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Maxillary canine displacement; further twists in the tale

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SUMMARY This report describes two cases seen over a 5-year period, each with a labially impacted maxillary canine found in close proximity to the adjacent first permanent premolar, which had a deviated palatal root.

The issue as to whether the premolar root deviation either produced the canine impaction or *vice versa* is discussed, both with reference to the processes considered to be involved in normal tooth eruption, and to three previously published similar cases.

Introduction

The incidence of impacted maxillary permanent canine teeth in the population has been estimated to be 1.7 per cent (Ericson and Kurol, 1986). Bishara (1992) outlined a number of potential aetiological factors, but it was Kerrigan and Sandy (1995) who first described two cases in whom deviation of the maxillary first permanent premolar palatal roots were surmised to have been contributory to the development of the palatal impactions of the adjacent canines.

Since then, one further case has been published (McNamara and McNamara, 2000), with both reports outlining different clinical solutions on how to solve the problem of moving the canine past the deviated premolar root in order to resolve its impaction. In the presence of crowding, the extraction of the premolar could be undertaken (Kerrigan and Sandy, 1995), while in the absence of crowding, the deviated palatal premolar root could either be surgically resected after endodontic treatment (Kerrigan and Sandy, 1995), or orthodontically rotated out of the way (McNamara and McNamara, 2000).

The purpose of this report is therefore twofold. The first is to present two similar cases of canine impaction, while the second is to consider an alternative hypothesis that perhaps the impactions caused the premolar root deviations rather than the obverse.

Subjects and methods

Case 1

A 16-year-old Caucasian female was referred to the orthodontic department by a community dental officer for advice regarding her malocclusion, after having not attended for general dental care for a number of years. She presented with a mild Class III malocclusion, together with a retained, firm upper left primary canine. The crown of the unerupted permanent canine was palpable on the labial aspect, high up in the sulcus. Both a dental pantomogram (DPT) and an upper left oblique occlusal radiograph were taken in order to locate the position of the impacted canine (Figure 1a,b), using the technique of vertical parallax (Southall and Gravely, 1987). These views confirmed the labial impaction, as well as the presence of a deviated palatal root on

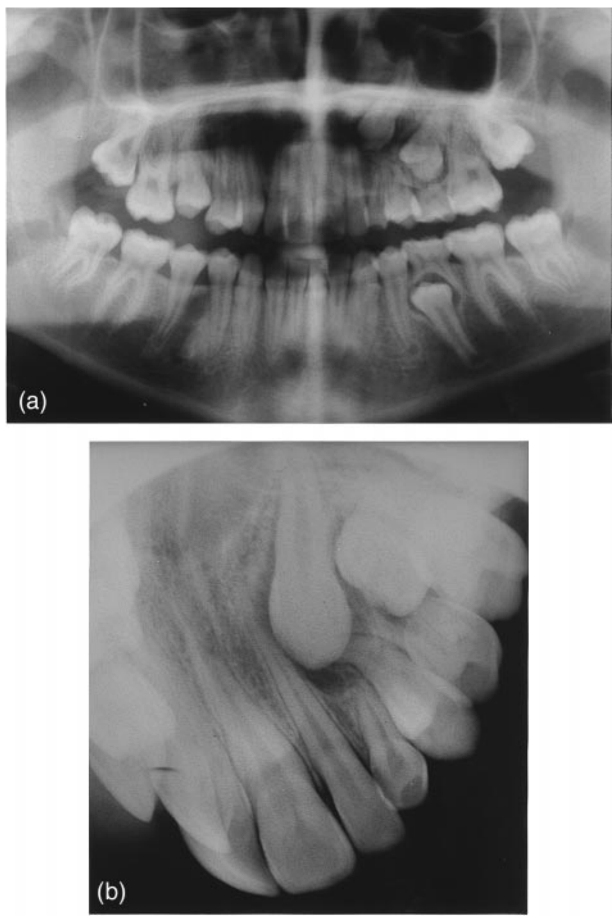

Figure 1 (a) DPT and (b) upper left oblique occlusal radiograph of case 1.

the adjacent first permanent premolar. After further discussion on a joint oral surgery clinic 3 months later, the patient declined to have any active orthodontic treatment, and consented only to the surgical removal of the tooth. Six months later her permanent canine was removed via a labial approach, with division of its crown, while her primary canine was retained. At follow up healing was uneventful, and she was discharged.

Case 2

A 13-year-old Caucasian female referred by her general dental practitioner for advice regarding the delayed eruption of her upper left canine. She presented with a Class II division 1 malocclusion, with a 7 mm overjet, and an increased overbite with contact onto the incisive papilla. The upper left primary canine was retained and firm, while the unerupted permanent canine was distinctly palpable on the labial aspect.

A DPT and an upper left oblique occlusal radiograph were taken (Figure 2a,b) which, through vertical parallax, also confirmed that the crown of the canine was labial to the roots of the upper left central and lateral incisors, while its root was above the apex of the palatal root of the first premolar and palatal to this tooth's buccal root. The palatal root of the first premolar was dilacerated, with the maximum bend extending palatal to the unerupted canine, but curving back buccally towards the apex. The apex of the impacted canine was buccal to the apex of the palatal root of the first permanent molar, and separately the upper right second permanent premolar palatal root was also deviated.

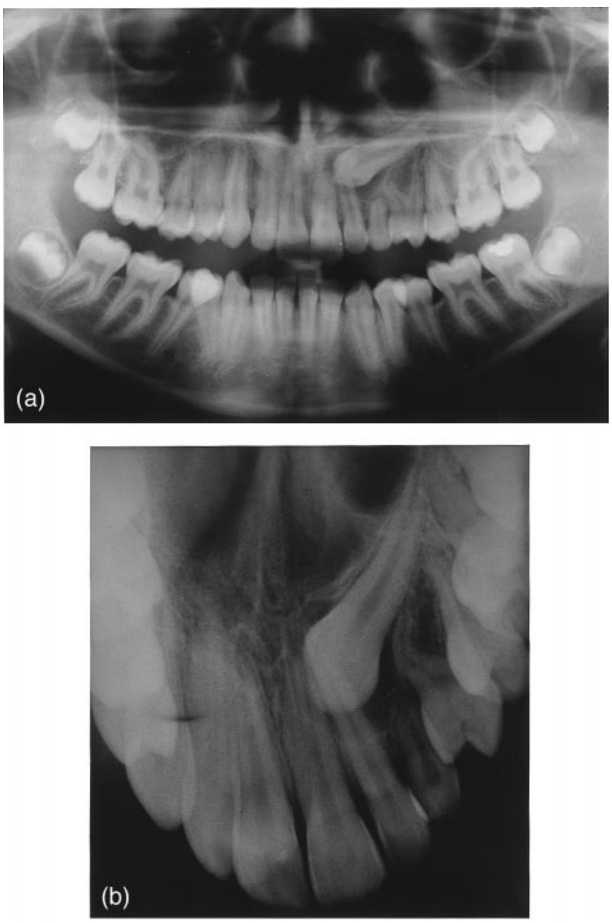

Figure 2 (a) DPT and (b) upper left oblique occlusal radiograph of case 2.

Despite being advised that retention of the canine could pose a significant risk of root resorption on the adjacent lateral incisor root (Ericson and Kurol, 2000), she declined to have either any orthodontic or surgical intervention, and with parental approval, discharged herself.

Discussion

Although Kerrigan and Sandy's (1995) two male cases, and McNamara and McNamara's (2000) single female all had palatal canine impactions, compared with the two females in this report with labial canine impactions, radiographically a number of similarities are present. In McNamara and McNamara's (2000) case, as well as case 1 in both this and Kerrigan and Sandy's (1995) study, the palatal roots of the first premolars adjacent to the impacted canines seemed to have developed a deviation half way through their formation, while in both this study and Kerrigan and Sandy's (1995) case 2 patients, the palatal roots of the first premolars seemed to have had deviations from the beginning of their formation, with a straightening deflection half way through their development.

There would seem to be three possibilities that could account for this. The first is that the palatal premolar root deviations produced the canine impactions. The second is that the canine impactions caused the root deviations, while the third is that the two are simply coincidental. Kerrigan and Sandy (1995) favour the first explanation, and they previously discounted the possibility of coincidence for two reasons. The first related to the absence of any root deviations in their patients' contralateral first premolars, which seemed to suggest that these were not a generalized feature. The second was that they felt the root deviations were unlikely to have arisen out of a traumatic non-axial displacement of the premolar, presumably because both the buccal and the palatal roots would otherwise have been dilacerated.

That both patients in the present report had premolars with only the palatal roots deviated, and whose antimeres also had straight roots, would seem to add support to this contention. However, in case 2 the contralateral second premolar did have a deviated palatal root, and given the general prevalence of displaced maxillary canines, of which 39 per cent impact on the buccal, and 50 per cent impact on the palatal aspect (Ericson and Kurol, 2000), with only five cases so far reported with this association, such a low level of detection may well be indicative of coincidence rather than causation.

Nevertheless, in order to try and resolve the dilemma, consideration needs to be given to the following questions.

Can a developing deviated palatal premolar root displace an unerupted canine?

Berkovitz *et al.* (1992) suggested two theories to explain the mechanism of tooth eruption, neither of which are fully supported by experimental evidence.

The first is that teeth are pushed out as a result of forces generated beneath them (e.g. alveolar bone growth and root growth, etc.), while the second is that teeth are pulled out as a result of periodontal ligament connective tissue tension. For the developing premolar root to deflect the unerupted canine, the concept of root formation progressing apically through the bone would have to apply. However the cross-sectional measurements made by Orban (1928) on primary and permanent maxillary incisors, as well as cross-sectional radiographic measurements on first permanent molars (Kronfeld, 1935), have shown no evidence of an active displacement of Hertwig's sheath into the jaw; rather that it maintains a stationary position, with growth of the tooth proceeding in an occlusal direction.

Further support for this concept comes from animal experiments which show that despite the considerable eruptive movements of ferret mandibular teeth, the root apices maintain a constant position to the lower border of the mandible (Berkovitz and Moxham, 1990). An earlier identical finding for human mandibular teeth was made by Darling and Levers (1975), but with reference to the inferior dental canal, which, in contrast to the mandibular lower border, Björk and Skieller (1972) have shown to be a stable natural reference structure in human growth analysis.

Indeed, Björk and Skieller's (1983) longitudinal implant studies have also shown that when root development of a tooth has started, the lower contour may be stationary in the bone for a period before upward movement begins, and that the root is also normally not lowered below its original level.

Additional evidence that developing roots do not progress apically through bone comes from experimental studies on dogs which have had their crowns removed and replaced by replicas. Marks and Cahill (1984) have shown that tooth eruption is a process of bone resorption and deposition on the occlusal and apical sides of the dental follicle, respectively, and that the tooth *per se* does not contribute to the process. Indeed, more recent studies have now identified the cascade of molecular signals generated in the dental follicle and stellate reticulum, which results in an influx of mononuclear cells into the follicle. These then fuse to become osteoclasts that resorb the alveolar bone to form an eruption pathway for the tooth (Wise and Lin, 1995; Que *et al.*, 1999; Wise *et al.*, 1999).

Can a deviated premolar root displace the canine without being resorbed?

Another aspect that undermines the hypothesis that the premolar root deflects the canine is the propensity for an impacted canine to induce root resorption.

While Ericson and Kurol (1987) initially estimated this risk to be 12.5 per cent for an adjacent lateral incisor using standard dental radiography, this has recently been revised after using more sophisticated computer tomography to 38 per cent, of which 60 per cent are sufficiently severe to result in pulpal exposure (Ericson and Kurol, 2000).

At what age does the erupting canine pass in proximity to the palatal root of the first premolar, and what level of root development does the premolar have at this stage?

Whichever of the two causation hypotheses are considered, knowing the answers to these questions would be helpful. For example, if a palatal premolar root deviation were to deflect an adjacent canine for this to result in a palatal impaction, the premolar root would probably have to make contact with either the canine crown or the coronal one-third of the root during its transition. Equally, for it to result in a labial impaction, it would most likely have to make contact with either the middle or apical third of the canine root instead.

Conversely, if a canine impaction were to distort the formation of a palatal premolar root, it would be pertinent to know what level of root development the premolar would have by the time the canine crown had reached the point where normal emergence would be anticipated, i.e. when it should no longer be in proximity to cause the distortion.

Two sources of data are available to provide some insight. Table 1 is an extract of longitudinal data taken from the serial radiographs of the Burlington growth study, which comprised Canadian children of white Anglo-Saxon origin (Anderson *et al.*, 1976), while Table 2 is an extract of some cross-sectional data taken of Finnish children (Haavikko, 1970). Both show that by the time the first premolar roots have reached one-half of their development (i.e. the time when the root deviations occurred in these patients), the canine roots are three-quarters developed. Table 2 also lists

Table 1 Age of attainment of the mineralization stages for the maxillary canine and first premolar teeth in males and females, expressed as means and standard deviations, in years. (Reproduced from Anderson *et al*., 1976, with kind permission from ASTM International.)

	Male				Female			
	Canine		First premolar		Canine		First premolar	
Stage	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Crown complete	4.9	0.53	5.8	1.00	4.1	0.49	5.1	0.56
Root initiation	5.8	0.61	6.9	1.00	4.9	0.57	5.8	0.59
Root 1/4	7.0	0.67	8.1	0.98	5.9	0.63	6.9	0.67
Root 1/2	8.2	0.76	9.0	0.96	7.0	0.72	7.8	0.73
Root 3/4	9.6	0.82	10.0	1.01	8.2	0.76	8.7	0.80
Root complete	11.1	0.95	11.1	1.01	9.4	0.81	9.7	0.90

Table 2 Age, medians, and dispersions (difference between the 90th and 10th percentiles) for tooth formation stages and eruption in years, for male and female maxillary canine and first premolar teeth. (Reproduced from Haavikko, 1970, with kind permission of the author and the Finnish Dental Society Apollonia.)

Stage	Male				Female			
	Canine		First premolar		Canine		First premolar	
	Median	Disp.	Median	Disp.	Median	Disp.	Median	Disp.
Crown complete	4.6	1.3	6.8	2.0	4.5	2.1	6.3	1.2
Root 1/4	7.0	1.9	8.4	1.9	6.3	1.3	8.0	1.4
Root 1/2	8.4	2.2	9.5	2.2	7.7	2.1	9.4	1.3
Root 3/4	9.8	2.7	10.7	2.4	9.0	1.9	10.4	2.6
Root complete	12.3	2.6	11.5	3.2	11.2	2.5	10.9	2.7
Alveolar eruption	11.2	3.1	9.8	3.6	9.3	3.2	9.0	2.8
Clinical eruption	12.1	3.6	10.2	3.6	10.6	3.7	9.6	3.5

the dates for alveolar eruption, which is when a crown completely resorbs the alveolar bone occlusal to it, prior to its clinical emergence. This shows that at the age of maxillary canine alveolar eruption, root formation of the adjacent first premolar is nearly complete in males, but only one-half complete in females. That is, for the three females so far reported, the canine crowns should have been well past the first premolar roots by the time these were one-half developed, and yet one of them still developed a palatal impaction (McNamara and McNamara, 2000), and the present two a labial impaction.

However, for Kerrigan and Sandy's (1995) two males with palatal canine impactions, the crowns of these teeth would most likely have still been in proximity to the half developed premolar roots. Therefore, for the males at least, there remains some equivocation as to causation. However, for the females, the data lend support to the hypothesis that the canine impaction may be responsible for the premolar root deviation.

Conclusion

Without larger clinical samples to study, perhaps with three-dimensional computed tomography, the final answer to this dilemma will remain unresolved. Nevertheless, the material presented in this report has raised the possibility of both an alternative hypothesis of causation, as well as evidence that may substantiate the concept of coincidence.

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