Original Article

Use of Tooth Clearing Technique to Determine Root and Canal Morphology of Permanent Maxillary Third Molars in Population of Peshawar: An in Vitro Cross-Sectional Study

Technique to Determine Root and Canal Morphology

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ABSTRACT

Objective: To use tooth clearing procedure to determine the number of roots, canals and canal configuration in permanent maxillary third molars.

Study Design: Cross- sectional

Place and Duration of Study: This study was conducted at the Surgery departments of three dental colleges of Peshawar, from 4th November 2022 to 3rd May 2023.

Methods: 193 maxillary third molars (MTM) were extracted from both genders, with fully developed roots. Following collection, the number of roots were visually assessed and cavity was prepared, the pulp was cleaned and canals were stained with Indian ink. Teeth were dehydrated in increasing alcohol concentrations after decalcification for five days in nitric acid. Teeth were completely transparent after being immersed in methyl-salicylate for 72 hours. Transparent teeth's root and canal numbers were recorded.

Results: Among 193 extracted MTM's, (54.9%) had three, (25.9%) single and (15.5%) had two roots. Three root canals (46.6%), followed by two (22.3%), one (18.1%) and four (13 %) canals respectively. The predominant canal configuration in mesiobuccal (64.7%), distobuccal (100%) and palatal root (98%) was Type I respectively in the three separate root specimen. For the three fused root form, Type VIII (70.9%) was the frequent configuration. There was no significant correlation between the maxillary third molar's root canal count and number of roots.

Conclusion: Three roots and three canals were the common patterns for maxillary third molars. Vertucci's Type 1 canal configuration was the predominant form.

Key Words: Canal configuration, Clearing technique, Third Molar, Vertucci's classification.

Citation of article: Khattak I, Khattak YJ, Sattar A, Shaheryar A, Arbab S, Khattak MA. Use of Tooth Clearing Technique to Determine Root and Canal Morphology of Permanent Maxillary Third Molars in Population of Peshawar: An in Vitro Cross-Sectional Study. Med Forum 2024;35(12):128-132. doi:10.60110/medforum.351228.

INTRODUCTION

The eruption of permanent maxillary third molars (MTM) occurs between the ages of 17-21. Its role complements that of the other molars in grinding [1], and its eruption age varies among races.

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Received: January, 2024
Accepted: April-May, 2024
Printed: September, 2024

Third molars (TM) are often extracted because of periodontal, gingival, caries, as well as pericoronitis conditions. They have been utilized to replace the hopeless first and second molar teeth in auto transplantation in modern dentistry[2]. After successful root canal therapy, prior knowledge of the shape, quantity, and locations of roots may be helpful for simple and less traumatic extractions during autotransplantation. For endodontic therapy to be successful, a thorough understanding of the intricate root anatomy of MTMs is therefore crucial. Even though the fundamentals of endodontics are followed, a lack of knowledge of the root canal system may lead to treatment failure because the root canal apparatus's complications are the most difficult assignment for any dentist planning a root canal treatment.[3]

Given that root morphology might change among various ethnic groups, the anatomy of MTMs has been described as unclear[4-5]. Ethnicity, age, and sex[6] may all contribute to this structural difference. Since it has been

shown that hereditary elements determine root structure and a range of root canal patterns in different individuals, it is vital to evaluate the root form in various ethnic communities[7].

The number of roots in MTM ranges from 1-5 and number of root canals were found to range from 1-6.This is not a constant number and it varies according to different studies[8,9].

The structure of root canals is compound and hard to study. For observing the root canal morphology in three extents, the solidified root tissue must be either detached or made transparent. Hence many methods have been used to evaluate the internal structure of the teeth consisting of root sectioning, canal remodelling, canal staining and clearing, micro CT, review of clinical records. All these are ex-vivo methods and the in-vivo methods include radiographic techniques such as conventional radiographs, radiopaque contrast media microcomputed tomography and cone beam computed tomography[2].

Canal staining and clearing is an easy and low-cost method for in vitro visualization of endodontically managed or unmanaged root canal systems. It allows 3-dimensional assessment of the root canal anatomy and maintains the unique shape of the root canals and their connection to the external root anatomy and gives the most exact and reproducible results that are best suited for educational and training purposes[3].

Using the canal staining and cleaning approach, no local research on the anatomy of roots, canals, and canal morphologies in permanent MTMs have been carried out, according to a thorough review of the literature. The number of roots, canals, and canal shape in MTMs of patients seeking treatment at Peshawar's three dental educational institutions will be analyzed in this study.

The results of the study will be helpful for gathering baseline data about the MTM root canal system. Additionally, when a less expensive fixed prosthesis may be used in place of costly implants, the clinicians will carry out endodontic procedures with a deep knowledge of TM anatomy, minimizing the need to remove TMs.

METHODS

This in-vitro cross-sectional study collected 193 extracted permanent MTM's from three dental colleges i.e Khyber College of Dentistry, Sardar Begum Dental College and Peshawar Dental College in Peshawar, Pakistan. Teeth were collected from patients treated between 4th November 2022 to 3rd May 2023,with prior informed consent. Patients information and consent were recorded.

An ultrasonic scaler was used to remove any calculus or tissue that had adhered after the teeth had been cleansed with water. After 30 minutes of soaking in 5.25% sodium hypochlorite, they were cleaned and kept in 10% formaldehyde until the 193 MTM sample was finished.

The number of roots in each tooth were visually inspected. To determine the number of canals and configurations, the teeth were treated using the Tooth Clearing Technique based on Vertucci's criteria.

Each tooth was cleaned, disinfected, air-dried, pulp material removed and cavities were drilled. The pulpal remnants were afterwards dissolved by immersing the teeth in a 2.5% NaOCL solution for a whole night. After washing and drying, black Indian ink was injected into each root canal. The teeth were then placed vertically for a day, allowing the ink to leak and dry, coloring the canal contours.

To demineralize the teeth, they were soaked in 5% nitric acid for 5 days, with the solution changed daily. A file was inserted to track decalcification and radiograph was taken. After demineralization, the teeth were rinsed with tap water, dehydrated in increasing ethanol concentrations, and then submerged in methyl salicylate, becoming completely transparent after 72 hours.

The teeth were examined using a 3x magnifying lens and adequate lighting, making the canal architecture visible. Data was recorded on structured sheets and classified according to Vertucci's criteria for root canal appearance.

Statistical Assessment:

- For the statistical analysis, SPSS software (version 25) was employed.
- The Pearson Chi-Square test was used to show a correlation between the number of roots and root canals.
- When the p-value was less than 0.05, any variations from the mean values were taken to be statistically significant.

RESULTS

193 MTMs were examined for the quantity of roots, root canals, and canal shapes. They were extracted from individuals with a mean age of 24.90 ± 2.96, of whom 48.7% were male and 51.29% were female. These teeth's frequency and percentage distribution by number of roots, root canals, and canal configurations are shown below.

Table No. 1: Distribution of maxillary third molar teeth by number of root canals and roots.

No. of roots and canals		No. of Teeth (Total No. = 193)	(%)
No. of roots	1	50	25.9
	2	30	15.5
	3	106	54.9
	4	7	3.6
No. of canals	1	35	18.1
	2	43	22.3
	3	90	46.6
	4	25	13.0

106 MTMs (54.9%) had 3 roots, 50(25.9%) had a single root. 2 and 4 rooted were in the descending order of 15.5% and 3.6% respectively.

90 (46.6%) had 3 canals followed by 2 canals found in 43(22.3%) specimens. Single canal and 4 canals were present in 35(18.1%) and 25(13%) of teeth respectively, Table 1.

Table 2, details the root canal configurations (RCC) for the MTMs. The most common RCC is Type (1-1) followed by Type (2-1) and Type (2-2).Type (1-1) configuration was the predominant type in MBRs 64.7%(33) , DBRs 100% (51) and PRs 98% (50) followed by Type (2-2) 21.6% and Type (1-2) 7.8% in the MBRs of the three separate root form of MTMs.

A variety of RCCs were displayed by the single rooted, with Type (1-1) accounting for 50% of the total, followed by Type (2-1) at 14%, Type (1-2-1) at 10%, and Type (2-2) at 8%.

Similarly, the three fused rooted specimens had Type (3-3), being the most common 70.9% (30) RCC's.

Table No. 2: Maxillary third molar tooth distribution according to RCCs (Vertucci's grouping).

Number of teeth (n)	Root morphology		Vertucci's Canal Configuration (VCC)								
			Type 1-1 % (n)	Type 2-1 % (n)	Type 1-2-1 % (n)	Type 2-2 % (n)	Type 1-2 % (n)	Type 2-1-2 % (n)	Type 1-2-1-2% (n)	Type 3-3 % (n)	Others
50	Single root		50 (25)	14 (7)	10 (5)	8 (4)	4 (2)	4 (2)	-	4 (2)	1-3-1(1), 3-1(1), 2-1-2-1(1)
17	Two separate roots	BR	58.8 (10)	11.8 (2)	17.6 (3)	-	11.8 (2)	-	-	-	-
		PR	14 (82.4)	-	-	-	17.6 (3)	-	-	-	-
13	Two fused roots		-	7.7 (1)	-	84.6 (11)	-	-	-	-	3-2-3 (1)
51	Three separate roots	MBR	64.7 (33)	2 (1)	2 (1)	21.6 (11)	7.8 (4)	2 (1)	-	-	-
		DBR	100 (51)	-	-	-	-	-	-	-	-
		PR	98 (50)	-	2 (1)	-	-	-	-	-	-
55	Three fused roots		-	-	1.8 (1)	3.6 (2)	-	-	-	70.9 (39)	4-4(4),3-4(3), 1-3-1(1), 3-2(2),3-1(2), 4-3(1)
6	Four separate roots	MBR1	100 (6)	-	-	-	-	-	-	-	-
		MBR2	100 (6)	-	-	-	-	-	-	-	-
		DBR	100 (6)	-	-	-	-	-	-	-	-
		PR	100 (6)	-	-	-	-	-	-	-	-
1	Four fused roots		-	-	-	-	-	-	-	-	4-4(1)
Total= 193	-		-	-	-	-	-	-	-	-	-

BR: Buccal root, PR: Palatal root, MBR: Mesiobuccal root, DBR: Distobuccal root.

When the number of roots and root canals of maxillary third molars were compared to one another, the Pearson

Chi-Square test's "p" value of 0.538 indicated a statistically non-significant difference (Table 3).

Table No. 3: The correlation between maxillary third molar teeth's root count and root canals.

No. of roots	No. of teeth "n" (%)				Total (n=193)	df	*P-Value
	1RC	2RC	3RC	4RC			
1	33	14	3	0	50 (25.9)	9	0.538
2	0	27	3	0	30 (15.5)		
3	2	2	84	18	106 (54.9)		
4	0	0	0	7	7 (3.6)		
Total	35(18.1)	43(22.3)	90(46.6)	25(13.0)	193(100)		

RC: Root canal, df = 9 as calculated by Pearson Chi Square Test, "P" value= 0.538,

*chi square applied.

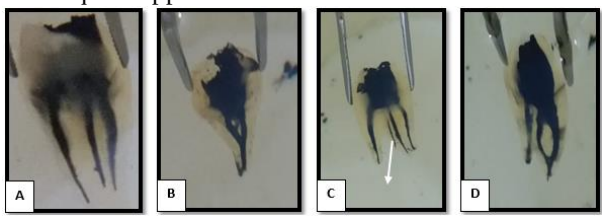

Figure No. 1: A sample of the RCCs seen during this investigation.

A) Three separate roots each with Type I (1-1) (Vertucci's Canal Configuration (Vcc)
B) Type II (2-1) Vcc, seen in a single root.
C) Three roots, four canals seen (MB-II) seen.
D) Buccal root, Type II (2-1) Vcc, Palatal root Type I (1-1) Vcc.

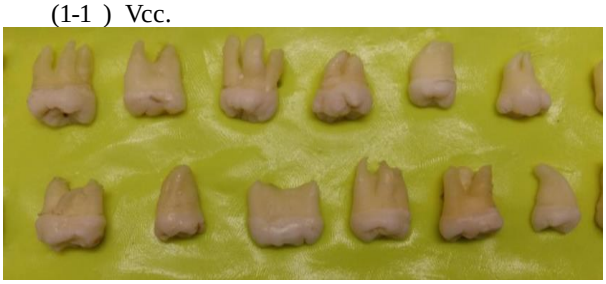

Figure No. 2: Different root forms of MTM's observed in this study.

DISCUSSION

A good dental procedure requires exact understanding of the form, structure, and anatomical variances of teeth on the inside as well as the outside.[4,9] Third molars with endodontic involvement may be successfully repaired and maintained as a functional and beneficial component of the maxillary arch with appropriate diagnosis and planning.

Because the clearing procedure was less expensive and didn't require any sophisticated, costly equipment, it was employed in this investigation to examine the internal anatomy of roots. After the teeth were made transparent, it was simple to study the root canal system's true course from the canal opening to the apical foramen to create a precise canal configuration. The same techniques have been applied by numerous researchers to evaluate the root canal patterns and form of the third molars in both arches.[8–13]

Three roots (54.9%), or 106 out of 193 teeth, had a greater proportion of maxillary third molars in the current investigation. These results were supported by the Russians (52.1%) and Burmese (55.6%) population, respectively[4,13]. The frequencies of three rooted molars were considerably higher than those reported earlier by Sidow et al. (45%)[4], Sert et al. (34.1%)[3] and Zhang et al. (25.4%)[7] , but were lower than the prevalence (88.1%), in other research (83.9%) and as reported by Ahmad et al (74.2%) in Jordanian subpopulation[2].

In the current study, the frequency of maxillary wisdom molars with a single root was 25.9% of teeth, which was lower than the prevalence of single rooted MTM's (51.5%, 47.9%, 35.5%) as reported earlier[4,8,12].

The discrepancy in results may be caused by various methods, sample sizes, and racial disparities between groups.

In the present study, (Table 1) three canals were the most prevalent 46.6%. This percentage was in accordance with the studies carried out in Burmese (47.2%), Thai (48.3%), Chinese (44.2%) and Turkish (46.9%) people[8,12,13] but lower than the results (57.3%, 75%, 55.1%, 72.3%) of earlier studies [4,9,11]. In our study two canals were found in 22.3% MTM's. This occurrence was significantly greater than those seen in previous research[9- 13] and in accordance with the findings (25% and 29.7%) of the work done by Ng et al[8] and Sert et al[3].

Since Vertucci's classification[3] is the only criterion that takes into account the canal orifice and apical foramina at the same time, it was used in the current study. Additionally, the majority of researchers who employed the in vitro clearing approach did so in order to determine the layouts of their canals [12, 13].

The results of the current investigation showed remarkable similarities to those of the previously stated studies. According to earlier reports, Vertucci Type I was the most common kind[6].

Similarly in our study for the maxillary RCC (Table 2), Type I Vertucci canal configuration was the predominant form. In the single rooted specimen for the MTM's Type I was the most frequent (50%) which was supported by the results reported in previous studies(63.2%, 63.1%, 66.8%,51.4%)[10, 11].

The two fused rooted MTMs were noticeable in Type IV in our investigation, 84.6% canal configuration which was supported by the incidence of 66.7% in the

study of Ahmad et al[6]. In the three separate roots of MTM's in our study, the mesiobuccal roots were again predominant in Type I canal configuration (64.7%) followed by Type IV 21.6% which were in accordance with the frequencies of 62.5% and 72.7% as reported earlier[12]. All DBR and PR's of the three separate rooted MTM's showed a frequency of 100% and 98% Type I RCC, respectively which was supported by all previous studies. In our study the three fused rooted MTM's showed a high incidence of Type VIII canal configuration 70.9% which was in accordance to 64.3% Type VIII RCC[11].

In our research, evaluating the roots of MTM with their root canals revealed a significant but statistically insignificant difference ($p>0.05$). The MBR of MTM and single root forms showed more diversity in the number of root canals between the two and three rooted groups, according to this study.

The current study has its own benefits, such as being cost-effective and practical, not requiring costly and sophisticated technological equipment and facilities, and offering a starting point for further research. However, because it is an in-vitro investigation, it has significant limitations that prevent dentists from identifying the abnormal morphology of the intact MTMs inside the oral cavity. The usage of contemporary dental devices, such as CBCT and dental operating microscopes, were inadequate..

CONCLUSION

A range of root and canal configurations were seen in MTM's from the Peshawar population under investigation. MTM's predominantly had three roots including three fused and separate root forms. Single rooted variants were the second in occurrence. Regardless of the number of roots, the majority of maxillary third molars had three root canals. The most prevalent root canal configurations in MBRs, DBRs, and PRs of MTMs were Vertucci's Type I (1-1) and Type IV (2-2) in MBRs.

Author's Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Imran Khattak, Yusra Jamil Khattak
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Final Approval of version:	All the above authors
Agreement to accountable for all aspects of work:	All the above authors

Conflict of Interest: The study has no conflict of interest to declare by any author.

Source of Funding: None
Ethical Approval: Prime/IRB/2021-315 Dated 15.12.2016

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