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The position and topography of the apical canal constriction and apical foramen

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Abstract. Two hundred and seventy extracted human teeth of unknown age were evaluated for apex to foramen and apex to constriction distances, in addition the topography of the apical portion of the root canal was studied under $\times 20$ magnification. The mean A-F distance was 0.38 mm and the mean A-C distance 0.89 mm, although it must be stressed that a wide range of values was observed. Four distinct types of apical constriction were routinely found, whilst a proportion of canals were apparently blocked. The study confirms the view that it is impossible, with complete certainty, to establish the position of the apical canal constriction during root canal therapy, but indicates that a combination of methods might be more successful than reliance on one.

Introduction

The significance of the apical canal constriction in endodontic therapy is well recognized (Ingle 1965, Chanoch 1966, Harty 1982), and all modern canal preparation techniques attempt to make use of its potential to act as a natural barrier between the contents of the canal and the apical tissues (Schilder 1967, Christie & Peikoff 1980a, b, Weine 1982). Although some of the complexities of the apical portion of the root canal have been reported in the past (Kuttler 1955, Green 1956, 1960, Chapman 1969), very little prominence has recently been given to the detailed anatomy of this region and, in particular, to the position and topography of the apical canal constriction.

This lack of emphasis is unfortunate, for it is only with a greater understanding of the anatomy of the root canal that operators will

be able to make intelligent assessments of the end point of preparation for each tooth being treated. This is especially relevant today, as it is apparent that reliance on the dictum that canal preparation should terminate 1 mm short of the radiographic apex is becoming increasingly unacceptable (Levy & Glatt 1970, Palmer *et al.* 1971, Kerekes & Tronstad 1977a, b).

The present study was, therefore, carried out in order to obtain further information about the topography of the apical portion of root canals of human teeth, and to see whether the shape or form of the apical constriction could influence root canal therapy procedures.

Materials and methods

A total of 270 extracted human teeth of unknown age, but with completely formed apices, were included in the study (Table I).

The position of the apical foramen was determined after briefly dipping the apices of the roots into molten blue inlay wax, and then immediately removing the excess with a paper tissue. This always left a small quantity of wax in the foramen. The distance from the apex of the root to the centre of the foramen was then measured at $\times 20$ magnification using a dissecting microscope and a graduated scale. A reference mark on the microscope stage was used to ensure that all measurements were taken in an identical position in order to eliminate any possible error due to parallax. By these means it was possible to work to an accuracy of 0.01 mm.

The root canal and apical constrictions were then exposed by carefully sectioning the root apices in a longitudinal direction using a diamond disc in a straight handpiece against the hand-held teeth. The area was then stained

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Table I. Tooth types making up sample

Tooth type	Maxilla		Mandible	
	Number	Per cent	Number	Per cent
Central incisors	23	8.5	40	14.8
Lateral incisors	22	8.2	37	13.7
Canines	29	10.7	28	10.4
Premolars	38	14.1	53	19.6
Total	112	41.5	158	58.5

with a blue food dye¹ to highlight the position of pulpal debris, which was carefully removed, and to improve the definition of the canal. The shape of the root canal in the proximity of the apical constriction was then studied at $\times 20$ magnification. Finally the distance from the root apex to the narrowest position of the canal, the apical constriction, was measured.

Results

Apex to foramen (A-F) distance

The A-F distances for all the teeth in the study are summarized in Fig. 1 and Table II. Figure 1 compares the percentage of teeth within groups of 0.1 mm throughout the observed range, whilst Table II describes the mean A-F distance for each tooth type.

The observed range of A-F distances was wide for all groups of teeth, being greatest with the premolar teeth (approximately 2 mm), followed by the lower canines, lower incisors, upper canines and smallest with the upper incisors (0.7 mm).

The mean A-F distance for each tooth type ranged from 0.47 mm for the lower canines, to 0.23 mm for the upper incisors. The overall mean A-F distance was 0.38 mm

Apex to constriction (A-C) distance

The A-C distances for all the teeth are summarized in Fig. 2 and Table III. Figure 2 compares the percentage of teeth within groups of 0.2 mm throughout the observed range whilst

Table II. Summary of apex to foramen distances (mm)

Tooth type	Mean	Observed range
Upper incisors	0.23 \pm 0.16	0-0.67
Lower incisors	0.36 \pm 0.23	0-1.38
Upper canines	0.36 \pm 0.22	0.06-0.76
Lower canines	0.47 \pm 0.35	0.06-1.52
Upper premolars	0.42 \pm 0.34	0-1.87
Lower premolars	0.44 \pm 0.39	0-1.93

Mean A-F distance for all tooth types = 0.38 mm.

Table III. Summary of apex to constriction distances (mm)

Tooth type	Mean	Observed range
Upper incisors	0.85 \pm 0.55	0.09-2.68
Lower incisors	0.79 \pm 0.55	0.07-2.66
Upper canines	0.84 \pm 0.51	0.20-2.18
Lower canines	0.95 \pm 0.50	0.13-2.38
Upper premolars	0.95 \pm 0.64	0.07-2.44
Lower premolars	0.99 \pm 0.57	0.20-2.69

Mean A-C distance for all tooth types = 0.89 mm.

Table III describes the mean A-C distance for each tooth type.

The observed range of A-C distances was again wide for all groups of teeth, being greatest for the upper and lower incisors

¹ Langdales, Vulcan Way, New Addington, Surrey, UK.

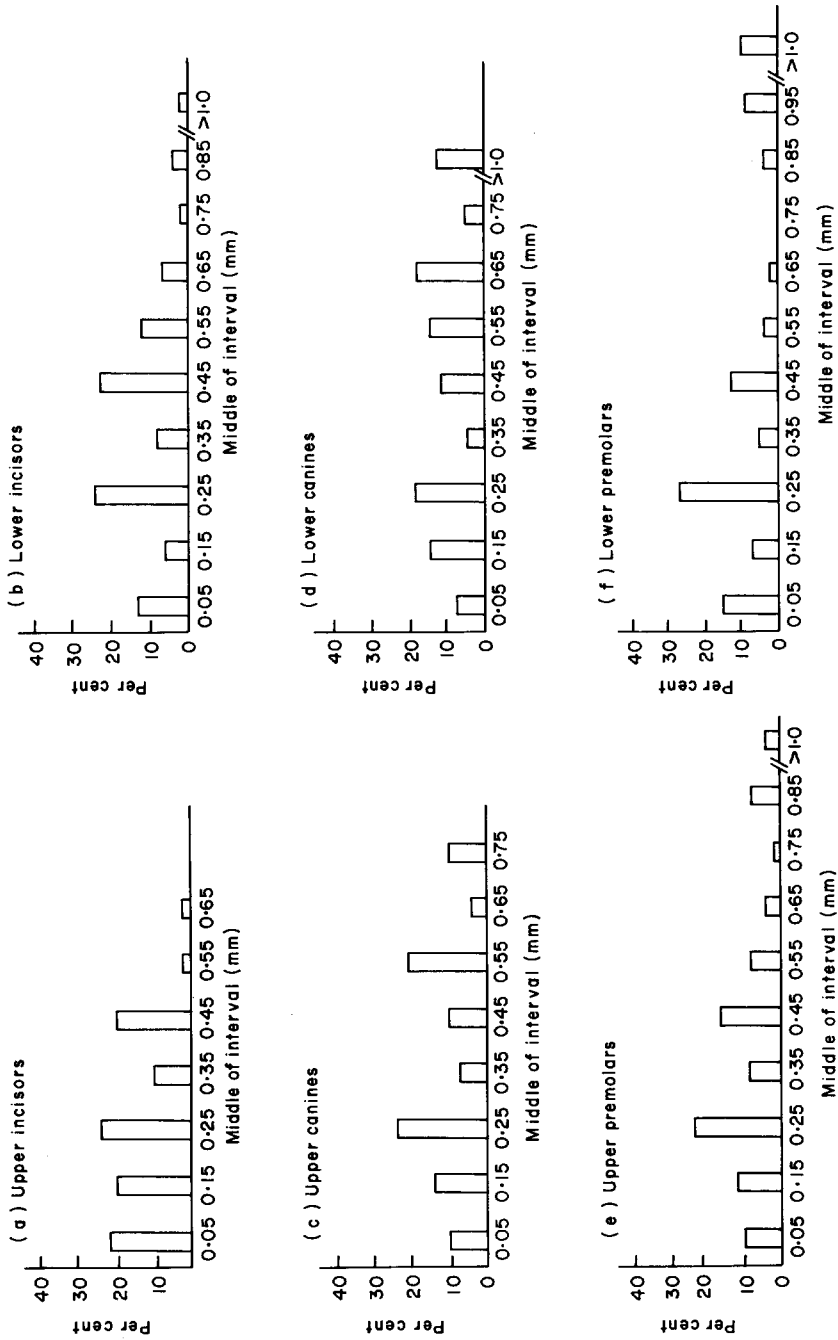


Fig. 1. Apex to foramen distances (mm) for various tooth types.

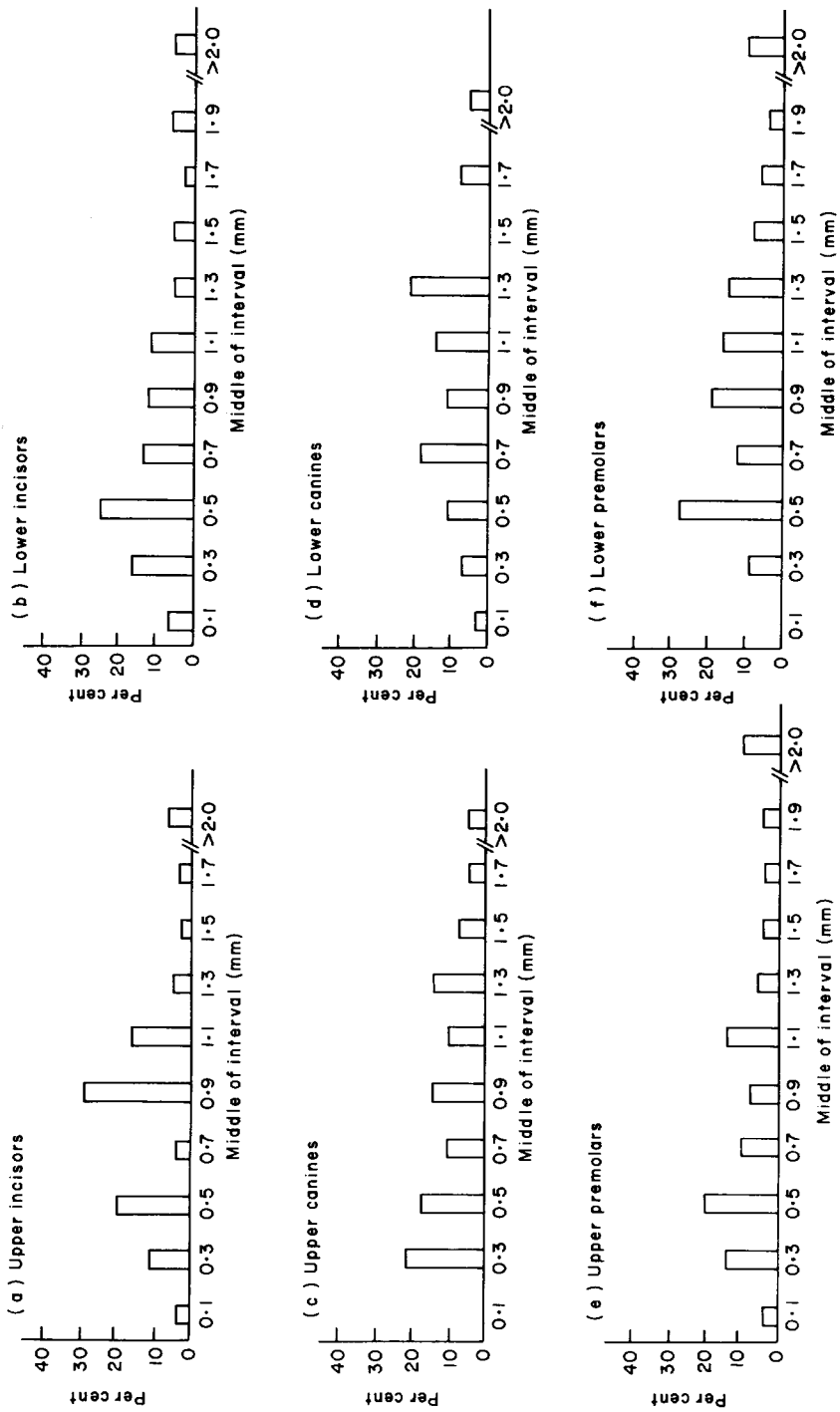
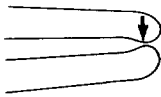


Fig. 2. Apex to constriction distance (mm) for various tooth types.

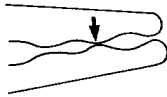
Type A: 'Traditional' single constriction



Type B: Tapering constriction



Type C: Multiconstricted



Type D: Parallel constriction

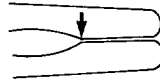


Fig. 3. Classification of apical constrictions. *Arrow* indicates narrowest portion of canal and point of measurement.

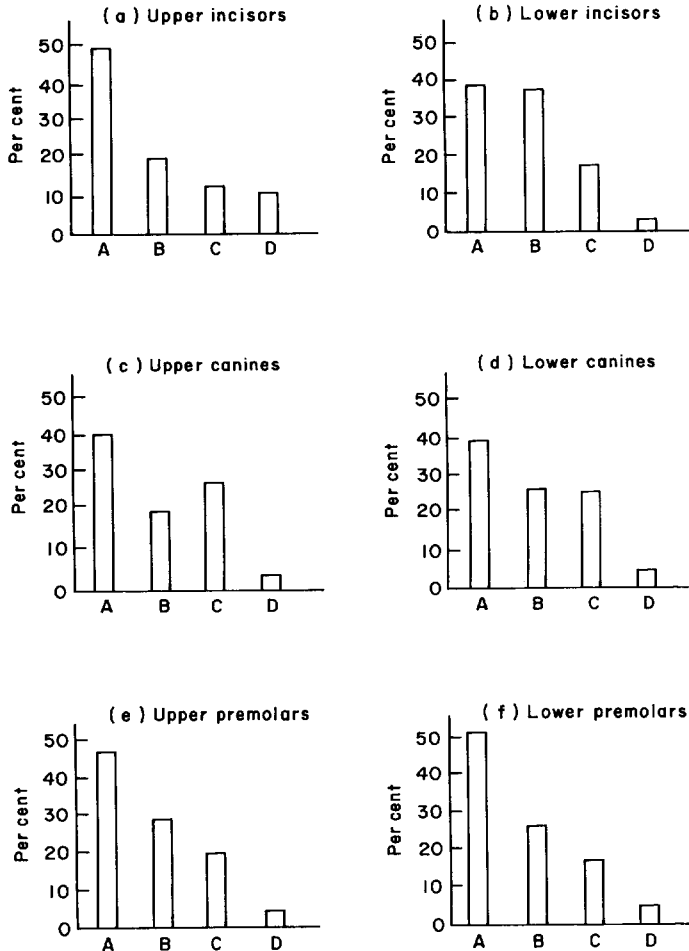


Fig. 4. Frequency of constriction types for various tooth types.

Table IV. Summary of apex to constriction distances (mm) for the various constriction types and their frequency (per cent)

	Mean	Observed range	Per cent
Type A	1.07 ± 0.55	0.09–2.69	46
Type B	0.52 ± 0.34	0.06–1.33	30
Type C	1.08 ± 0.59	0.20–2.25	19
Type D	1.14 ± 0.59	0.67–2.68	5

(2.6 mm) and least for the canines (approximately 2 mm).

The mean A–C distance for each tooth type ranged from 0.99 mm for the lower premolars, to 0.79 mm for the lower incisors. The overall mean A–C distance was 0.89 mm

Topography of the apical constriction

After the apical root canals of all the teeth were studied, it became clear that the topography of the apical constriction was not constant. However, out of the 270 teeth examined, only four definite and distinguishable shapes or types were ever seen (Fig. 3).

These have been classified as: Type A, the 'traditional' single constriction; Type B, a tapering constriction with the narrowest portion of the canal very near the actual apex; Type C, where a number of constrictions were present; and Type D, where the constriction was followed by a narrow, parallel portion of canal. A fifth type was also seen where the canal had been completely blocked with secondary dentine or cementum (6 per cent of total).

A summary of the frequency of the constriction types in all teeth and the A–C distances for the various constriction types is given in Table IV. Figure 4 provides a frequency distribution of the apical constriction types for the various teeth.

Discussion

The results of the measurement of the apex to foramen distances in this study are in close agreement with previous findings. The overall mean apex to foramen distance of 0.38 mm reported here can be compared to the 0.36 mm

for maxillary anterior teeth and 0.34 mm for mandibular anterior teeth, described by Chapman (1969). If only the anterior teeth are considered then the mean A–F distance in this study is 0.36 mm. Kuttler (1955) stated that the A–F distances in groups of teeth from young and old patients were 0.48 mm and 0.6 mm respectively. Green (1956, 1960) reported the distance to be 0.43 mm in posterior teeth and 0.29 mm in anterior teeth. Burch & Hulen (1972) found the A–F distance to be 0.59 mm in a study of all tooth types.

These slight variations are to some degree due to the varying methods used to measure the distance as well as to the different reference points that were probably used (Birch & Hulen 1972). However, an obvious trend emerges from all of the studies, namely that the A–F distance in posterior teeth is greater than in anterior teeth and greater in older age groups than younger. Little or no difference has been reported between maxillary and mandibular teeth.

The apex to constriction distances found in this study are also comparable with those reported by others. Chapman (1969) noted that the vast majority of constrictions (92.5 per cent) were found between 0.5 and 1 mm from the apex. Kuttler (1955) described the narrowest part of the canal in all tooth types to be on average 0.59 mm from the foramen. In this study of mainly anterior teeth the distance was 0.51 mm (A–C distance of 0.89 mm less A–F distance of 0.38 mm, Tables II and III).

Although the measurements described above are occasionally documented in the literature, very little work has been reported on the topography of the apical constriction. Kuttler (1955) measured the diameter of the constriction and commented in detail on its relationship with the foramen. Chapman (1969) also measured the diameter of the constriction and in addition briefly described the morphology of the terminal 3 mm of the root canal when viewed in cross-section. He reported the region as being either circular, oval with circular constriction or oval with oval constriction, concluding that 83 per cent of canals had circular constrictions.

The various types of apical constriction reported here (Fig. 3) are, of course, based on

the examination of longitudinal sections which is far more relevant to clinical endodontics and in particular to the apical extent of the canal preparation. The topography of the constrictions found in this study seems to have an important influence on the A-C distance (Table IV) and is thus likely to affect the establishment of an accurate 'working distance'. For example, adopting the generally accepted view that the constriction is 1 mm from the radiographic apex would suffice in general for constriction Types A, C and D but would result in under-preparation of canals with Type B constrictions. On the other hand, purely tactile methods of working distance estimation (Sommer *et al.* 1966) might produce satisfactory results in constriction Types A, B and D, but would probably result in under-preparation of canals with constriction Type C.

The findings of this study would, therefore, appear to encourage the use of a combination of methods for assessing the true position of the apical constriction for all teeth where root canal therapy is to be carried out.

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