## ABSTRACT

**OBJECTIVE:** To find out number of roots, root-canals and canal configuration in permanent mandibular third molars through tooth clearing technique.

**METHODS:** In this cross-sectional study, 193 extracted human mandibular permanent third molars with completely formed apical foramen and intact roots were collected from both genders treated at dental hospitals in Peshawar, Pakistan from 1 July to 31 December 2019. After collection teeth were visually inspected to count number of roots, followed by access cavity preparation, pulp extirpation and canal staining with black Indian ink. Decalcification was done by placing teeth in nitric acid for 5 days followed by dehydration in ascending concentrations of alcohol. Complete transparency was achieved by immersing teeth in methyl-salicylate for 72 hours. Transparent teeth were inspected again for number of roots and root-canals.

**RESULTS:** Among 193 extracted mandibular third molars, (n=161; 83.4%) had two-roots and (n=24; 12.4%) were single-rooted. Two-canals were present in vast majority (n=142; 73.6%) whereas three and one-canal were seen in (n=37; 19.2%) and (n=13; 6.7%) teeth respectively. Most common type of root canal pattern was Vertucci’s Type-I in mesial-roots (n=79; 63.7%) and distal-roots (n=120; 96.8%). Vertucci’s Type-II and Type-IV were (n=15; 12.1%) and (n=12; 9.7%) in the mesial-roots respectively. Mandibular third molars didn’t present with any configurations that didn’t fullfill Vertucci’s criteria. Correlation between number of roots and root-canals of mandibular third molars was non-significant.

**CONCLUSION:** Two-roots and two-canals were common patterns for mandibular third molars. Mesial and distal roots were predominant in Type-I followed by Type-II and Type-IV Vertucci’s classification.

**KEY WORDS:** Canal configuration (Non-MeSH); Clearing technique (Non-MeSH); Molar, Third MeSH); Vertucci's classification (Non-MeSH); Dental Pulp Cavity (MeSH); Tooth Root (MeSH).

## INTRODUCTION

Permanent mandibular third molars erupt at the age of seventeen to twenty-one years. Its eruption age varies in different races, and its function complements the other molars in grinding.

Third molars are routinely extracted due to caries, pericoronitis, gingival and periodontal diseases. In modern dentistry they have been used in auto transplantation as a replacement for hopeless first and second molar teeth. Prior knowledge regarding shape, number and positions of roots may be advantageous for easy and less traumatising extractions following successful root canal therapy in autotransplantation. Hence, a detailed knowledge regarding the complex root structure of third molars is very important for a successful endodontic therapy because the complication of the root canal apparatus is the utmost task for any dental practitioner planning root canal procedure, therefore insufficient understanding about root canal system may result in treatment failure, even though the basic principles of endodontics are followed.

The structure of mandibular third molars has been reported as uncertain since root morphology may vary among different population groups. This structural disparity may be an outcome of ethnicity, chronological age, and sex. It has been found that hereditary elements influence the root structure and a diversity of root canal arrangements in distinct individuals, hence it is mandatory to evaluate the root form in separate ethnic groups.

The common mandibular third molar may have 1-4 roots, with numbers of encased root canals varying from 1-6, still the number varies according to different studies. Kuzekanani M, et al. reported from Iran that the bulk of sample (73%) had two roots, (21%) were single rooted and 5.5% of the sample had three roots. In 2016 Ahmad I, et al. carried a study using the clearing technique in a Jordanian population using 159 extracted third molars. He reported that 74.3% of lower third molars presented with 2
roots and 2 (38.6%) and 3 (45.7%) canals. Razumova S, et al. also reported that mandibular third molar is found frequently with 2 roots, a mesial and a distal root with 2 or 3 canals. Most of the previous authors not only worked on the external form of mandibular third molar but also explained the internal form applying mostly the Vertucci’s classification (1984). It was reported from a Jordanian population that the mandibular third molars showed Type- I configuration in distal roots (94.3%) and a maximum percentage of mesial roots (56%) had 2 canals out of which Type- IV and Type- II were the most dominant configurations (26.5% and 20.6%, respectively). And lastly in 2019, few authors using CBCT from Russia reported that out of a sample of 210 mandibular third molars, majority were Type- I for the mesial and distal roots of two and single rooted specimens.

On extensive literature review, no local research has been done on the figure of roots, canals, and canal morphologies in permanent mandibular third molar teeth. This investigation will evaluate the number of roots, canals, and canal shape in lower third molars in patients reporting at the three dental teaching hospitals in Peshawar. The results obtained from this study will be helpful in establishing a baseline data about the root canal system of mandibular third molars. Also, the clinicians will have a very good knowledge about the anatomy of third molars while performing endodontic procedures. This will aid in saving third molars from being extracted in cases where it can help in conservative and less costly fixed prosthesis in comparison to the costly implants in future.

## METHODS

In this in-vitro cross sectional study, a total sample of 193 extracted permanent mandibular third molar teeth were collected from the Department of Oral and Maxillofacial Surgery of Peshawar Dental College, Khyber College of Dentistry and Sardar Begum Dental College and Hospital - Peshawar - Pakistan via non-probability convenience type sampling from patients treated at the hospital after taking prior permission from 1st July 2019 to 31st December 2019. Patient’s details and informed consent were taken on pre-structured data sheets before collecting the teeth for research purpose.

The teeth were washed gently with tap water to remove any blood or food debris. If any dental calculus or soft tissue remnants being adhered to any tooth, were removed using an ultrasonic scaler. The samples were stored in 5.25% sodium hypochlorite (NaOCL) for half an hour for the dissolution of organic matter after extraction. Following wash in running tap water, each tooth was then placed in a small, labelled plastic bottle that contained 10% formaldehyde and were stored until a total sample of 193 mandibular third molars were collected.

After completion, all teeth were visually examined to count the number of roots. The sample of the extracted third molars were processed with the application of tooth clearing technique to know the number of canals and configurations according to Vertucci’s criteria. Before use each tooth was cleaned in normal tap water, disinfected, and dried at room temperature. Cavities were drilled and the pulp substance was removed. The individual teeth were again dipped in 2.5% NaOCL solution overnight to liquefy any pulpal residues. The samples were again cleaned in tap water for 2 hours, dried at room temperature and black Indian ink was administered in the root canals of each tooth via 27-gauge needle.

<table>
<thead>
<tr>
<th>Number of roots &amp; root canals</th>
<th>Number of Teeth ( n=193 )</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of roots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24</td>
<td>12.4</td>
</tr>
<tr>
<td>2</td>
<td>161</td>
<td>83.4</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>3.6</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Number of root canals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>6.7</td>
</tr>
<tr>
<td>2</td>
<td>142</td>
<td>73.6</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
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</tbody>
</table>

The results obtained from this study will be helpful in establishing a baseline data about the root canal system of mandibular third molars. Also, the clinicians will have a very good knowledge about the anatomy of third molars while performing endodontic procedures. This will aid in saving third molars from being extracted in cases where it can help in conservative and less costly fixed prosthesis in comparison to the costly implants in future.

Figure 1: Radiographs taken to assess the process of demineralization post nitric acid (HNO3) decalcification after 24 hrs each. i) Before Nitric Acid treatment at (0 hours) ii) At 24 hours iii) At 48 hours iv) At 72 hours v) At 96 hours vi) At 120 hours
Root canal morphology was documented in the pre-structured data collection sheets. Data was recorded in magnification. Visualisation with the naked eye using good lighting and a magnifying glass of (3X) magnification. The two rooted specimens were the most prevalent (n=161; 83.4%) out of which two separate and two fused were in the order of 77% and 22.9% respectively. Type-I (1-1) was in majority, mostly in mesial roots (n=79; 63.7%) and distal roots (n=120; 96.8%) of two separate root third molars and in a single rooted (n=11; 45.8%) mandibular third molars. Followed by Type-II (2-1) and Type-IV (2-2) canal configurations in the order of (n=15; 12.1%) and (n=12; 9.7%) for the mesial roots of two separate and (n=5; 13.5%) and (n=28; 75.7%) for the two fused rooted mandibular third molars respectively.

**RESULTS**

A total of 193 extracted human mandibular third molar teeth were assessed for the presence of the number of roots, root canals and canal configurations. They were collected from both male (48.7%) and female (51.29%) patients. One hundred and sixty-one mandibular third molar teeth (83.4%) had two roots compared to 24 (12.4%) having a single root (Table I). Similarly two canals were observed in 142 (73.6%) mandibular third molars, followed by three canals found in 37 (19.2%) teeth (Table I).

The two rooted specimens were the most prevalent (n=161; 83.4%) out of which two separate and two fused were in the order of 77% and 22.9% respectively. Type-I (1-1) was in majority, mostly in mesial roots (n=79; 63.7%) and distal roots (n=120; 96.8%) of two separate root third molars and in a single rooted (n=11; 45.8%) mandibular third molars. Followed by Type-II (2-1) and Type-IV (2-2) canal configurations in the order of (n=15; 12.1%) and (n=12; 9.7%) for the mesial roots of two separate and (n=5; 13.5%) and (n=28; 75.7%) for the two fused rooted mandibular third molars respectively.

Single rooted specimens showed a range of configurations with Type I (1-1) 45.8% being the predominant type followed by Type-II (2-1) 29.2% and Type-IV (2-2) 12.5%. Few molars (n=4; 10.8%) in the two fused forms and all three fused rooted (n=2; 100%) had Type-VIII (3-3) canal configuration as shown in Table II.

Samples of root canal configurations observed are given in figure 2.

**DISCUSSION**

Precise knowledge of the exterior and interior structure and form of teeth along its anatomical variations is necessary for a successful dental treatment. With correct diagnosis and planning, endodontically involved third molars may...
Effective and useful element in the mandibular arch. In the present study clearing technique has been used for studying the internal anatomy of roots as it was less costly, did not require any modern, complex, and expensive armamentarium. Following rendering the teeth transparent, the actual path of the root canal system was easily studied all the way beginning at the canal opening to the apical foramen to yield accurate canal configuration. Same methodology has been adopted by several researchers for the evaluation of root canal morphology and patterns for the third molars of both the arches. In the present study 83.4% mandibular third molars demonstrated two roots which was certainly lower than the findings (100%, 86.7%) of Burmese and Thai population respectively. Both the studies were done using the clearing technique. The two rooted mandibular third molars were higher than those seen in Jordanian population (74.3%) and in Iranians (72.6%) and Turkish population (74.3%) and in third molars were higher than those seen technique. The two rooted mandibular arches.

In the present study clearing technique effectively be restored and preserved as an effective and useful element in the mandibular arch. In the present study clearing technique has been used for studying the internal anatomy of roots as it was less costly, did not require any modern, complex, and expensive armamentarium. Following rendering the teeth transparent, the actual path of the root canal system was easily studied all the way beginning at the canal opening to the apical foramen to yield accurate canal configuration. Same methodology has been adopted by several researchers for the evaluation of root canal morphology and patterns for the third molars of both the arches. In the present study 83.4% mandibular third molars demonstrated two roots which was certainly lower than the findings (100%, 86.7%) of Burmese and Thai population respectively. Both the studies were done using the clearing technique. The two rooted mandibular third molars were higher than those seen in Jordanian population (74.3%) and in Iranians (72.6%) and Turkish population (69.5%) respectively.

The incidence of 83.4% two rooted mandibular third molars hold the results of Razumova S, et al. (2018) who showed that the Russian natives had a prevalence of 80% for two rooted mandibular third molars and 77% in a group of Americans. The prevalence of single root mandibular wisdom molars in the present study was 12.4% which was in accordance with (11.6%) in Thai population but was lower than the findings of (56%, 47.7%, 24.9%, 21.4% respectively). The dissimilarity in findings may be due to different methods used, sample size and race variations amongst different populations. Similarly, three and four rooted variants were the least in the order of (3.6%) and (0.5%) sequentially in the present study.

In the present study clearing technique used it for researchers who practised the in vitro clearing technique used it for determining canal configurations. In the current study, Vertucci’s classification was made use of in its original form with no modifications because it is the only criteria that considered both the canal orifice and apical foramina simultaneously. Also, most of the researchers who practised the in vitro clearing technique used it for determining canal configurations.

In the present study, the findings were interestingly similar with the aforementioned studies. Vertucci Type-I was the predominant form as previously reported.

The single rooted variant showed a range of canal configurations with Type-I being the most common form (45.8%) in the current study, which was in accordance (65.6%, 31.2%, 55.6%, 42.7%) to the previous studies that reported Type-I being the most prevalent canal configuration in single rooted mandibular third molars. The incidence of Type-II (29.2%) and Type-IV (12.5%) in single rooted teeth were in accordance with the previous studies mentioned.

The mesial root of two separate rooted lower third molars were predominant in the current study with Type-I (63.7%) canal configuration followed by Type-IV (12.1%) and Type-IV (9.7%) which was in accordance with the work published by Sert S, et al. 2011 (59%), Kuzekanani M, et al. 2012 (54.1%) and Zhang W, et al. 2018 (68.3%) for the Type-I canal configuration. Similarly, for the distal root of two separate rooted

<table>
<thead>
<tr>
<th>Number of roots</th>
<th>Number of teeth “n” (%)</th>
<th>Total (n=193)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1RC</td>
<td>2 (8.3%)</td>
<td>24 (12.43%)</td>
</tr>
<tr>
<td>2RC</td>
<td>11 (6.83%)</td>
<td>161 (83.4%)</td>
</tr>
<tr>
<td>3RC</td>
<td>0</td>
<td>7 (3.6%)</td>
</tr>
<tr>
<td>4RC</td>
<td>0</td>
<td>1 (0.51%)</td>
</tr>
<tr>
<td>Total</td>
<td>13 (6.7%)</td>
<td>193 (100%)</td>
</tr>
</tbody>
</table>

**TABLE III: RELATION BETWEEN THE NUMBER OF ROOTS AND ROOT CANALS OF MANDIBULAR THIRD MOLAR TEETH**

<table>
<thead>
<tr>
<th>Number of roots</th>
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</tr>
<tr>
<td>Total</td>
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<td>193 (100%)</td>
</tr>
</tbody>
</table>

* Chi-square applied, RC: Root canal. "P" value = 0.538, df = 9 as calculated by Pearson Chi-Square Test.

Figure 2: Sample of Root Canal Configurations observed in this study. (a) Type I (1-1), (b) Type II (2-1), (c) Type III (1-2-1), (d) Type IV (2-2), (e) Type V (1-2), (f) Type VI (2-1-2), (g) Type VIII (3-3), (h) Type 4-4.

KMUJ 2021, Vol. 13 No.4
specimens were likewise prevalent in Type-I canal shapes (96.8%) in the current study which was in accordance with (99.2%, 92.7%, 93.8%, 100% respectively) as reported previously. The two fused rooted teeth were predominant in Type-IV (75.7%) which agreed with the results of Ahmad et al. 2016 (45%).

In our study, there was a high statistically non- significant difference (p>0.05) when the number of roots of mandibular third molar teeth were compared with their root canals. It was noted in this study that the mesial root of mandibular third molar teeth displayed greater variation in the number of root canals among the two and three rooted groups. This finding was supported by the result of one of earlier study published in the literature.

The current study has its own advantages i.e., it is economical and convenient not requiring expensive and advanced technical facility and tools and provides a baseline for advanced studies. It however has certain limitations i.e., it is an in-vitro study, so it cannot help the clinicians in detecting the atypical morphology of the intact mandibular permanent third molars inside the oral cavity. The use of modern dental tools was lacking i.e., the dental operating microscope.

**CONCLUSION**

Mandibular third molars of the investigated population of Peshawar revealed a variety of root and canal patterns. Mandibular third molars predominantly had two roots including two separate and two fused roots forms. The two rooted variant with two root canals i.e mesial and distal canal was the common and predominant form occurring followed by three root canals to a limited extent. Vertucci’s Type- I (1-1) was the most usual and typical root configuration in both the roots of mandibular third molars followed by Type- II (2-1) and Type- IV (2-2) in the mesial roots.

**ACKNOWLEDGMENT**

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Use of tooth clearing technique to determine root and canal morphology of permanent mandibular third molars in population of Peshawar: An in vitro cross-sectional study


AUTHOR’S CONTRIBUTION
Following authors have made substantial contributions to the manuscript as under:

IK: Conception and study design, analysis, and interpretation of data, drafting the manuscript, critical review, approval of the final version to be published

MAIK: Conception and study design, critical review, approval of the final version to be published.

YJ: Acquisition of data, drafting the manuscript, approval of the final version to be published.

SA: Acquisition, analysis, and interpretation of data, critical review, approval of the final version to be published.

MR: Acquisition, analysis, and interpretation of data, drafting the manuscript, approval of the final version to be published.

SAS: Study design, drafting the manuscript, critical review, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST
Authors declared no conflict of interest

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Authors have declared no specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors

DATA SHARING STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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KMUJ web address: www.kmuj.kmu.edu.pk
Email address: kmuj@kmu.edu.pk