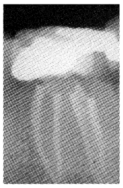

CLINICAL ARTICLE

The radix entomolaris in mandibular first molars: an endodontic challenge

R. J. G. De Moor, C. A. J. G. Deroose & F. L. G. Calberson
Department of Operative Dentistry and Endodontology, Dental School, Ghent University, Ghent University Hospital, Gent, Belgium

Abstract

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Aim To present cases of mandibular first molars with an additional distolingual root (radix entomolaris, RE) and to survey the literature on the incidence of this anatomical feature.

Summary A major anatomical variant of the two-rooted mandibular first molar is a tooth with an additional distolingual and third root: the RE. The prevalence of these three-rooted mandibular first molars appears to be less than 3% in African populations, not to exceed 4.2% in Caucasians, to be less than 5% in Eurasian and Asian populations, and to be higher than 5% (even up to 40%) in populations with Mongolian traits. A total of 18 cases (12 root filled and six extracted mandibular first molars) with an RE were collected during the years 2000–2003 in patients of Caucasian origin. As far as the access was concerned, entering the root canal in the RE required a modification of the opening in a distolingual direction resulting in a trapezoidal opening cavity. None of the orifices was located midway between the mesial and distal root component. Based on the anatomy of the extracted samples and the bending of ISO 10 files after scouting of the root canal in the RE, three types of curvature were detected: (I) straight or no curvature (two cases); (II) coronal third curved and straight continuation to the apex (five cases); and (III) curvature in the coronal third and buccal curvature from the middle third or apical third of the root (11 cases).

Key learning points

- Clinicians should be aware of this unusual root morphology in mandibular first molars in Caucasian people.
- Radiographs exposed at two different horizontal angles are needed to identify this additional root.
- The access cavity must be modified in a distolingual direction in order to visualize and treat the RE, this results in a trapezoidal access cavity.

Keywords: anatomical variations, endodontic treatment, mandibular first molar, radix entomolaris.

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Correspondence: Prof. Dr Roeland De Moor, Department of Operative Dentistry and Endodontology, Dental School, Ghent University, Ghent University Hospital, De Pintelaan 185 (P8), B-9000 Gent, Belgium (Tel.: +32 (0)9 240 00 00/40 01; fax: +32 (0)9 240 38 51; e-mail: roeland.demoor@ugent.be).

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Introduction

The main objective of root canal treatment is the thorough mechanical and chemical cleansing of the entire pulp cavity and its complete obturation with an inert filling material and a coronal filling preventing ingress of microorganisms. One of the main reasons for failure of root canal treatment in molars is because the clinician has not removed all the pulp tissue and microorganisms from the root canal system (Cohen & Brown 2002).

It is of utmost importance that the clinician be familiar with root and root canal anatomy. The majority of Caucasian first molars are two-rooted with two mesial and one distal canal (Barker *et al.* 1974, Vertucci 1984). The major variant in this tooth type is the presence of an additional third root; a supernumerary root which can be found lingually. This macrostructure, which is first mentioned in the literature by Carabelli (1844), is called radix entomolaris (RE) (Bolk 1915).

In European populations it has been reported that a separate RE is present in the mandibular first molar with a maximum frequency of 3.4–4.2% (Taylor 1899, De Souza-Freitas *et al.* 1971, Skidmore & Bjorndahl 1971, Curzon 1973, Ferraz & Pécora 1992, Steelman 1986) (Table 1). In African populations (Bantu, Bushmen, Senegalese) a maximum of 3% is found (Drennan 1929, Shaw 1931, Sperber & Moreau 1998). In Eurasian and Indian populations the frequency is less than 5% (Tratman 1938). In populations with Mongoloid traits, such as Chinese, Eskimo and American Indians, the RE occurs with a frequency of 5% to more than 40% (Tratman 1938, Laband 1941, Pedersen 1949, Curzon & Curzon 1971, De Souza-De Freitas *et al.* 1971, Somogyl-Csizmazia & Simons 1971, Turner 1971, Curzon 1974, Hochstetter 1975, Jones 1980, Reichart & Metah 1981, Walker & Quackenbush 1985, Walker 1988, Ferraz & Pécora 1992, Yew & Chan 1993, Gulabivala *et al.* 2001) (Table 1). The high degree of RE in these Mongoloid populations has provoked more specific analyses of the heritable basis of this supernumerary radicular structure (Tratman 1938, De Souza-De Freitas *et al.* 1971, Turner 1971, Curzon 1974). More specifically, only Curzon (1974) suggested that certain traits such as the 'three-rooted molar' had a high degree of genetic penetrance as its dominance was reflected in the fact that pure Eskimo and Eskimo/Caucasian mixes had similar prevalence of the trait.

Apart from its role as a genetic marker, RE has significance in clinical dentistry (Carlsen & Alexandersen 1990). Whereas the RE is not typical in a Caucasian population, knowledge of its occurrence and its location are important.

Reports

A clinical and radiographic prospective evaluation was made of 18 mandibular first molars with an RE in 17 patients (i.e. 12 teeth examined in patients and six teeth after extraction). The pulp chambers of the six extracted teeth were accessed, and in all cases the orifice of the RE was located distolingually from the main canal or canals in the distal root. The position was also characteristic for the root filled molars examined *in situ*. Based on the external root morphology and scouting of root canals of all RE with a Flexofile ISO 10 (Dentsply Maillefer, Ballaigues, Switzerland) the RE could be classified in three groups on the basis of the curve of the root/root canal (Fig. 1). This classification is based on a classification proposed by Ribeiro & Consolaro (1997): type I refers to a straight root/root canal (two cases), type II to an initially curved entrance and the continuation as a straight root/root canals (five cases), type III to an initial curve in the coronal third of the root canal and a second buccally orientated curve starting from the middle to apical third (11 cases – in one of the root filled teeth this was a 90° buccal curve). Irrespective of the root canal

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Table 1 Prevalence of three-rooted mandibular first molars – survey of available studies

Study	Origin	Total number of teeth	Number of teeth with three roots	Percentage of total (%)
Taylor (1899)	United Kingdom	119	4	3.4
Bolk (1915)	Netherlands	1713	18	1.0
Campbell (1925)	Australian Aborigine	176	0	0.0
Drennan (1929)	South African Bushman	23	0	0.0
Shaw (1931)	African Bantu	68	0	0.0
Tratman (1938)	Chinese	1615	95	5.8
	Malay	475	41	8.6
	Javanese	110	12	10.9
	Indians	453	1	0.2
	Eurasians	262	11	4.2
	Japanese	168	2	1.2
Laband (1941)	Malay in N. Borneo	134	11	8.2
Pedersen (1949)	Greenland Eskimo	64	8	12.5
Somogyl-Csizmazia & Simons (1971)	Canadian Indians	250	39	16.0
De Souza-De Freitas *et al.* (1971)	European	422	27	3.2
	Japanese	233	83	17.8
Skidmore & Bjorndahl (1971)	Caucasian	45	1	2.2
Turner (1971)	Aleut Eskimo	263	84	32.0
	American Indian	1983	116	5.8
Curzon & Curzon (1971)	Keewatin Eskimo	98	28	27.0
Curzon (1973)	United Kingdom	377	13	3.4
Curzon (1974)	Baffin Eskimo	69	15	21.7
Vertucci & Williams (1974)	Not stated	100	0	0.0
Hochtstetter (1975)	Guam	400	52	13.0
Jones (1980)	Chinese	52	7	13.4
	Malaysian	149	25	16.0
Reichart & Metah (1981)	Thai	364	70	19.0
Walker & Quackenbush (1985)	Hong Kong Chinese	213	31	14.6
Steelman (1998)	Hispanic children	156	5	3.2
Walker (1988)	Hong Kong Chinese	100	15	15.0
Loh (1990)	Chinese (Singapore)	304	24	7.9
Younes *et al.* (1990)	Saudi	581	17	2.92
	Egyptian	739	6	0.01
Ferraz & Pécora (1992)	Japanese	105	12	11.4
	Negroid	106	3	2.8
	Caucasian	117	5	4.2
Yew & Chan (1993)	Chinese	832	179	21.5
Sperber & Moreau (1998)	Senegalese	480	15	3.0
Gulabivala *et al.* (2001)	Burmese	139	14	10.1

type the orifice of the RE remained located distolingually from the root canal(s) in the classical distal root.

Case 1 – type I curve

A 25-year-old Caucasian male presented with an extensive mesial carious lesion in the mandibular right first molar and a fracture of the mesiobuccal cusp. He also complained of spontaneous pain from the tooth. The tooth was percussion sensitive, cold and heat sensitive, although there was no referred pain. Two radiographs with different horizontal angulations (Fig. 2a,b) were made with the Rinn set (Dentsply Rinn, Elgin, IL, USA). From Fig. 2(b) it is clear that there was an additional lingual root. The tooth was anaesthetised,

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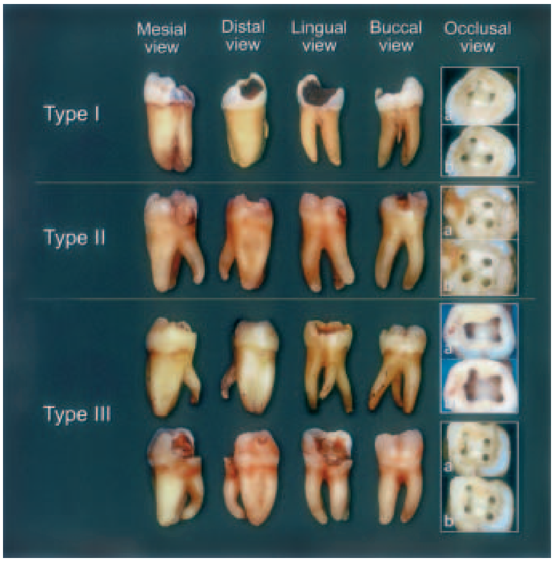

Figure 1 Classification of the extracted mandibular first molars with a radix entomolaris (RE) and occlusal view on the pulp chamber and root canal orifices (a: original opening cavity; b: modification of the opening cavity for the localization of the orifices of the RE and the preparation of the root canal). Type I: a straight root/root canal; type II: initially curved entrance of the root canal and the continuation as a straight root/root canals; type III: initial curve in the coronal third of the root canal and a second buccally orientated curve starting from the middle third; the radix entomolaris may also have a pronounced curve in the apical part of the root (in one of the root filled teeth of this case study this was a 90° buccal curve).

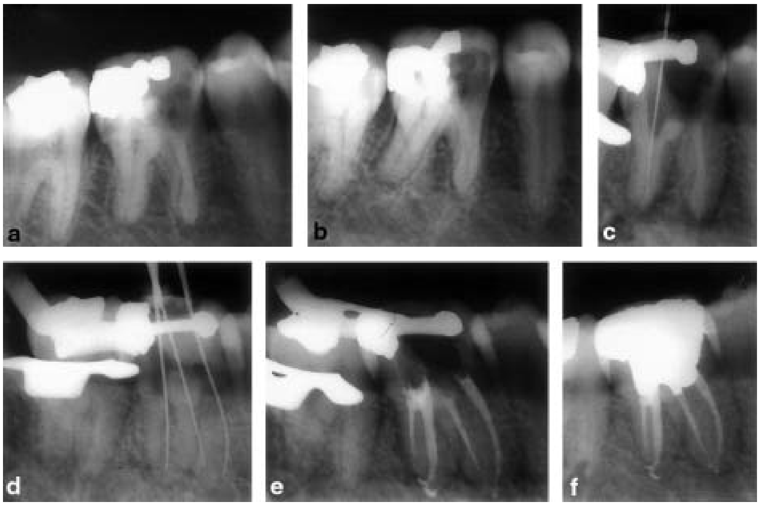

Figure 2 (a) Radiograph of tooth 46 showing decay and fracture of the mesiobuccal cusp. (b) A second preoperative radiograph of tooth 46 taken with a more mesial angulation and revealing the presence of a lingually located additional distal root. (c) Length-determination radiograph of the root canal in the radix entomolaris. (d) Length-determination radiograph of the conventional root canals (one distal root canal and two mesial canals). (e) Radiographic control following obturation of the four root canals. (f) Radiographic control 1 year postoperatively revealing a continuous periodontal space with no signs of periapical periodontitis.

isolated with rubber dam and after removal of the caries the pulp chamber was opened; bleeding pulp tissue was found. The conventional triangular access cavity was modified into a more trapezoidal cavity in order to locate and open the orifice of the distolingually

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located RE. After scouting of the root canals and flaring of the coronal thirds with Gates Glidden burs (Nos 3–2) in a crown-down mode, radiographic length-determination was completed by means of two radiographs, one with a file in the RE (Fig. 2c) and one with the instruments inserted into the mesial and distal canals (Fig. 2d). In order to verify the working lengths, an electronic apex locator was used (AFA Apexfinder; EIE Analytic Technology, Orange, CA, USA). The root canals were prepared in a crown-down/step-back method using Flexofiles. During root canal preparation RC Prep (Premier, Norristown, PA, USA) was used and the root canals were irrigated with sodium hypochlorite solution (2.5%). The root canals were filled with gutta-percha and AH 26 (De Trey Dentsply, Konstanz, Germany) using the hybrid gutta-percha condensation with gutta-percha condensers (Dentsply Maillefer) according to De Moor & Hommez (2002) (Fig. 2e). The tooth was restored coronally with an amalgam restoration, amalgam was placed into the enlarged root canal orifices (amalgam coronal-radicular restoration). Radiographic control 1 year postoperatively revealed a continuous periodontal space with no signs of periapical periodontitis (Fig. 1f).

Case 2 – type II curve

A 19-year-old Caucasian female patient was referred by her general dental practitioner for endodontic treatment of the right (tooth 46) (Fig. 3) and left (tooth 36) (Fig. 4) mandibular first molars. Clinical examination showed an extensive occlusal filling close to the pulp on both molars. The molars were sensitive to percussion. The medical history was noncontributory. Radiographic examination revealed a peri-apical lesion on both teeth (Fig. 3a). Each tooth was treated on separate occasions in two sessions.

Routine access was made after the rubber dam was applied. Both teeth were treated without anaesthesia. When the floor of the pulp chambers was reached, three canal orifices were initially identified. On further exploration a second distal and more lingually located canal was found.

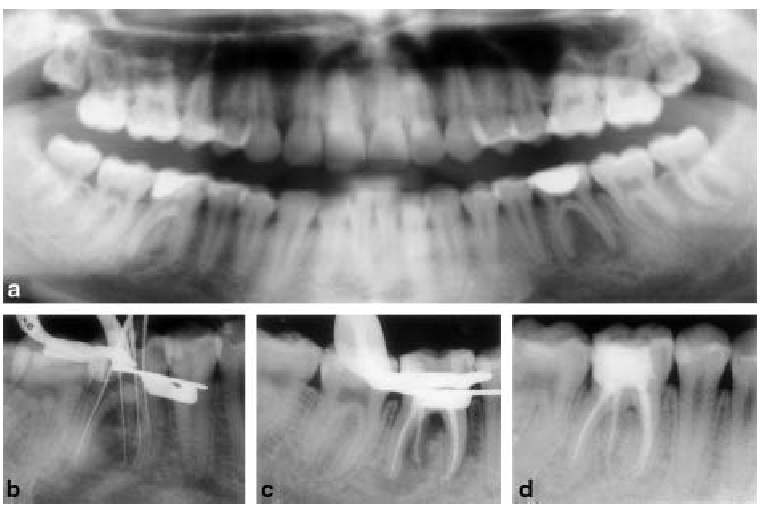

Figure 3 (a) Panoramic radiograph showing tooth 36 with an extensive coronal restoration and periapical radiolucency; and tooth 46 with a class II restoration and periapical radiolucency. (b) Length-determination radiograph (tooth 46) of the conventional root canals (one distal root canal and two mesial canals) and the root canal of the radix entomolaris. (c) Radiographic control following obturation of the four root canals. (d) One-year postoperative radiographic control indicating healthy apical bone structure with no radiographic signs of apical periodontitis.

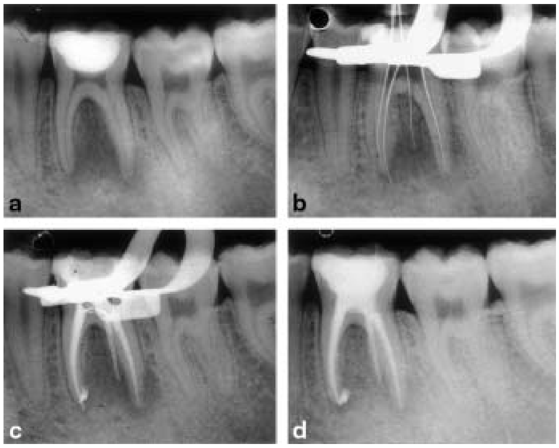

Figure 4 (a) Preoperative radiograph of tooth 36 showing the presence of the radix entomolaris projected on the distal root. (b) Length-determination radiograph of the conventional root canals (one distal root canal and two mesial canals) and the root canal of the radix entomolaris. (c) Radiographic control following obturation of the four root canals. (d) One-year postoperative radiographic control indicating healthy apical bone structure with no radiographic signs of apical periodontitis.

The preoperative radiographs (Figs 3a and 4a) revealed the presence of an additional distolingual root. Canal lengths were checked with the AFA Apexfinder and confirmed by means of a length determination radiograph taken from a mesial angulation (Figs 3b and 4b). All canals were cleaned and shaped with ProTaper files (Dentsply Maillefer) up to the F2-ProTaper. Instrumentation was completed using a size 30 K-File. An interappointment calcium hydroxide dressing (Ultracal XS; Ultradent Products Inc., South Jordan, UT, USA) was placed in the canals and covered with Fuji IX (GC Corp., Tokyo, Japan).

The patient returned after 2 weeks for completion of the treatment and in each case the teeth were asymptomatic. Instrumentation was repeated to a MAF size 30 K-file. Canals were filled with AH-26 root canal sealer and gutta-percha using the hybrid gutta-percha condensation technique (Figs 3c and 4c). The access cavity was sealed with Fuji IX. The patient was referred to her general practitioner for the permanent coronal restoration. Radiographic control 1 year postoperatively revealed a continuous periodontal space with no signs of periapical periodontitis (Figs 3d and 4d).

Case 3 – type III curve

A mandibular right first molar of a 25-year-old Caucasian male was root filled by a general dentist after complaints of sporadic tenderness and diffuse pain. Two weeks before referral acute symptoms of pain and moderate swelling were relieved by means of the administration of painkillers (Brufen forte, 600 mg, maximum 3 × 600 mg daily) (Abbott S.A., Ottignies, Belgium) and antibiotic therapy (Clamoxyl, 500 mg, twice 1 g daily) (GlaxoSmithKline s.a./n.v., Genval, Belgium). On initial presentation in the endodontic practice the tooth was still percussion sensitive. Radiographic examination (Fig. 5a) showed an inadequate filling of the root canals, without signs of apical periodontitis. A distinct second distal root with root filling was clearly visible. Opening of the pulp chamber revealed an untreated mesiolingual canal. The orifice of the RE was located distolingually of the orifice of the distal root canal. Length determination was verified electronically (AFA Apexfinder) and radiographically (Fig. 5b). Four root canals were cleaned using EDTA (File Eze; Ultradent Products Inc.) and 2.5% sodium

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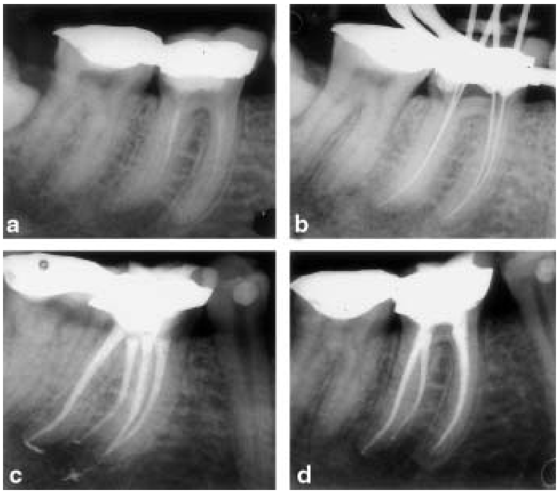

Figure 5 (a) Radiograph of tooth 46 restored with a ceramic-metal crown and inadequate root fillings, despite symptoms of swelling in the buccal fold and sensitivity to percussion and palpation there are no signs of apical radiolucencies. (b) Length-determination radiograph of the conventional root canals (one distal root canal and two mesial canals) and the root canal of the radix entomolaris. (c) Radiographic control following definite obturation of the four root canals. (d) One-year postoperative radiographic control indicating healthy apical bone structure with no radiographic signs of apical periodontitis.

hypochlorite, and shaped with ProFiles (Dentsply Maillefer). Exudate from the distobuccal root during root canal preparation was noted. After drying of the root canals with paper points, a calcium hydroxyde interappointment dressing (Ultracal XS) was placed.

Two weeks later, after removal of the calcium hydroxide and copious irrigation with 2.5% sodium hypochlorite, the canals were obturated with thermomechanically condensed (hybrid condensation) gutta-percha and AH Plus sealer (Dentsply Maillefer) (Fig. 5c). The opening cavity was sealed with KetacFil glass–ionomer cement (Espe, Seefeld, Germany) and the patient was referred to his general dental practitioner for the permanent coronal restoration. The 1-year control radiograph showed a continuous periodontal space with no signs of periapical periodontitis (Fig. 5d).

Case 4 – type III curve

A 46-year-old Caucasian female was referred for the treatment of a persisting sinus tract at the marginal gingiva distally of the mandibular right first molar. This patient had no complaints of pain, but had noticed a localised swelling of the gingiva in the location where 6 months before tooth 47 was extracted. Tracing of the sinus tract with a conventionally tapered size 25 gutta-percha point (Fig. 6a) did not reveal any immediate relation with tooth 46. A second radiograph taken with a more pronounced mesial angulation showed the presence of a second distal more lingually located root (Fig. 6b). During the first appointment access through the ceramic-metal crown was performed, a rubber dam was placed and the pulp chamber opened. The tooth was treated without anaesthesia. A distolingual extension of the contour of the pulp chamber cavity was necessary in order to localise the orifice of the distolingual root and to have optimal access. The length of the four canals was determined electronically (AFA Apexfinder) and the preparation was performed with ProFiles (MAF.04/35) and Flexofiles. Sodium hypochlorite 2.5% and EDTA (Salvizol, Ravens, Konstanz, Germany) were used for

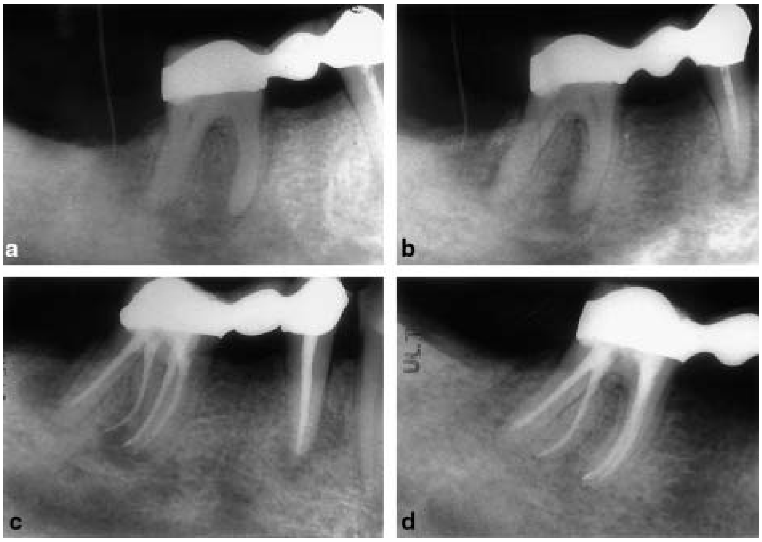

Figure 6 (a) Radiograph of tooth 46 (restored with a ceramic-metal crown and being part of a fixed bridge covering 46-45-44) – tooth 47 had been extracted 6 months earlier. Sinus tract was traced by means of a conventionally tapered gutta-percha size 25. (b) A second preoperative radiograph of tooth 46 taken with a more mesial angulation and revealing the presence of lingually located additional distal root as well as more outlined periapical lesions. (c) Radiographic control following obturation of the four root canals. (d) One-year postoperative radiographic control indicating healthy apical bone structure without radiographic signs of apical periodontitis.

irrigation, disinfection and removal of the smear layer. After initial cleaning and shaping a calcium hydroxide interappointment dressing (Ultracal XS) was placed and the pulp chamber was sealed with a sterile cotton pellet and KetacFil glass–ionomer cement.

Two weeks later the sinus had disappeared and the root canals were filled with thermomechanically condensed gutta-percha and AH Plus root canal sealer (Fig. 6c). The access cavity was sealed with KetacFil and the patient was referred to her general dental practitioner for the permanent coronal restoration. Re-examination 1 year later showed complete healing of the periapical lesions (Fig. 6d).

Discussion

Anatomical variations of mandibular molars are documented in the literature. Nonetheless, variations of the anatomy of the root canal system in molars are not appreciated by a great number of general practitioners (Slaus & Bottenberg 2002, Hommez *et al.* 2003). The variability of root canal anatomy in the distal root of mandibular molars may not be common knowledge (Christie & Thompson 1994). Next to the second distolingual canal, a third distolingual root in mandibular molar teeth, with an incidence ranging from 0.9 to 20% is possible in some populations (Table 1).

These variations in distal root anatomy may be identified through careful reading of angled radiographs. Slowley (1974) has demonstrated how difficult it is to detect extra roots, let alone extra canals. On the contrary, completing a thorough radiographic study of the involved tooth with exposure from three different horizontal projections, the standard buccal-to-lingual projection, 20° from the mesial, and 20° from the distal reveals the basic information regarding the anatomy of the tooth in order to perform endodontic treatment (Ingle *et al.* 2002). However, using the buccal object rule with two radiographs with

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different horizontal angulations may suffice to determine the position of a lingual root (Walton 1973, Goerig & Neaverth 1987). One of these radiographs is taken in the orthoradial position and the other taken either 30° mesially or distally. This buccal object rule has also been called Clark's rule, the same lingual, opposite buccal (SLOB rule) and Walton's projection (Ingle *et al.* 2002).

Predictably successful root canal treatment is dependent on following the basic principles: access, cleansing and shaping, and obturation of the entire root canal system. These principles have evolved from clinical concepts established through clinical practice and basic research. Of the three, perhaps the most important is the principle of 'straight-line' access (Christie & Thompson 1994). It should be emphasized that the ultimate objective of endodontic access is to provide access to the apical foramen, and not merely to locate the canal orifice. With the distolingually located orifice of the RE a modification of the classical triangular opening cavity to a trapezoidal form in order to better locate and access the root canal is essential; straight line access must be established. Based on the present findings (although only 18 cases) together with the data from Ribeiro & Consolaro (1997) (analysis of the structure of 54 extracted mandibular molars with RE) it was found that the majority of the radices entomolaris were curved (in some cases with an additional curve starting from the mid root portion or in the apical third).

Conclusion

The high frequency of a fourth canal in mandibular first molars makes it essential to anticipate and find all canals during molar root canal treatment. The possibility of an extra root should also be considered and looked for carefully. Proper angulation and interpretation of radiographs help to identify chamber and root anatomy. In the case of an RE the conventional triangular opening cavity must be modified to a trapezoidal form in order to better locate and access the distolingually located orifice of the additional root. Straight-line access, in this respect, has to be emphasized as the majority of the radices entomolaris are curved.

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