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Prevalence of Additional Canals in Maxillary First Molars in a Nigerian Population

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Abstract

Aim: The aim of this study was to investigate the prevalence of additional canals in maxillary first molars in a selected population in Nigeria.

Methods and Materials: One hundred extracted teeth were collected from the Pedodontic and Oral Surgery clinics of the University College Hospital in Ibadan, Nigeria. The teeth were identified and their root planed to remove adherent soft tissues. Each tooth was sectioned at the cementoenamel junction (CEJ) and then again at 2 mm below the CEJ. The number of canals present in each root was noted. For the clinical aspect of the study, 30 patients with clinical and radiological evidence of pulpal involvement participated in the study. These patients had root canal therapy performed on their maxillary first molars and the number of canals was confirmed with periapical radiographs.

Results: In the laboratory phase of the study 77% of the teeth sectioned had three canals while 22% had four canals with the fourth canal being a second mesiobuccal canal. Only one tooth had five canals with two canals in the palatal root, two canals in the mesiobuccal root, and the remaining canal in the distobuccal root. For the clinical phase of the study, 29 (96.7%) out of 30 patients treated had three canals while only one (3.3%) had four canals with the fourth canal being a second mesiobuccal canal.

Conclusion: Clinicians should assume there are additional canals in each root when performing endodontic therapy on the maxillary first molar. Only after a thorough search for extra canals and after it is determined

further preparation would be fruitless or could cause perforation should the clinician proceed with treating only one canal per root.

Clinical Significance: If root canal therapy fails, it may be due to the existence of an extra canal that was not located and treated in the first place. This should be considered carefully during re-treatment either by surgical or non-surgical methods.

Keywords: Maxillary first molar, additional canals, mesiobuccal root, cementoenamel junction, CEJ

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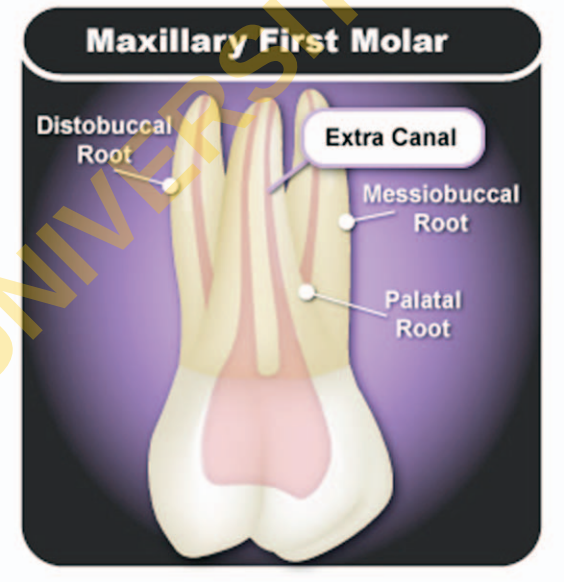
Introduction

The internal anatomy of the human teeth has been studied by many investigators[1-3] using replication techniques, ground sections of teeth,[1] clearing techniques,[2] and radiography.[3] The maxillary first molar usually has three roots. They include the mesiobuccal, distobuccal, and palatal roots with a single canal located in each root except for the mesiobuccal root in which a second canal may be present. *In vitro* studies indicate this second mesiobuccal canal is present in the mesiobuccal root in 55-74% of extracted teeth[4] while *in vivo* studies have produced much lower figures (18-50%).[5,6] This apparently reflects the difficulty in locating the extra canal in clinical endodontic practice if unaided by the use of magnifying aids such as surgical loupes or an operating microscope.[6]

The inability to locate extra canals will result in failure of endodontic treatment. An undetected canal will harbor microorganisms which can cause an acute exacerbation resulting in a patient presenting with pain and subsequent failure of the initial root canal therapy. It is important to have a good understanding of the anatomy of the maxillary first molar as it will aid in locating extra canal(s) if present. The three dimensional obturation of all the canals present in the tooth will lead to a reduction in the failure rate of such endodontically treated teeth.



Various techniques have been used by different authors to study the internal anatomy of human teeth which have provided valuable insight into the size, shape, and form of the pulp space. Maxillary first molars are usually three rooted with a canal in each root, except for the mesiobuccal root in which a second canal may be present. *In vitro* studies indicate a second mesiobuccal canal is present in 55-74% of extracted teeth while *in vivo* studies have produced much lower figures (18-50%).

Current knowledge of pulp space anatomy is based primarily on research findings and case reports involving Caucasian populations[7] and a few Asian populations.[8] However, there is no documented study on the presence of additional canals in maxillary first molars in Nigerians. The aim of this study was to investigate the prevalence of additional canals in the maxillary first molar in a selected population in Nigeria.

Methods and Materials

Laboratory Phase

One hundred extracted maxillary first molars with intact root from patients aged 10 to 40 years were collected from the Pedodontic and Oral

Surgery clinics of the University College Hospital in Ibadan, Nigeria. Consent to use the extracted teeth of children 10-16 years was obtained from their accompanying parents while consent was obtained directly from older patients.

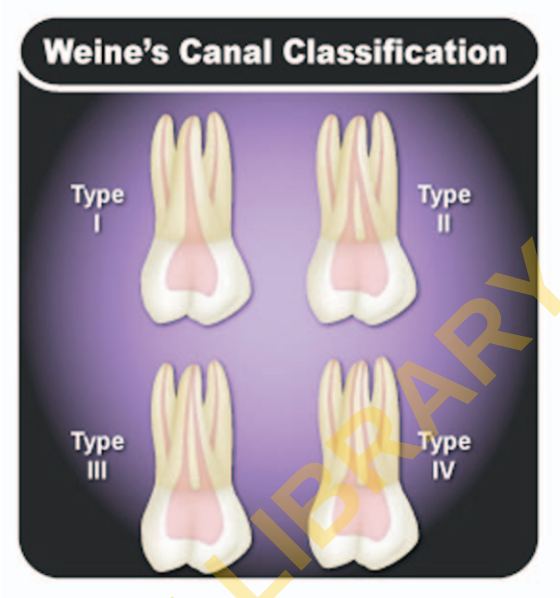
The selected teeth were identified by their distinctive anatomical features. The roots were planed using periodontal scalers to remove adherent soft tissues. Each tooth was rinsed under running water and then preserved in 10% formalin solution. Prior to sectioning, each tooth was rinsed in normal saline. A 31x41 mm pre-operative radiograph was take of each extracted tooth from the proximal and buccal aspects using D-speed Kodak Ultraspeed film (Batch number: 3903001803, Eastman Kodak, Rochester, NY, USA) and a Chirana Model X-ray machine (Buckingham PLH Medical Limited, Hertfordshire, UK). Images were produced using 70KV and 8mA and then processed manually according to manufacturer's instructions.

An access cavity was prepared on each tooth to facilitate location of the root canals. Each tooth was then sectioned using a cutting disc at the cementoenamel junction (CEJ) and the number of canals was noted. Each tooth was sectioned again approximately 2 mm below the CEJ and additional canals were noted. Illumination was done using a tabletop fluorescent lamp (Philips, TED 36W/54 Philips, Suresnes Cidex, France) directed against the sectioned tooth. Visualization was aided using 4X Visor Surgical loops (Universal Dental Company, Boyertown, PA, USA). The canal patency and number were determined using a size 10 K-file.

Clinical Phase

A clinical investigation was also done. The maxillary first molars of 30 consecutive consenting patients aged 10-40 years who presented with clinical and radiological evidence of pulpal disease were analyzed. The canal configurations of the molars were typed according to Weine's classification[9] as follows:

- **Type I:** A single canal which terminate in a single apical foramen
- **Type II:** Two orifices with separate canals that merge in the middle to form a single root canal with one foramen



- **Type III:** Two orifices with separate canals that merge short of the apex to form a single root canal with one foramen
- **Type IV:** Two or more separate canals which remain distinct throughout the length and exit through two or more distinct foramina

A Chi-square statistical analysis was employed to test the strength of association between variables where appropriate with level of significance set at $p<0.05$.

Results

Macroscopic examination of all the extracted teeth showed each tooth had three separate roots with the palatal root being the longest. The average length of the palatal root, the mesiobuccal, and the distobuccal root measured 20.2±0.8mm, 19.6±1.5mm, and 18.9±1.6mm, respectively.

Examination of the cut sections of the extracted teeth at the CEJ showed 77 of the 100 teeth had a single mesiobuccal canal from the pulp chamber to the apex. Two mesiobuccal root canal orifices were observed within the pulp chambers of 23 teeth. Two palatal root canal orifices were also observed within the pulp chamber of a single tooth while all the distobuccal root canals had a single canal orifice from the pulp chamber to the apex (Table1).

Different canal configurations were observed in roots containing more than one canal as shown

Table 1. Distribution of canals in both *in vitro* and *in vivo*.

Canals	*In Vitro* (%)	*In Vivo* (%)
Mesiobuccal		
1 canal	77	96.7
2 canals	23	3.3
Distobuccal		
1 canal	100	100
2 canals	—	—
Palatal		
1 canal	99	100
2 canals	1	—

in Figures 1a to 1e. Canal configurations seen in the examination of the cut sections of these teeth 2 mm below the CEJ showed no additional canal orifices to those located clinically at the CEJ.

There were 12 (40%) males and 18 (60%) females involved in the clinical phase of the study with a male to female ratio of 1:1.5. Twenty-nine (96.7%) mesiobuccal roots out of the 30 cases treated endodontically had a single canal while only one (3.3%) had two canals in the mesiobuccal root. The distobuccal and palatal roots all had a single canal.

Discussion

The prevalence of additional canal(s) in *in vitro* studies especially in the mesiobuccal root has produced much higher figures than in clinical cases.[10,11] In the present study, a second mesiobuccal canal was located in 22% of the extracted teeth and 3.3% in clinical cases. This could be compared with a study by Zing[10] among a South East Asia population in which a second mesiobuccal canal was found in 50% of extracted maxillary first molars but only 19% of these canals could be located clinically.

Otoh et al.[12] found pulp chambers with key holes and elliptical shapes are more likely to have an additional canal than the other frequently occurring shapes of the pulp chamber. Out of the 22 extracted teeth in which a second mesiobuccal canal was located, only 12 were negotiable. A combination of factors such as the small diameter of the second mesiobuccal canal, the change in orifice position, and the presence of pulp stones in the chamber or even calcification could account for this problem (Table 2).

Several methods have been described for the location of a fourth canal. Foremost was a modification of the access preparation to a rhomboidal shape for maxillary molars as compared to the classical triangular outline.[13] This outline provides better visibility and accessibility. Thorough probing of the fissure or groove between the main canals was done to locate the orifice of another canal. This fissure or groove often has to be deepened to remove any dentin projections that might conceal the opening of the fourth canal.

The second mesiobuccal canal can be challenging to negotiate. It is well known in normal development, or in response to carious or restorative insults, the second mesiobuccal canal becomes hidden by an overhanging dentinal shelf.[13] Unlike older patients, young patients have

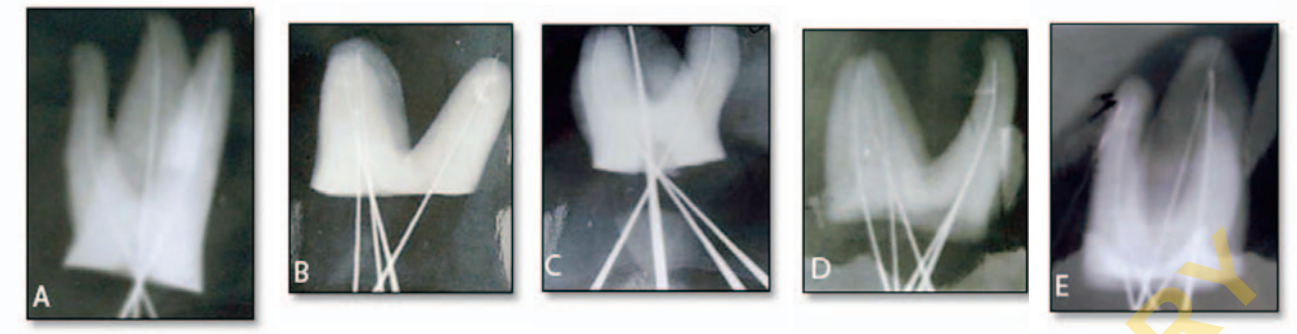


Figure 1. A. Sectioned maxillary first molar with three canals. **B.** Weine's Type II canal configuration in the mesiobuccal root with four canals (one in the distobuccal, one in the palatal, and two in the mesiobuccal which merge just before entering into a single apical foramen). **C.** Weine's Type III canal configuration in the mesiobuccal root with four canals where the two mesiobuccal canals join at the apical third to end in a single foramen. **D-E.** Weine's type III canal configuration in the mesiobuccal and palatal roots with five canals (two in the mesiobuccal, one in the distobuccal, and two in the palatal). The two canals in the palatal join at the apical third to end in a single foramen while the two mesiobuccal canals also merge just before ending in a single foramen.

Table 2. Distribution of extra canals as reported in various part of the world.

Population	Percentage Frequency of Occurrence of Canals (%)				
	Mesiobuccal		Palatal		Distobuccal
	1 Canal	2 Canals	1 Canal	2 Canals	1 Canal
American: Seidberg,[11] 1973					
(L)	38.0	62.0	100	—	100
(C)	66.7	33.3	100	—	100
Sub–Japanese: Weine et al.,[25] 1999					
(L)	27.4	72.6	N/A	—	N/A
South Asian/Pakistan: Wasti et al.[8] 2001					
(L)	47	54	100	—	100
Thai Population: Alavi et al.[7]	35	65	100	—	100
Brazilians: Teixeira,[2] 2003					
(L)	70	29.5	N/A	—	N/A
Nigerians: Present Study					
(L)	77	23	99	1	100
(C)	96.7	3.3	100	—	100

(L represents laboratory phase, C represents clinical phase, N/A—not available)

two treatable canals in the mesiobuccal roots.[14] On occasions, the second mesiobuccal canal shares an orifice with the main mesiobuccal canal.[7] According to Vasuder and Goel[14] when there is a shared or common orifice it is usually oval in shape. This shape makes it very difficult to locate the orifice of a second mesiobuccal canal.

Among those who receive endodontic treatment, 96.7% of the mesiobuccal roots in the present study were found to have a single canal with a Type I canal configuration while 3.3% had two canals with a Type II canal configuration. This result is in contrast to reports by others.[15-17] Buhrley et al.[17] reported the prevalence of a second mesiobuccal canal when examined using traditional techniques to be 17.2%, but with the use of magnifying aids such as operating microscope the findings increased to 62.5%. Stropko,[16] in an eight-year study, found a second mesiobuccal canal in 73.2% of teeth treated endodontically by traditional means. Of these, the second mesiobuccal canal occurred as a separate canal in 54.9% of cases seen. However, the frequency of occurrence increased as more time was scheduled for treatment and a dental operating microscope was routinely used. This suggests the differences in the percentages of an additional canal observed might be attributed to the lack of availability of magnifying aids such as an operating microscope. These microscopes magnify 16 to 32 times which would enhance canal location allowing results to compare favorably with others when such visual aids were used.

The distobuccal roots in the sectioned teeth as well as the teeth in the clinical phase who received endodontic treatment all had a single canal with a Type I canal configuration. This is similar to the findings in studies by Wong[18] and Jacobsen.[19] However, other researchers[20] reported a contrasting result. Bond[20] reported a case of maxillary first molar with six canals: two in the mesiobuccal, two in the distobuccal, and two in the palatal root.

The presence of additional canals in the palatal root of maxillary molars has been reported to be 2 to 5.1%.[21] Christie and Thompson[22] speculated maxillary molars with two palatal roots may be encountered once every three years in a busy endodontic practice. In this study only one out of the 100 teeth sectioned had two canals in the palatal root while there was only a single canal in the palatal root of each endodontically treated tooth. However, Stephen[23] reported a case of a maxillary first molar with two canals in the palatal root in which the canal join at the apical one third. Although, the incidence of an extra canal in the palatal root is not high, it is important to take this variation into consideration during root canal therapy in order to ensure success.

The present study (*in vitro* and *in vivo* phases) is in agreement with what has been widely documented by others in terms of the frequency of location of extra canals is higher in *in vitro* studies than *in vivo* even though the incidence of an extra canal is quite low in this study but meaningful.

Conclusion

Clinicians should assume there are additional canals in each root when performing endodontic therapy on the maxillary first molar. Only after a thorough search for extra canals and after it is determined further preparation would be fruitless or could cause perforation should the clinician proceed with treating only one canal per root.

Clinical Significance

If root canal therapy fails, it may be because extra canals were not located and treated in the first place. This should be considered carefully during re-treatment either by surgical or non-surgical methods.

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