Research Article

The Variation of Root Canal Configuration of Permanent Mandibular Dentition among Saudi Population: A Systemic Review

Ayman Mandorh[1*], Ahmed Alzahrani[2], Basmah Abdulfatah[3], Harith Alharthi[2], Zaid Alotaibi[2], Raed Solan[4], Jawad Alahmadi[2], Abdulaziz Bukhari[2], Bushra Alghamdi[5], Khames T Alzahrani[7], Soltan Alotni[6], Anas Aljarad[6], Abdulaziz Alateek[6]and Raghad Ahmed[4]

[1]Restorative Department, Taif University, Taif, Saudi Arabia; [2]Dental intern, Vision Colleges, Jeddah, Saudi Arabia; [3]General Dentist, Ministry of Health, Jazan, Saudi Arabia; [4]General Dentist, Vision College, Jeddah, Saudi Arabia; [5]General Dentist, King Abdulaziz University, Jeddah, Saudi Arabia; [6]College of Dentistry, Prince Sattam Bin Abdulaziz university, Kharj, Saudi Arabia. [7]BDS, PGD in Endo, Ministry of Health, Taif, Saudi Arabia

Corresponding author:
Khames T Alzahrani,
BDS, PGD in Endo,
Ministry of Health,
Taif, Saudi Arabia,
E-mail: dr.khames.alzahrani@gmail.com

Abstract

Background: A full understanding of the dental anatomy of permanent teeth is essential for all treatment aspects of these teeth. Knowledge of the normal and abnormal architecture of permanent teeth is necessary for making diagnosis and treatment decisions in patients. The aim of this study was to do a systematic review of the literature on root morphology and root canal configuration in permanent mandibular dentition. **Methods:** Between September 2020 and October 2021. The PROSPERO database was used to record this systematic review, which followed the PRISMA criteria. To find and gather published literature on the anatomy of the root and root canal configuration of all permanent mandibular teeth in the Saudi population. **Results:** A search of electronic databases showed up 268 studies that were relevant. Seven more studies were included after cross-referencing. 246 of the 275 articles were deleted after a full-text analysis and duplication reduction. There were four prospective clinical trials, seven in *vitro* studies, and twenty-one *in vivo* investigations discovered. **Conclusion:** The data for this comprehensive analysis comes from 9682 mandibular teeth that were examined in various Saudi Arabian regions. The findings of this study's Saudi population are equivalent to those of morphological research conducted across the world. Any morphological changes in the anterior teeth were quite uncommon. The number of roots and canals in some teeth, on the other hand, varied greatly.

Keywords: Mandibular dentation; Root canal configuration; Vertucci classification.

Introduction

To achieve the main goal of Root Canal Treatment (RCT), which is to prevent and/or treat apical periodontitis, chemo-mechanical cleansing and shape of the root canal system, as well as three-dimensional obturation, are required. [1] There are several anatomical variances in root canal systems, some of which can greatly enhance the difficulties of endodontic treatments. Prior to beginning treatment, learning the anatomy and morphology of a root canal system can improve the quality of treatment and, as a result, the long-term prognosis of endodontic therapy. [2] 2D radiography, root canal staining, hard tissue slice, micro-CT, and Cone-Beam Computed Tomography (CBCT) scanning were all used to determine root canal configuration. [3] 80% of the mandibular first premolars had a single root, (18%) had two roots, and two percent (2%) had three roots. [4] The present understanding of the morphology of the mandibular first molar root canal space is based on Hess' work. He used vulcanite casts to recreate the anatomy of the pulp area, and found that 21 teeth (4%) out of 512 had four root canals. [5] Most of the teeth had one root (99.8%). Type I canal configuration (95.4%) was the most prevalent observation. [6] There is no systematic review research related to our topic in Saudi Arabia. The aim of this study was to do a systematic review of the literature on root morphology and root canal configuration in permanent mandibular dentition.

Literature Review

The PRISMA principles were followed, and the PROSPERO database was used to record this systematic review (258869). To reach and identify the published literature related to the anatomy of the root and the root canal configuration of all permanent mandibular teeth in the Saudi population, two independent teams conducted a comprehensive search using Cohen's kappa agreement for title selection (0.97), abstract selection (0.77), and full-text selection (0.70). Each group was comprised of two analysts who directed a consolidated hunt dependent on distinct and concurred together upon consideration and avoidance rules. On the off chance that any of the groups can't concede to which article to pick, an outsider (fifth scientist) will settle on a ultimate choice. All examinations should be done on Saudi

How to Cite this Article: Mandorh A, et al. The Variation of Root Canal Configuration of Permanent Mandibular Dentition among Saudi Population: A Systemic Review. Ann Med Health Sci Res. 2021;11:S6:48-56.

residents, using human extremely durable mandibular teeth and an example size of somewhere around 10 teeth (power). Case reports, case series, or survey studies should be liberated from abnormalities, for example, deciduous teeth test size, non-human teeth, non-Saudi populace, case reports, case series, or audit examines. Root trench life structures or root waterway morphology or root channel design and Kingdom of Saudi Arabia or Saudi Arabia or KSA were used in a methodical writing search using the PubMed web crawler. At the point when the pursuit started in August 2020, there were no time cut-off points or language limitations. Scopus, Web of Science, Embase, Cochrane, and Direct Science were completely looked with similar rules and search approach. A manual inquiry was additionally completed, whic h included cross-referring to every one of the chose papers' reference records to guarantee that all applicable articles had been surveyed.

Data Collection

The studies were chosen using a "three-step examination. "All relevant literature titles and abstracts were examined in the first step, taking into account the study's inclusion/exclusion criteria. The whole text of the selected publications was studied, analyzed, and rated in the second step, using the same criteria as before. The third phase involved subjecting the selected relevant studies to a critical appraisal in order to determine the quality of each article. For greater accuracy and convenience, each study was assigned a unique ID number. Information was separated into two groups from each of the clinical and laboratory studies: 1st Matrix: (Ia) Title (IIa) Author (IIIa) Year (IVa) Journal (VA) Institution (VIa) Region. Matrix 2: (Ib) Author (IIb) Year (IIIb) The method used to study tooth morphology (IVb) Tooth (Vb) Study design (VIb) Sample size (VIIb) Gender (VIIIb) Age (IXb) Outcome (number of roots, number of root canals, and their configurations) Another table was made to organize all of the papers based on their main goals and tooth samples. I C Shaped canal studies; (ii) Maxillary canine; (iii) Maxillary first premolar; (iv) Maxillary second premolar; (v) Maxillary first molar; (vi) Maxillary second molar; (vii) maxillary first molar; (vii) Maxillary Second Molar after that, an excel document with many sheets was produced, each with its own set of categories. Each sheet had multiple columns, beginning with the study ID number, year of publication, year of sample size collection, tooth, number of sample size, gender (male, female, both genders), area (which was divided into five main regions: northern, southern, central, eastern, and western), study design, method of examination (CBCT, lab, clinical), operator number, and gender (male, female, both genders). The results of each investigation were then displayed in the same excel sheet (if mentioned) the number of roots, the number of roots, the number of roots, the number of roots, the canals, vertucci categorization (types 1-8), C-shaped canals, fused roots, merged canals, correlations, bilateral symmetry, gender differences [Figure 1].

Scientific assessment

The Critical Appraisal Skills Program (CASP) tool for systematic reviews and Centre for Evidence-Based Medicine (CEBM) had been used in this systematic review to assess the scientific merit of the full texts. CASP checklist contains 12 questions to help the reader make sense of a systematic review. Each of them will be critically appraised by using (CASP) and (CEBM) by one of the researchers.

Data Analysis

The electronic database search yielded 268 studies that were

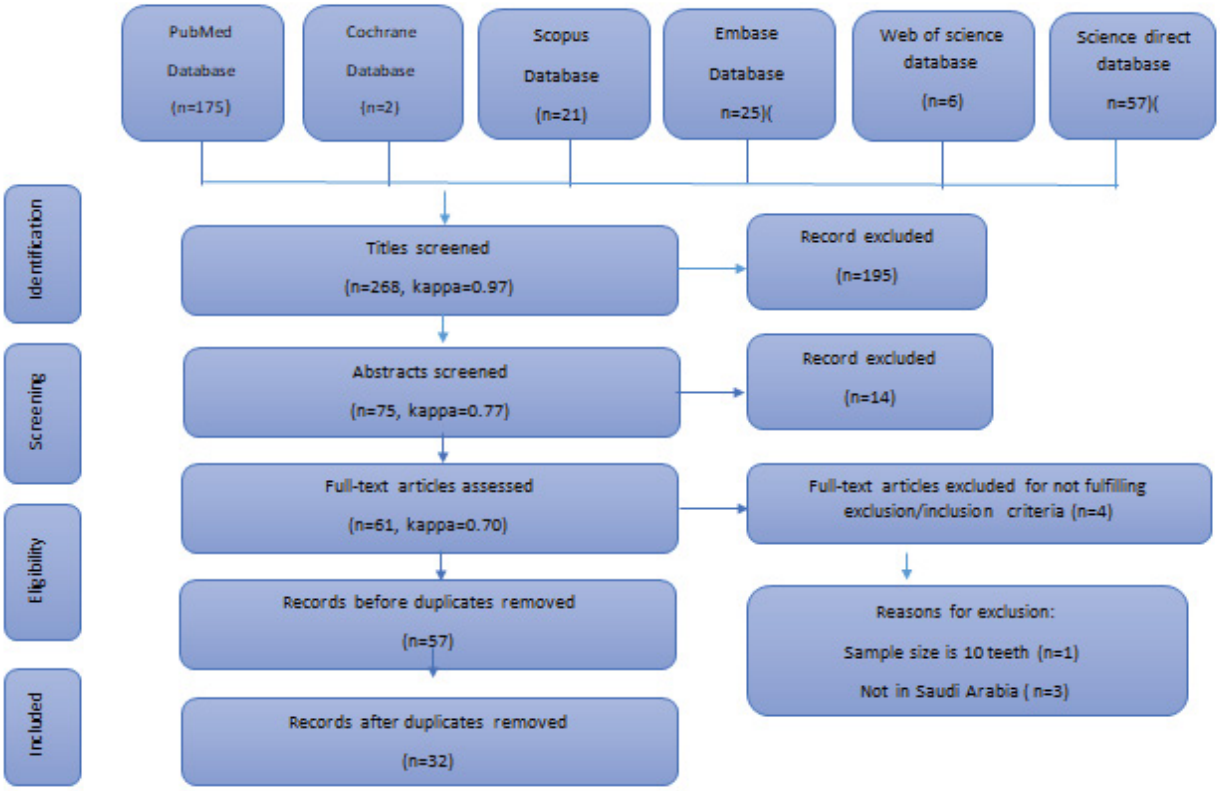

Figure 1: The study's inclusion/exclusion criteria.

relevant. After cross-referencing, further seven studies were added. After a full-text analysis and duplicate reduction, 246 of the 275 articles were eliminated. Four clinical (prospective) studies, seven *in vitro* studies, and twenty-one *in vivo* research were found.

Matrix development

The information mentioned earlier in the technique was gathered from the 17 studies that were included. They've been arranged and classified in the table accordingly [Table 1]. This table summarizes the various methods used by the various studies, as well as the features of their sample size and study team.

Data extraction

Sample size, tooth number, gender, location, methodology used, root morphology, canal classifications, and number were all gathered from the selected articles. For the second step of this systematic review, all data was entered into an excel sheet and numerically coded.

Data grouping and filtering

All data was filtered and double-checked after the traditional data extractions to eliminate any human or systemic errors. Following that, filters were applied to the data sheets, and the data was organized by tooth.

Table 1: Matrix development.

Title	Authors	Years	Journal	Institution	Region
Root canal morphology of mandibular premolars in a Saudi population using cone beam computed tomography	Alam F, et al.	2020	Pakistan Journal of Medical and Health Sciences	College of Dentistry, Aljouf University	Aljouf
Anatomical evaluation of mandibular molars in a Saudi population: An *in vivo* cone-beam computed tomography study	Mashyakhy, et al.	2021	International Journal of Dentistry	College of Dentistry, Jazan University	Jazan
Interpretation of root canal anatomy of maxillary and mandibular permanent canines in saudi subpopulation: A Cone-Beam Computed Tomography (CBCT) Study	Almohaimede A, et al.	2021	Internationl Journal of Dentistry	College of Dentistry at King Saud University	Riyadh
Ethnical anatomical differences in mandibular first permanent molars between indian and saudi arabian subpopulations: A retrospective cross-sectional study	Mashyakhy M, et al.	2020	Journal of Contemporary Dental Practice	College of Dentistry, Jazan University	Jazan
Evaluation of root canal configuration of mandibular incisors among a Saudi subpopulation of Qassim region using cone-beam computed tomography: A retrospective study	Mohame A, et al.	2021	Saudi Endodontic Journal	College of Dentistry	Qassim region
Evaluation of root canal morphology of mandibular premolars in a Saudi population using cone beam computed tomography: A retrospective study	Alfawaz H, et al.	2019	Saudi Dental Journal	College of Dentistry, King Saud University	Riyadh
Permanent teeth anatomy in a Saudi Arabian population	Mashyakhy M, et al.	2019	Nigerian Journal for dental practice	College of Dentistry, Jazan University	Jazan
Evaluation of mandibular first permanent molars to determine the incidence of three roots and four canals in Aljouf region of Saudi Arabia	Iqbal A, et al.	2019			
Prevalence of C-shaped canal system in mandibular first and second molars in a Saudi population assessed via cone beam computed tomography: A retrospective study	Alfawaz H, et al.	2019	Clinical Oral Investigations	College of Dentistry, King Saud University	Riyadh
Cone-beam computed tomographic evaluation of root canal morphology of mandibular canines in a Saudi subpopulation	Al-Dahman Y, et al.	2017	Saudi Endodontic Journal	College of Dentistry, King Saud University	Riyadh
Root canal morphology of mandibular first premolars in Saudi Arabian southern region subpopulation	Chourasia H, et al.	2019	Saudi Endodontic Journal	dental schools and primary health care centers	southern regions
Prevalence of three-rooted mandibular permanent first and second molars in the Saudi population	Riyahi AM, et al.	2019	Saudi Dental Journal	King Saud University Dental Hospital	Riyadh
Anatomical variations and bilateral symmetry of roots and root canal system of mandibular first permanent molars in Saudi Arabian population utilizing cone-beam computed tomography	Mashyakhy M, et al.	1999	Saudi Dental Journal	The Institutional Review Board (CODJU-1811F)	Southern region
Incidence of four canals in root-canal-treated mandibular first molars in a Saudi Arabian sub-population	Al-Nazhan S, et al.	2012	International Endodontic Journal	King Saud University, College of Dentistry	Riyadh
Incidence of two canals in extracted mandibular incisors teeth of Saudi Arabian samples.	Al-Fouzan, et al.	2020	Saudi Endodontic Journal	National Guard dental clinics	Saudi Arabia

The mid-mesial canal prevalence in mandibular molars of a Saudi population: A cone-beam computed tomography study	Aldosimani, et al.	2020	Saudi Dental Journal	King Saud University Dental Hospital	Riyadh
Prevalence and characteristics of three-rooted mandibular molars in Saudi population: A retrospective radiographic analysis	Alahmed, et al.	2018	Journal of Contemporary Dental Practice	College of Dentistry, Majmaah University	Al Zulfi
Three-rooted mandibular first molars in a Saudi Arabian population: A CBCT study	Patil, et al.	2019	Pesquisa Brasileira em Odontopediatria e Clinica Integrada	College of Dentistry, Jouf University	Aljouf
The Evaluation of Mandibular First Permanent Molars to Determine the Incidence of Three Roots and Four Canals in Aljouf Region of Saudi Arabia	Iqbal, et al.	2019	International Journal of Medical Research	College of Dentistry Aljouf University	Aljouf
Morphological variations of mandibular first premolar in a Saudi Arabian subpopulation evaluated using Cone Beam Computed Tomography CBCT	Algarni, et al.	2019	The Saudi Dental Journal	Armed Forces Hospitals	Asir region
Anatomical analysis of permanent mandibular incisors in a Saudi Arabian population: An in Vivo cone-beam computed tomography study	Mashyakhy M, et al.	2002	Nigerian Journal of Clinical Practice	College of Dentistry, Jazan University	Jazan
C-shaped root canals in mandibular second molars in a Saudi Arabian population	Khalid S, et al.	2001	International endodontic jornal	King Fahad National Guard Hospital	Ryiadh
The microscopic diagnosis and treatment of a mandibular second premolar with four canals	Khalid S, et al.	2018	International endodontic jornal	*	*
Prevalence of c-shaped root canals in mandibular second molars in a sample population of Saudi Arabia	Laila AB, et al.		Pakistan Oral & Dental Journal	*	Jeddah, Makkah, and Albaha

Data synergizing

The mean was recalculated using the filtered and selected data for each tooth, based on the selected studies that have a similar design and are homogeneous. After correcting for sample size in each study, the new mean was computed. The new mean and range are shown in separate Tables 2-4 for each tooth in the following section.

Anterior teeth

The number of roots of the mandibular anterior teeth was evaluated by four studies. [6-9] These studies include 2980 mandibular anterior teeth, most of mandibular anterior teeth was one root (86.4%), (13.6%) of anterior teeth were 2 roots.

The number of canals of the mandibular anterior teeth was evaluated by four studies. These studies include 1913 mandibular anterior teeth, most of mandibular anterior teeth was one canal 1736 (90.74%), 198(10.3%) of mandibular anterior teeth was 2 canals. The frequency of vertucci types was evaluated by two studies, these studies include 2980 mandibular anterior teeth, the majority of the sample 806(27%) had vertucci type I, 41(1.37%) was type II,189(6.3%) was type III, 7(0.23%) was type IV, 25(0.83%) was type V, 0(0%) was type VI. [6-9]

First premolar

The number of roots of the mandibular first premolar was evaluated by four studies [3,10-12] these study include 1640 mandibular first premolar, most of mandibular first premolar was one root 1460 (89.02%), 176 (10.73%) of first premolar was 2 roots, and 4 (0.24%) was three roots. The number of canals of the mandibular first premolar was evaluated by three studies. [1,3,4] These studies include 1249 mandibular first premolar, most of mandibular first premolar was one canal 888 (71.09%), 355 (28.42%) of first premolar was 2 canal, 6 (0.48%) was three canals. The frequency of vertucci types was evaluated by two studies. These studies include 491 mandibular first premolar, the majority of the sample 413(84.11%) had vertucci type I, 22(4.48%) was type II, 16(3.25%) was type III, 24(4.88%) was type IV, 8(1.62%) was type V, 1(0.20%) was type VI, 6 (1.22%) had type VIII, and one tooth had an aberrant root canal morphology. [3,10-12]

Second premolar

The number of roots of the mandibular second premolar was evaluated by four studies [3,11-13] these study include 1475 mandibular second premolar, most of mandibular second premolar was one root 1371 (92.94%), 102 (6.91%) of second premolar was 2 roots, and 2 (0.13%) was three roots. The number of canals of the mandibular second premolar was evaluated by three studies [1,3,13] these studies include 1132 mandibular second premolar, most of mandibular second premolar was one canal 907 (80.12%), 220(19.43%) of second premolar was 2 canal, 4 (0.35%) was three canals, and 1 (0.08) was four canals. The frequency of vertucci types was evaluated by two studies [1,3] these studies include 722 mandibular second premolar, the majority of the sample 676 (93.62%) had vertucci type I, 15 (2.07%) was type II, 7 (0,96%) was type III, 9 (1.24%) was type IV, 6 (0.83%) was type V, 6 (0.83%) was type VI, and out of the sample, there were 3 (0.41%) teeth had one root, 3 canals, and C-shape configuration.

First molar

The number of roots of the mandibular first molar was evaluated by eight studies. [1,5,14-19] These studies include 2854 mandibular first molars; most of the mandibular first molars had 2 roots 2736 (95.86%), and 118 (4.1%) had three roots. The number of canals of the mandibular first molar was evaluated by four studies [1,5,15,19] These studies include 1238 mandibular first molar, most

Table 2: Distribution of mandibular permanent teeth according to numbers of root.

Tooth	Number of roots		
	1 root	2 roots	3 roots
Mandibular anterior teeth (N=2980)	N=2574 (86.4%)	N=405 (13.06%)	0
Mandibular first premolar (N=1640)	N=1460 (89.02%)	N=176 (10.73%)	N=4 (0.24%)
Mandibular second premolar (N=1475)	N=1371 (92.94%)	N=102 (6.91%)	N=2 (0.13%)
Mandibular first molar (N=2854)		N=2736 (95.86%)	N=118 (4.10%)
Mandibular second molar (N=733)	N=62 (8.46%)	N=657 (89.63%)	N=14 (1.90%)

Table 3: Distribution of mandibular permanent teeth according to number of canals.

Tooth	Numbers of canals			
Mandibular anterior teeth (N=1913)	1 canal N=1736 (90.74%)	2 canals N=198 (10.3%)		
Mandibular first premolar (N=1249)	1 canal N=888 (71.09%)	2 canals N=355 (28.42%)	3 canals N=6 (0.48%)	
Mandibular second premolar (N=1132)	1 canal N=907 (80.12%)	2 canals N=220 (19.43%)	3 canals N=4 (0.35%)	4 canals N=1 (0.08%)
Mandibular first molar (N=1238)	2 canals N=15 (1.21%)	3 canals N=788 (63.65%)	4 canals N=435 (35.13%)	
Mandibular second molar (N=733)	2 canals N=46 (6.27%)	3 canals N=589 (80.3%)	4 canals N=40 (5.45%)	Other N=58 (7.9%)

Table 4: Distribution of mandibular permanent teeth according to canal configuration.

Tooth	Vertucci classification						
	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII
Mandibular anterior teeth (N=2980)	N=806 (27%)	N=41 (1.37%)	N=189 (6.3%)	N=7 (0.23%)	N=25 (0.83%)	0%	
Mandibular first premolar (N=491)	N=413 (84.11%)	N=22 (4.48%)	N=16 (3.25%)	N=24 (4.88%)	N=8 (1.62%)	N=1 (0.20%)	N=6 (1.22%)
Mandibular second premolar (N=722)	N=676 (93.62%)	N=15 (2.07%)	N=7 (0.96%)	N=9 (1.24%)	N=6 (0.83%)	N=6 (0.83%)	
Mandibular first molar (N=987) Mesial root	N=17 (1.7%)	N=361 (36.57%)	N=13 (1.3%)	N=574 (58.15%)	N=21 (2.1%)	N=1 (0.1%)	
Mandibular first molar (N=987) Distal root	N=736 (74.56%)	N=54 (5.47%)	N=110 (11.1%)	N=22 (2.22%)	N=64 (6.4%)	N=2 (0.2%)	
Mandibular second molar (N=675) Mesial root	N=42 (6.22%)	N=172 (25.48%)	N=108 (16%)	N=266 (39.4%)	N=87 (12.88%)		
Mandibular second molar (N=676) Distal root	N=646 (95.56%)	N=6 (0.88%)	N=6 (0.88%)		N=18 (2.66%)		

of mandibular first molar was three canals 788 (63.65%), 15 (1.21%) of first molar was tow canal, 435 (35.13%) was four canals. The frequency of vertucci types was evaluated by three studies, [2,6,7] these studies include 987 mandibular first molar, The majority of the sample 736 (74.56%) had vertucci (distal root) type I, 17(1.7%) was vertucci (mesial root) type I, 361(36.57%) was vertucci (mesial root) type II, 54(5.47%) was vertucci (distal root) type II, 13(1.3%) was vertucci (mesial root) type III, 110(11.1%) was vertucci (distal root) type III, 574(58.15%) was vertucci (mesial root) type IV, 22(2.22%) was vertucci (distal root) type IV, 64(6.4%) was vertucci (distal root) type V, 21(2.1%) was vertucci (mesial root) type V, 1(0.1%) was vertucci (mesial root) type VI, 2(0.2%) was vertucci (distal root) type VI, and out of the sample, from other two studies [15,19] there was only one C-shaped mandibular first molar observed (0.19%) in study, [2] and in the study [20] there were 9 (1.3%) mid-mesial canals at the mandibular first molar.

Second molar

The morphology of the mandibular second molar was evaluated by two studies. [11,19] These studies include 733 mandibular second molar, most of mandibular second molar was two roots 657 (89.63%), 62 (8.45%) of second molar was one root, and 14 (1.9%) was three roots. 589 (80.35%) of mandibular second molars reported three root canals, 46 (6.27%) was 2 root canals, and 40 (5.45%) was have four root canals, 58 (7.9%) of these teeth display other canals configuration. The frequency of vertucci type IV 266 (39.4%) was the highest in mesial canals followed by vertucci type II 172 (25.5%). In contrast, vertucci type I was the most frequent type in the distal canals 646 (95.6%) and vertucci type IV was not detected in the distal canal. C-shaped root canals in the mandibular second molar was evaluated by three study [2,21,22] and include 1054 mandibular second molar, 110 (10.43%) of these teeth was have the of C-shaped canals.

Discussion

All canals must be located, debrided, shaped, disinfected, and obturated for a successful endodontic therapy, and the first crucial step in canal debridement is to identify the canals and a full grasp of the internal anatomy of teeth. The clinician must have sufficient information of the canal design and morphology in order to determine the number of canals in the tooth being treated. Each group of teeth has a different root canal arrangement and anatomy. Additional canals or atypical root canal configuration can occur when many roots are present.

Anterior teeth

Number of roots: The number of roots of the mandibular anterior teeth was evaluated. [6-9] These studies include 2980

mandibular anterior teeth, most of mandibular anterior teeth was one root (85.4%), (0.70%) of anterior teeth were 2 roots. While in Indian subpopulation these studies include 102 and all mandibular anterior teeth had one root 100%

Number of canals: The number of canals of the mandibular anterior teeth was evaluated. [6-9] These studies include 1913 mandibular anterior teeth, most of mandibular anterior teeth was one canal 1736 (90.74%),198 (10.3%) of mandibular anterior teeth was 2 canals. While in Indian sub population the study includes 102 mandibular anterior teeth 83 (81.37%) had one canal and 29 (28.43%).

Root configuration: The frequency of vertucci types was evaluated by two studies, [7,8] these studies include 2980 mandibular anterior teeth, The majority of the sample 806 (27%) had vertucci type I, 41 (1.37%) was type II, 189 (6.3%) was type III, 7 (0.23%) was type IV, 25 (0.83%) was type V, 0 (0%) was type VI. While in Indian subpopulation these studies include 102 mandibular anterior teeth typeI canal configuration was the most prevalent 66 (64.71%) type II 24 (23.53%) type III 9(8.82%) type V 3 (2.94). [7,8]

First premolar

Number of roots: The number of roots of the mandibular first premolar was evaluated. [3,10-12] These studies include 1640 mandibular first premolar, most of mandibular first premolar was one root 1460 (89.02%), 176 (10.73%) of first premolar was 2 roots, and 4 (0.24%) was three roots. while in Gujarati population these studies include 138 mandibular first premolars 134 (97.10%) had one root, 4 (2.89%) was two roots. And in Chinese population the study includes 178 mandibular first premolar, nearly all mandibular first premolars have a single root (177/178). Two roots were found in only 1 (0.6%). [23,24]

Number of canals: The number of canals of the mandibular first premolar was evaluated by three studies. [10-12] These study include 1249 mandibular first premolar, most of mandibular first premolar was one canal 888 (71.09%), 355 (28.42%) of first premolar was 2 canal, 6 (0.48%) was three canals. while in Gujarati population these studies include 138 mandibular first premolars, 122 (88.40%) had one canal and 16 (11.59%) had two canals and in Chinese population the study includes 178 mandibular first premolar, of 178 mandibular first premolars, 114 (64.04%) was single canal system, whilst 61 (34.27%) had two canals and 3 (1.69%) had three canals.

Root configuration: The frequency of vertucci types was evaluated by two studies, these studies include 491 mandibular first premolar, The majority of the sample 413(84.11%) had vertucci type I, 22(4.48%) was type II, 16 (3.25%) was type III, 24 (4.88%) was type IV, 8 (1.62%) was type V, 1(0.20%) was type VI, 6 (1.22%) had type VIII, and one tooth had an aberrant root canal morphology. while in Gujarati population these studies include 138 mandibular first premolars, type I canal configuration was the most prevalent 93 (67.39%), 11 (7.97%) teeth had type II canal configuration, 5 (3.62%) was type III canal configuration, 4(2.89%) teeth were type IV, the type V canal configuration was observed in 24 (17.39%) cases, and only one tooth (0.72%) was type IV and in southwestern China population the study includes 115 specimens, 75(65.2%) was identified as type I, 26(22.6%) as type V, 3(2.6%) as type III, and 1(0.9%) was type VII, ten specimens did not fit vertucci's classification. Additional types identified included: 2.6% (3 of 115) type 1-3-2, 5.2% (6 of 115) type 1-3, and 0.9% (1 of 115) type 1-2-3. [23,24]

Second premolar

Number of roots: The number of roots of the mandibular second premolar was evaluated. [3,11-13] These studies include 1475 mandibular second premolar, most of mandibular second premolar was one root 1371 (92.94%), 102 (6.91%) of second premolar was 2 roots, and 2 (0.13%) was three roots. while in western Chinese populations [25] these studies include 178 and all mandibular second premolars had one root (100%) and in Korean population [26] the study includes 789 mandibular second premolar, most of mandibular second premolar was one root 784 (99.4), and 5 (0.6%) was two roots.

Number of canals: The number of canals of the mandibular second premolar was evaluated. [3,11-13] These study include 1132 mandibular second premolar, most of mandibular second premolar was one canal 907 (80.12%), 220 (19.43%) of second premolar was 2 canal, 4 (0.35%) was three canals, and 1 (0.08%) was four canals. while in eastern Chinese populations the study includes 178 mandibular second premolar, 173(97.2%) had one canal and 4(2.2%) had two canals, the prevalence of C-shaped canals was 1 (0.6). [26,27]

Root configuration: The frequency of vertucci types was evaluated by two study, these studies include 722 mandibular second premolar, The majority of the sample 676 (93.62%) had vertucci type I, 15 (2.07%) was type II, 7 (0.96%) was type III, 9 (1.24%) was type IV, 6 (0.83%) was type V, 6 (0.83%) was type VI, and out of the sample, there were 3 (0.41%) teeth had one root, 3 canals, and C-shape configuration. while in Turkish population [28] these study include 549 mandibular second premolar teeth, type I canal configuration was the most prevalent (98.9%) and only one teeth had type II canal configuration. The type V canal configuration was observed in three cases. Type IV, VII, and VIII canal configurations were not found in all teeth and in western Chinese population [25] the study includes 178 mandibular second premolar, the majority of the sample was type I 173 (97.2%), 1(0.55%) was type II, 3(1.7%) was type V, 1(0.55) was C shaped canal.

First molar

Number of roots: The number of roots of the mandibular first molar was evaluated by eight studies [1,5,14-19] These studies include 2854 mandibular first molars; most of the mandibular first molars had 2 roots 2736 (95.86%), and 118 (4.1%) had three roots. While in the vietnamese subpopulation [29] which included 332 mandibular first molars, there were 291(87.6%) molars with two roots and 41(12.3%) molars with three roots. While in Jordanian population [30] which included 330 mandibular first molars, most of them 314 (95.2%) had two separate roots, and 3 (0.9%) had two fused roots, three separate roots were found in 13 (3.9%) molars. While in Taiwan's Chinese [31] population which included 183 mandibular first molars, most of them 141(77%) had two roots, and 6 (3%) had one root, three roots were found in 36 (20%) molars.

Number of canals: The number of canals of the mandibular first molar was evaluated by four studies [1,5,15,19] These studies include 1238 mandibular first molar, most of mandibular first molar was three canals 788 (63.65%), 15 (1.21%) of first molar was tow canal, 435 (35.13%) was four canals. While in the Vietnamese subpopulation [29] which included 332 mandibular first molars, Most of them had three canals 221 (66.6%), and there were 15(4.5%) molars with two canals, and 96 (28.9%) molars had four canals. While in Jordanian population [30] which included 330 mandibular first molars, most of them had three canals 159 (48.2%), and there were 2 (0.6%) molars with two canals, and 151 (45.8%) molars had four canals, and five canals were found in 18 (5.5%) molars. While in Taiwan's Chinese population [31] which included 183 mandibular first molars most of them had three canals 93 (51%), and there were 6 (3%) molars with two canals, and 84 (46%) molars had four canals.

Canals configurations: The frequency of vertucci types was evaluated by three studies, [1,19] these studies include 987 mandibular first molar, The majority of the sample 736 (74.56%) had vertucci (distal root) type I, 17 (1.7%) was vertucci (mesial root) type I, 361 (36.57%) was vertucci (mesial root) type II, 54 (5.47%) was vertucci (distal root) type II, 13 (1.3%) was vertucci (mesial root) type III, 110 (11.1%) was vertucci (distal root) type III, 574 (58.15%) was vertucci (mesial root) type IV, 22 (2.22%) was vertucci (distal root) type IV, 64 (6.4%) was vertucci (distal root) type V, 21(2.1%) was vertucci (mesial root) type V, 1 (0.1%) was vertucci (mesial root) type VI, 2 (0.2%) was vertucci (distal root) type VI, and out of the sample, from other two studies [2] there was only one C-shaped mandibular first molar observed (0.19%) in study no 4, and in the study no 5 there were 9(1.3%) mid-mesial canals at the mandibular first molar. While in the Vietnamese subpopulation which included subtotal two rooted mandibular first molar (n=291), The majority of the sample 235(80.8%) had vertucci (distal root) type I, 16(5.5%) was vertucci (mesial root) type I, 89 (30.6%) was vertucci (mesial root) type II, 15 (5.2%) was vertucci (distal root) type II, 6 (2.1%) was vertucci (mesial root) type III, 16 (5.5%) was vertucci (distal root) type III, 177 (60.8%) was vertucci (mesial root) type IV, 19 (6.5%) was vertucci (distal root) type IV, 5 (1.7%) was vertucci (distal root) type V, 0 (0.0%) was vertucci (mesial root) type V, 3 (1.0%) was vertucci (mesial root) type VI, 1 (0.3%) was vertucci (distal root) type VI. While in Jordanian population [30] which included 317 two rooted mandibular first molars, The majority of the sample 168 (50.9%) had vertucci (distal root) type I, and also 168 (50.9%) was vertucci (mesial root) type IV, 2 (0.6%) was vertucci (mesial root) type I, 113 (34.2%) was vertucci (mesial root) type II, 56 (17%) was vertucci (distal root) type II, 2 (0.6%) was vertucci (mesial root) type III, 15 (4.5%) was vertucci (distal root) type III, 30(9.1%) was vertucci (distal root) type IV, 36 (10.9%) was vertucci (distal root) type V, 3 (0.9%) was vertucci (mesial root) type V, 9 (2.7%) was vertucci (mesial root) type VI, 4 (1.2%) was vertucci (distal root) type VI, 0(0.0%) was vertucci (mesial root) type VII, 2(0.6%) was vertucci (distal root) type VII, 1(0.3%) was vertucci (mesial root) type VIII, 0 (0.0%) was vertucci (distal root) type VIII. While in Taiwan's Chinese population [31] which included 183 mandibular first molars, The majority of the sample 101(55%) was vertucci (mesial root) type IV, 99 (54%) had vertucci (distal root) type I, 6 (3%) was vertucci (mesial root) type I, 54 (30%) was vertucci (mesial root) type II, 23 (12%) was vertucci (distal root) type II, 5 (2%) was vertucci (mesial root) type III, 12 (7%) was vertucci (distal root) type III, 46 (25%) was vertucci (distal root) type IV, 3 (2%) was vertucci (distal root) type V, 3 (2%) was vertucci (mesial root) type V, 3 (2%) was vertucci (mesial root) type VI, 0 (0.0%) was vertucci (distal root) type VI, 1 (1%) was vertucci (mesial root) type VII, 0 (0.0%) was vertucci (distal root) type VII, 10 (5%) was vertucci (mesial root) type VIII, 0 (0.0%) was vertucci (distal root) type VIII.

Second molar

Number of canals: The mandibular second molar has been evaluated in 2 studies in this papers, [11,19] most of mandibular second molar was two roots 657 (89.63%), 62 (8.45%) of second molar was one root, and 14 (1.9%) was three roots. While in Turkish individuals, the most of the mandibular second molars (85.4%) had two separate roots, whereas 1.29% had one root. Thirty-two patients (3.45%) were detected to have a three-rooted and only eight molars had four roots. And in Iranian population, of 100 examined teeth; 6% had one root, 89% had two roots, 2% had three roots and 3% had C-shaped roots.

Number of root canals: In this paper, 589 (80.35%) of mandibular second molars reported three root canals, 46 (6.27%) was 2 root canals, and 40 (5.45%) was have four root canals, 58 (7.9%) of these teeth display other canals configuration. While in Turkish individuals, 72.8% of the mandibular second molars had three canals, 22.8% had two canals, and no had five canals. And in Iranian population, 3% had single canal, 6% two canals, 54% three canals, 34% four canals, whilst 3% had C-shaped roots.

Canal configuration: In this paper, the frequency of vertucci type IV 266 (39.4%) was the highest in mesial canals followed by vertucci type II 172 (25.5%). In contrast, vertucci type I was the most frequent type in the distal canals 646 (95.6%) and vertucci type IV was not detected in the distal canal. while in Turkish individuals, The most common were type IV (34.8% in female, 39.8% in male) and type II (36.4% in female, 35.4% in male). Of the distal roots, 94.4% (in females) and 95.8% (in males) had one canal. There were no teeth with three mesial or distal canals. In the three or four rooted molars, all disto-lingual roots (100%) possessed type I canal configuration. And in Iranian population, based on the vertucci classification, the most prevalent canal configuration in the mesial root was type II and in the distal root was type I.

Conclusion

The dentist should be familiar with the most prevalent root and root canal morphology in their area. This understanding is essential for a successful therapy. The data for this systematic study came from various locations of Saudi Arabia, and it comprised an investigation of 9682 mandibular teeth. The findings of this study's Saudi population are comparable to those of worldwide morphological studies. Any morphological alterations that may occur in the anterior teeth were infrequent. On the other hand, the number of roots and canals in some teeth varied by a large amount.

Acknowledgement

Taif university researchers supporting Project number (TURSP-2020/256) Taif University, Taif, Saudi Arabia and also thanks to Vision College, Jeddah, Saudi Arabia.

References

1. Mashyakhy M, Chourasia HR, Halboub E, Almashraqi AA, Khubrani Y, Gambarini G. Anatomical variations and bilateral symmetry of roots and root canal system of mandibular first permanent molars in Saudi Arabian population utilizing cone-beam computed tomography. Saudi Dent J. 2019;31:481-6.
2. Alfawaz H, Alqedairi A, Alkhayyal AK, Almobarak AA, Alhusain MF, Martins JNR. Prevalence of C-shaped canal system in mandibular first and second molars in a Saudi population assessed *via* cone beam computed tomography: A retrospective study. Clin Oral Investig. 2019;23:107-12.
3. Alfawaz H, Alqedairi A, Al-Dahman YH, Al-Jebaly AS, Alnassar FA, Alsubait S, et al. Evaluation of root canal morphology of mandibular premolars in a Saudi population using cone beam computed tomography: A retrospective study. Saudi Dent J. 2019;31:137-42.
4. Chourasia H, Boreak N, Tarrosh M, Mashyakhy M. Root canal morphology of mandibular first premolars in Saudi Arabian southern region subpopulation. Saudi Endod J. 2017;7:77-81.
5. Al-Nazhan S. Incidence of four canals in root-canal-treated mandibular first molars in a Saudi Arabian sub-population. Int Endod J. 1999;32.
6. Al-Dahman Y, Alqedairi A, Alfawaz H, Alnassar F, Al-Jebaly A. Cone-beam computed tomographic evaluation of root canal morphology of mandibular canines in a Saudi subpopulation. Saudi Endod J. 2019;9:113-8.
7. Almohaimede AA, Alqahtani AA, Alhatlani NM, Alsaloom NS, Alqahtani SA. Interpretation of root canal anatomy of maxillary and mandibular permanent canines in saudi subpopulation: A Cone-Beam Computed Tomography (CBCT) study. Int J Dent. 2021;2021.
8. Bdelaleem, Aldakheel, FarMohamed A, Alhirabi A, Elsantawy A. Evaluation of root canal configuration of mandibular incisors among a Saudi subpopulation of Qassim region using cone-beam computed tomography: A retrospective study. Saudi Endod J. 2021;11:49-53.
9. Mashyakhy M. Anatomical analysis of permanent mandibular incisors in a Saudi Arabian population: An *in Vivo* cone-beam computed tomography study. Niger J Clin Pract. 2019;22:1611-6.
10. Chourasia H, Boreak N, Tarrosh M, Mashyakhy M. Root canal morphology of mandibular first premolars in Saudi Arabian southern region subpopulation. Saudi Endod J. 2017;7:77-81.
11. Alam F, Iqbal A, Khattak O, Khan AM, Khattak A, Irshad M, et al. Root canal morphology of mandibular premolars in a Saudi population using cone beam computed tomography. Pakistan J Med Heal Sci. 2020;14:1272-4.
12. Patil SR, Maragathavalli G, Araki K, Al-Zoubi IA, Sghaireen MG, Gudipaneni RK, et al. Three-rooted mandibular first molars in a Saudi Arabian population: A CBCT study. Pesqui Bras Odontopediatria Clin Integr. 2018;18:1-7.
13. Mohammed M, Thilla SV, Anandhi SA, Apathsakayan R, Abdulwahab A, Mazen A, et al. Ethnical anatomical differences in mandibular first permanent molars between Indian and Saudi Arabian subpopulations: A retrospective cross-sectional study. J Contemp Dent Pract. 2021;22:484-90.
14. Alahmed AA, Alabduljabbar RM, Alrashed ZM, Uthappa R, Thomas T, Alroomy R, et al. Prevalence and characteristics of three-rooted mandibular molars in Saudi population: A retrospective radiographic analysis. J Contemp Dent Pract. 2020;21:197-201.
15. Riyahi AM, Alssum K, Hadadi H, Alsayyari A, Alebrah T, Aljarbou F. Prevalence of three-rooted mandibular permanent first and second molars in the Saudi population. Saudi Dent J. 2019;31:492-5.
16. Iqbal A. The evaluation of mandibular first permanent molars to determine the incidence of three roots and four canals in aljouf region of Saudi Arabia. IJMRP. 2019;9:2-8.
17. Mashyakhy M, Jabali A, Alabsi FS, AbuMelha A, Alkahtany M, Bhandi S. Anatomical evaluation of mandibular molars in a Saudi population: An *in vivo* cone-beam computed tomography study. Int J Dent. 2021;2021.
18. Aldosimani MA, Althumairy RI, Alzahrani A, Aljarbou FA, Alkatheeri MS, AlGhizzi MA, et al. The mid-mesial canal prevalence in mandibular molars of a Saudi population: A cone-beam computed tomography study. Saudi Dent J. 2020.
19. Jain A, Bahuguna R. Root canal morphology of mandibular first premolar in a gujarati population-an *in vitro* study. Dent Res J. 2011;8:118-22.
20. Liu N, Li X, Liu N, Ye L, An J, Nie X, et al. A micro-computed tomography study of the root canal morphology of the mandibular first premolar in a population from southwestern China. Clin Oral Investig. 2013;17:999-1007.
21. Yu X, Guo B, Li KZ, Zhang R, Tian YY, Wang H, et al. Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. BMC Med Imaging. 2012;12:18.
22. Park JB, Kim N, Park S, Kim Y, Ko Y. Evaluation of root anatomy of permanent mandibular premolars and molars in a Korean population with cone-beam computed tomography. Eur J Dent. 2013;7:94-101.
23. Panepinto JA, Brandow A, Mucalo L, Yusuf F, Singh A, Taylor B, et al. Coronavirus disease among persons with sickle cell disease. Emerg Infect Dis, 2020;26:2473-2476.
24. Bulut DG, Kose E, Ozcan G, Sekerci AE, Canger EM, Sisman Y. Evaluation of root morphology and root canal configuration of premolars in the Turkish individuals using cone beam computed tomography. Eur J Dent. 2015;9:551-7.
25. Pham K Van, Le AHL. Evaluation of roots and canal systems of mandibular first molars in a vietnamese subpopulation using cone-beam computed tomography. J Int Soc Prev Community Dent. 2019;9:356-62.
26. Al-Qudah AA, Awawdeh LA. Root and canal morphology of mandibular first and second molar teeth in a Jordanian population. Int Endod J. 2009;42:775-84.
27. Chen G, Yao H, Tong C. Investigation of the root canal configuration of mandibular first molars in a Taiwan Chinese population. Int Endod J. 2009;42:1044-9.
28. Mashyakhy M, Vinothkumar TS, Arthisri AS, Renugalakshmi

A, Alamir A, Alkahtany M, et al. Ethnical anatomical differences in mandibular first permanent molars between indian and saudi arabian subpopulations: A retrospective cross-sectional study. J Contemp Dent Pract. 2021;22:484-90.

29. Aldosimani MA, Althumairy RI, Alzahrani A, Aljarbou FA, Alkatheeri MS, AlGhizzi MA, et al. The mid-mesial canal prevalence in mandibular molars of a Saudi population: A cone-beam computed tomography study. Saudi Dent J. 2021;33:581-6.
30. Demirbuga S, Sekerci AE, Dinçer AN, Cayabatmaz M, Zorba YO. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular first and second molars in Turkish individuals. Med Oral Patol Oral Cir Bucal. 2013;18:e737-44.
31. Zare JM, Jafari GF, Mashhadi EM, Moouavizahed S, Sarami M. Root and canal morphology of mandibular second molar in an Iranian population by clearing method. J Dent. 2013;14:78-81.