and severe root resorption during orthodontic treatment. Recently, Kjær[24] postulated that neuro-ectodermal deviation from normal development may not only affect the eruption of the tooth, but may also cause anomalous root shapes. Disturbances of ameloblastic activity have also been thought to be the cause of dental invagination.[32]

## Conclusion

Patients with at least one form of anomalous dental morphology showed significantly higher rates of root resorption than patients without anomalous morphology. Of all the teeth examined in this study, teeth with invaginations, short or blunt roots, or thin or pipette-shaped roots were more predisposed to root resorption than those without such anomalies. The presence of such anomalous dental morphology should be taken into account in orthodontic treatment planning.

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