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ISSN: 0015-5659

e-ISSN: 1644-3284

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DOI: 10.5603/fm.98475

Article type: Review article

Submitted: 2023-12-09

Accepted: 2024-05-19

Published online: 2024-06-18

REVIEW ARTICLE
DOI: 10.5603/fm.98475
Anna Olczyk et al., Maxillary third molar anatomy

Root anatomy and canal configuration of human permanent maxillary third molar — systematic review

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ABSTRACT

Knowledge of the root canals configuration is essential for the success of endodontic treatment. The main aim of the systematic review is to determine the number of roots and the number of root canals in maxillary third molars, in addition, where possible, to determine the Vertucci classification. This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines. The study protocol was registered and approved on the International Prospective Register of Systematic Reviews PROSPERO (Reg. No: CRD42022366444) before the start of the study. Twelve studies were included in the analysis, differing in sample origin and methodology. The combined studies were analyzed based on the number of roots, number of canals, and root canal configurations, and the findings were compared with those of other international studies. Analyzing the available research results regarding the root anatomy and canal configuration of the third maxillary molar, the most commonly maxillary third molars had 3 roots (59.00%). Single-rooted teeth (24.20%) or double-rooted teeth (13.80%) were less common. In addition, it was observed that maxillary third molars typically possessed three root canals (47.28%) and the MB (mesiobuccal), DB (distobuccal), and P (palatal) canals most often showed Vertucci Type I (59.53%, 95.83% and 98.61%, respectively) in three-rooted form. Due to the small number of available studies, it is necessary to conduct further

analyses taking into account demographic and ethnic differences that may affect the anatomical and morphological structure of the teeth.

Keywords: maxillary third molars, root canal anatomy, root canal morphology, upper third molars, Vertucci classification

INTRODUCTION

Background

The ability to correctly localize, chemomechanically prepare, and obturate the root canal system, and then perform tight-seal reconstruction of the crown of the tooth, is the basis for the success of endodontic treatment [19, 36]. Familiarity with the anatomy and morphology of the root canal system is a basic and necessary part of endodontic treatment. It is imperative to anticipate and master the knowledge of internal anatomy relationships. The presence of morphological differences in the localization of canal orifices, the number of root canals, as well as their structure and course should be taken into account. The outcome of endodontic treatment depends on the knowledge of the root canal configuration. It is necessary to use magnification and modern imaging techniques to achieve a positive therapeutic effect [4, 5, 25, 28, 44].

Familiarization with the technique used to assess the morphology of the canal is the key to its understanding. In past studies, radiography, clearing technique, micro-computed tomography (micro-CT), and cone-beam computed tomography (CBCT) have been used as methods to describe root canal morphology [18, 19, 25]. The appropriate radiological assistance is essential when assessing the complexity of root canal systems. One cannot properly diagnose, then plan the treatment, and obtain a positive outcome in root canal treatment without radiography. The omission of root canals may be the result of an incomplete image provided by a two-dimensional (2D) standard radiography. A better alternative to traditional radiographs is the implementation of a cone-beam computed tomography (CBCT). It gives a high-resolution, detailed three-dimensional image of a tooth, with the possibility of measuring the root length, canal curvature direction, assessing the number of canals and size of periapical lesions, as well as giving the general picture of the neighboring anatomical structures [5, 25, 28].

Several classifications of root canal morphology have been created. As early as 1969 Weine [53] categorized root canals into three types, and in 1982 [52] he added the fourth type to his classification. Vertucci's research in 1974 on the maxillary second premolars distinguished a classification that included 8 types of root canals [51]. Study on Burmese teeth in 2001 added an additional seven canal types to the earlier classifications [29]. In 2004 Sert and Bayrili, in turn, introduced 14 different types of root canals [40].

Third molars are characterized by considerably variable anatomy, which significantly hinders therapeutic procedures. The maxillary third molars exhibit distinct anatomical characteristics when juxtaposed with their mandibular counterparts, thereby precluding a direct comparative analysis between the two [16, 41, 46]. With the development of dentistry, in many clinical situations, it is possible to perform endodontic treatment of third molars for restorative, orthodontic, and prosthodontic reasons. Third molars may be used as abutment teeth for fixed partial dentures or in cases of teeth that cannot be restored, and then autotransplantation procedure may take place [6].

There are numerous publications concerning the anatomy of maxillary and mandibular molars [9, 23, 32, 48] however, the number of papers concerning the anatomy of maxillary third molars is scarce. As a result of the small number of studies devoted to this issue, and due to the differences in the anatomical structure of the maxillary and mandibular third molars, an attempt was made to prepare a review of the available literature in order to systematize the knowledge on the structure of the third molars of the maxilla. Since there was no published review article regarding the root anatomy and canal configuration of the third maxillary molar, this systematic review was conducted on investigations and retrospective studies published concerning the anatomy and morphology of the root canal system of the maxillary third molar.

Objective

The main purpose of this study is to analyze the number of roots and the number of root canals in maxillary third molars, and where possible, to determine the Vertucci classification.

MATERIALS AND METHODS:

Selection criteria

Study design. The primary outcome of this systematic review was to inspect the prevalence of root morphology, root number and where possible root canal configurations of permanent maxillary third molars based on the Vertucci classification.

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines [33]. The study protocol was registered and approved on the PROSPERO International Prospective Register of Systematic Reviews (Reg. No: CRD42022366444) before the commencement of the study.

The study protocol was approved by the Bioethics Committee of the Wroclaw Medical University (permission no. KB 206/2022) under the Declaration of Helsinki.

Inclusion criteria

A literature search was conducted to identify root anatomy in maxillary third molars. The literature review was carried out with the use of online electronic databases such as PubMed, Embase, Web of Science, and Science Direct, each time using the following keywords: maxillary third molars, root canal anatomy, and root canal morphology. A total of 34 results from PubMed, 21 from Embase, 34 from Web Of Science, and 143 from Science Direct were compiled. Additionally, the search was extended to include journals not listed in Journal Citation Reports, revealed 34 more studies, 11 reports were sought for retrieval. After assessment for eligibility, 4 studies were excluded due to lack of clear information on the number of roots, which led to inclusion of total number of 12 studies (Fig. 1).

Exclusion criteria

Repeated studies, case reports, case series, reviews, and studies that did not describe the anatomy of maxillary third molars were excluded.

Search methods, data collection and data analysis

After comparing the results from the four databases, the titles and abstracts of the received articles were examined by two independent reviewers and if deemed relevant, the corresponding full-text articles were consulted. Articles that did not meet the inclusion criteria were excluded. Duplicates or repeated articles were rejected. Only articles in English were taken into consideration. Ultimately, twelve studies were incorporated into this review, focusing on the subject of maxillary third molars, specifically addressing the number of roots and root canals. In addition, six of the included articles featured Vertucci's classification, which was also comprised as a variable in the study.

The frequency of root canal configurations, the number of teeth, the number of roots, and the place of origin of the samples analyzed were presented in tables. Publication year and study details/characteristics of the participants at baseline, and data were recorded when available. The corresponding results, including relevant aspects, were summarized in tables.

PICO [17]

P — Population: human permanent maxillary third molar.

O — Outcomes: root canal morphology according to the Vertucci and Sert and Bayrili classification.

S — Study design: *in vitro* and *in vivo* studies.

Quality assessment in individual studies

Two reviewers (AO and BM) manually searched the reference lists of all selected studies for additional relevant articles. Disagreements between the two reviewers were resolved by discussion. If a disagreement persisted, the opinion of a third reviewer (KSM) was considered decisive.

The AMSTAR 2 (a critical appraisal tool for systematic reviews that include randomized or non-randomized studies of healthcare interventions, or both) scale was used to evaluate the risk of bias (RoB) and methodological quality of the included studies which were evaluated independently by two authors [42]. Overall assessment of the methodological quality of this review was high quality (++). The majority of the criteria were met. Little or no risk of bias was detected.

RESULTS

Twelve studies were included in the analysis, differing in methodology and sample origin – India [36, 45], Myanmar [29], Thailand [2], China [54], Türkiye [41], Poland [50], Iran [13], USA [43], Russia [38], Jordan [3], Romania [49]. Almost all of the studies were performed on extracted teeth, one was based on CBCT scans examination [38], while anatomy assessment was based on CBCT image [36, 38], micro-CBCT (50), 2 radiographs with ISO 15 K file [13], perpendicular sections to the axis of the root in the cervical third and apical third [49], staining method with Indian ink [2, 3, 29, 41, 43, 45] or staining method with Chinese ink [54] (Table 1).

Out of the total number of 2123 teeth included in this analysis, maxillary third molars most commonly had three roots (59%). Single-rooted teeth (24.2%) and double-rooted teeth (13.8%) were less frequent, while four-rooted forms accounted for a negligible percentage (2.9%) and five-rooted teeth were also very rare (0.03%) (Fig. 2). Four-rooted teeth occurred in seven regions — Myanmar, Thailand, Turkey, Iran, USA, Jordan and Romania. Five-rooted teeth occurred only in Jordan. The presence of C-type canals was found only in two studies [3, 36] where they accounted for 3.4% and 1.69% respectively of the examined teeth and

0.46% for all examined teeth (Tables 1, 2). Most frequently maxillary third molars had three canals (47.28%) (Table 3).

Among single-rooted teeth, Vertucci type I was the most common (52.83%). According to Sert & Bayirili, an additional classification was necessary due to the occurrence of root canal types not classified by Vertucci. It concerned type XV (8.29%), XVIII (0.19%), and XXIII (4%) (Table 4).

Among double-rooted teeth with two separate roots, both in the buccal and palatal regions, Vertucci type I was the most common configuration (71.65% and 86.09%, respectively) (Table 5). Among the two-rooted fused teeth, Vertucci type IV was the most common (51.43%), followed by type I (17.14%), type II (17.14%), and type VIII (7.14%). In addition, 7.14% of the teeth had type XV roots according to Sert and Bayrili (Table 6).

As far as three-rooted maxillary third molars are concerned, the MB (mesiobuccal), DB (distobuccal) and P (palatal) roots most commonly showed Type I configuration (59.53%, 95.83%, and 98.61%, respectively) (Table 7). On average, in a three-rooted maxillary third molars with three separate roots, the mesiobuccal second (MB2) canal was present in 16.28% of cases. In the case of fusion of all three roots in the maxillary third molar, Type I (30.22%) and VIII (25.33%) according to Vertucci were most prevalent (Table 8). In the case of fusion of only the buccal roots, the most frequent type in the fused MB and DB root was Type II and IV in the same amount (31.25% and 31.25%, respectively), while the palatal root was present only in Type I according to Vertucci (Table 9).

In the rare cases of four-rooted maxillary third molars, when all roots were fused, Sert & Bayirli Type XXIII was most common, while when there were four separate roots, each root was only Vertucci Type I (Table 10).

DISCUSSION

Based on the analysis of twelve studies [2, 3, 13, 29, 36, 38, 41, 43, 45, 49, 50, 54] it was found that maxillary third molars most often had three roots (59%) and three canals (47.28). The presence of a second mesiobuccal canal (MB2) in the case of three-rooted maxillary third molars with three separate roots was observed in an average of 16.28% of cases. Of the 12 studies included in the review, only 6 concerned canal types according to Vertucci's classification, which allowed the conclusion that in the case of three-rooted maxillary third molars, MB, DB and P roots most often showed type I according to Vertucci (59.53%, 95.83%, and 98.61%, respectively).

A systematic review [14] on the anatomy of maxillary second molars found that three-rooted teeth are the most common and four-rooted teeth are the least common. The most common root canal types in palatal and mesiodistal root was type I. The presence of the second mesiobuccal canal in different studies varied and ranged from 11.53% to 93.7% [14] and the most common canal configurations were Vertucci types I, II and IV [35]. Barbhai et al., 2022 [5] after analyzing 533 studies, used 35 studies for data extraction, which showed that three rooted maxillary first molars were most frequently reported. The distobuccal and palatal roots mostly had a single root canal and type I of root canal configuration was the most frequent root canal configuration. The anatomy of the mesiobuccal canal appears to be more complex due to the high frequency of occurrence the second mesiobuccal canal (68.2%) and reported a higher prevalence of Vertucci types I, II and IV in the mesiobuccal root [5].

The morphology of root anatomy is influenced by the age, gender, number of teeth, and methodology of the study. Information can be found in the literature that the anatomical structure of maxillary molars may be sex-dependent [5]. Several studies have conducted analyses to identify possible relationships between the morphology of the root canal and the gender and age of the patient. Based on the research by Naseri et al. [28], on maxillary first molars, there were no differences in canal configuration related to gender and age, as well as in the frequency of roots or the number of canals. Study on Yemeni [27] population on the same group of teeth also revealed no significant gender differences relating to the number of roots, as well as no gender predilection in complete fusion of teeth. They obtained the same conclusion with the variations of the root canals in context of Vertucci classification of root canals. Study on Saudi [26] population found statistically significant differences between number of canals and canal variations, between males and females in maxillary teeth. Study on Korean [20] population found there was higher prevalence of MB2 canal in males than females. Study on Polish [30] population by Olczak and Pawlicka also concluded that MB2 canals were more frequent in males than females. Moreover there were differences in age prevalence of MB2 canal. Higher prevalence was in patients aged between 31 and 40 years of age and 21 and 30 years of age in maxillary second molars, while the prevalence of MB2 canal in the maxillary first molars was nearly equally distributed in the two age groups (21–30 and 31–40 years). Study on Thai [35] population also found greater prevalence of MB2 canal in males than in females. They found also correlation between age groups, higher prevalence was in younger groups in first maxillary molars, while in the second maxillary molars highest prevalence was in oldest groups. Study on Turkish [40] population found differences in the maxillary incisors, second canal was more prevalent in females than in males.

Only in two studies included in our analysis — Tomaszewska's et al. [50] and Rawtiya [36] — mentioned division of teeth based on sex. The analysis of Vertucci classification indicated that Type I was statistically significant and predominant in both male and female subjects with single-rooted maxillary third molars. Additionally in males was observed also Type IV (14.3%), V (28.6 %), and VI (14.3%) and in females Type II (30%) and Type III (20%) of Vertucci classification. Whereas in two rooted third maxillary molar females had predominantly Type IV (66.7%) and males Type I (75%) of Vertucci classification of root canal. To sum up it cannot be clearly stated, whether features such as age and gender have a significant impact on the anatomical structure of the teeth, and above all, the number of studies performed is small and their results are not always consistent, which makes their general interpretation impossible.

Other factors influencing the results of the study may be the geographical location of specific populations and the ethnicity of the studied population [12, 24, 25, 31, 32, 37, 44, 47]. The differences in the findings may be present due to certain genetic predispositions [24, 34]. Unfortunately, the lack of suitable data in the papers included in the literature review prevented the analysis of this aspect. Studies included in the review were mainly conducted in Asia — namely India [36, 45], Myanmar [29], Thailand [2], China [54], Turkey [41], Iran [13], Jordan [3] and Russia [38]. There were two studies conducted in Europe: Poland [50] and Romania [49] and one study in the North America, namely USA [43]. In the future, studies of maxillary third molars covering more regions of other continents and races should be conducted in order to verify the hypothesis of anatomical differences between populations

In studies aimed at assessing the morphology of the canal system, it becomes necessary to look at the technique used to evaluate this information. Clearing techniques, radiography, micro-computed tomography (micro-CT), and cone-beam computed tomography (CBCT), as well as classical radiography examination with endodontic files and cross-sections of the roots were used in laboratory studies to establish root canal morphology [21, 22, 31, 47]. The ability of rendering the tooth transparent by demineralization after injecting liquid materials like ink, gelatine, or molten metal made the clearing technique dominate the majority of earlier studies. The fundamental disadvantage of this technique is that it produces permanent changes in the tooth structure and creates artifacts, which may distort the actual morphology of the root canal [31]. Kim et al. [21] compared two-dimensional (2D) and three-dimensional (3D) micro-CT image reformatting with standard tooth clearing for studying mandibular first molar mesial root canal morphology. Combined 2D and 3D micro-CT images yielded much more accurate canal configurations and fine anatomical structures than the clearing technique

[21]. It is definitively beneficial to use the CBCT technique in assessing the anatomy of root canals, as it provides a three-dimensional image in high resolution with a relatively low radiation dose [47]. Domark found no difference in canal counts between micro-CT and CBCT. Both methods are better than digital radiography [10]. To achieve the best image quality Ordinola-Zapata used similar laboratory conditions for both imaging methods (micro-CT and CBCT). Even though both micro-CBCT and CBCT devices showed highly accurate images, that allowed us to identify the canal configuration, some fine anatomical structures were not detected in CBCT images compared with micro-CT images [31]. It should be noted that most of the studies included in this review were performed using the staining technique, and only one evaluated anatomy with the use of CBCT, so differences in methodology may have influenced the results. The cross-section method of examining tooth root morphology, while useful in certain contexts, is associated with some disadvantages: limitations of two dimensional image, potential alteration of tissue structure, time-consuming and resource intensive methods, risk of misinterpretation, destruction of specimen.

When analyzing the anatomical variability of third molars, it should be mentioned that tooth agenesis (the congenital absence of one or more teeth) occurs in approximately 20% of the population [1]. Based on data in systematic review and meta-analysis of Carter at al. the worldwide rate of agenesis was found to be 22.63%. The highest rate of agenesis of third molars, 29.7%, occurs in the Asian population, which would confirm the thesis about the influence of race on the variability of anatomy. Moreover, agenesis of third molars [7] was gender-dependent — it occurred more common in women than in men. Some studies have shown that in the absence of other teeth, increasing the chance of third molar agenesis [8, 11]. The frequency of agenesis of third molars (55.8%) in the European population, when agenesis of other teeth was diagnosed, was approximately 2.5 times higher than in the control group [39]. The origin of tooth agenesis is genetic, but agenesis of third molars is not clarified, the significant impact of both environmental and genetic factors is taken into account. Agenesis of third molars is not a developmental disturbance, but rather an evolutionary adaptation of the dentition. Due to the high prevalence of agenesis of third molars, the absence of third molars when all other permanent teeth are present is perceived as a normal phenotype [15]. Gkantidis et al. [15], in 2021 found that missing of one or more third molars is associated with a smaller maxilla, a smaller mandible, and a smaller overall facial configuration. The authors concluded that isolated agenesis of third molars is associated with a reduction in the size of the craniofacial, which may be the result of an evolutionary process in humans leading to less and smaller teeth, as well as smaller facial structures.

CONCLUSIONS

The analysis of the available research results regarding the root anatomy and canal configuration revealed that most commonly, maxillary third molars had three roots (59%). Single-rooted teeth (24.2%) or double-rooted teeth (13.8%) were less common. In addition most commonly third maxillary molars had 3 root canals (47.28%) and the MB, DB, and P canals most often showed Vertucci Type I (59.53%, 95.83%, and 98.61%, respectively). Due to the small number of available studies, it is necessary to conduct further analyses taking into account demographic and ethnic differences that may affect the anatomical and morphological structure of the teeth.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement

The reported systematic review and meta-analysis are registered with PROSPERO reg. no.: CRD42022366444. The datasets used and analyzed during the current study are available as the Supplementary files.

Author contributions

Anna Olczyk: conceptualization, methodology, data curation, formal analysis, investigation, writing — original draft, project administration. **Barbara Malicka:** conceptualization, methodology, data curation, formal analysis, investigation, writing — original draft, validation, writing — review & editing, project administration. **Katarzyna Skośkiewicz-Malinowska:** supervision, validation, writing — review & editing, project administration, funding acquisition.

Ethics statement

The study protocol was approved by the Bioethics Committee of Wroclaw Medical University (permission no. KB 206/2022) under the Declaration of Helsinki.

Funding

The study was supported with funds from the Wrocław Medical University from the co-financing of tasks under the subsidy for the maintenance and development of research potential in 2022.

Conflict of interest

The authors declare no conflict of interest.

Supplementary materials

The online version includes supplementary materials available at https://doi.org/10.5603/fm.98475.

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Table 1. Characteristics of the studies

Authors	Method of the study	Sample size	Region
Rawtiya et al. [36]	CBCT	116	Central India
Ng et al. [29]	Indian ink staining	72	Myanmar
Alavi et al. [2]	Indian ink staining	151	Thailand
Singh and Pawar [45]	Indian ink staining	100	South — Asian India
Weng et al. [54]	Chinese ink staining	43	China, Guanzhong area
Sert et al. [41]	Indian ink staining	290	Turkey, Ankara
Tomaszewska et al. [50]	Micro-CT	78	Poland, Cracow
Faramarzi et al. [13]	two radiographs with K file number 0.15	179	Iran
Sidow et al. [43]	Indian ink staining	150	USA, Georgia
Razumova et al. [37]	CBCT	238	Russia
Al-Qudah et al. [3]	Indian ink staining	592	Jordan
Todor et al. [49]	Perpendicular sections to the axis of the root in the cervical and apical third	114	Romania

Table 2. Frequency (%) of roots in third maxillary molars

Authors	Single rooted	Double rooted	Fused double rooted	Triple rooted	Fused triple rooted	Quadruple rooted	Fused quadruple rooted	Quintuple rooted

Rawtiya et al. [36]	31.0	13.00	0.00	**55.20**	0.00	0.00	0.00	0.00
Ng et al. [29]	19.44	19.44	19.44	**55.56**	30.56	5.56	5.56	0.00
Alavi et al. [2]	3.31	6.62	6.62	**88.08**	37.09	1.99	1.99	0.00
Singh and Pawar [45]	20.00	33.00	0.00	**47.00**	0.00	0.00	0.00	0.00
Weng et al. [54]	0.00	0.00	0.00	**100.00**	44.19	0.00	0.00	0.00
Sert et al. [41]	**35.52**	28.62	0.00	34.14	0.00	1.72	0.00	0.00
Tomaszewska et al. [50]	38.46	0.00	0.00	**61.54**	61.54	0.00	0.00	0.00
Faramarzi et al. [13]	15.08	11.73	0.00	**67.60**	8.94	5.59	0.00	0.00
Sidow et al. [43]	15.33	32.00	0.00	**45.33**	0.00	7.33	0.00	0.00
Razumova et al. [37]	**47.90**	0.00	0.00	52.10	0.00	0.00	0.00	0.00
Al-Qudah et al. [3]	10.81	9.80	5.24	**69.93**	28.89	9.12	8.11	0.34
Todor et al. [49]	**53.51**	11.40	11.40	31.58	3.51	3.51	0.00	0.00
Average	24.20	13.80	3.56	**59.00**	17.89	2.90	1.30	0.03

Table 3. Frequency (%) of canals in third maxillary molars

Authors	**Single**	**2-**	**3-**	**4-**	**5-**

	canal	canals	canals	canals	canals
Rawtiya et al. [36]	19.0	0	**37.90**	24.10	3.40
Ng et al. [29]	2.78	5.56	**29.17**	22.22	0.00
Alavi et al. [2]	9.93	7.95	**31.79**	6.62	0.00
Singh and Pawar [45]	19.00	33.00	**43.00**	5.00	0.00
Weng et al. [54]	27.91	11.63	**44.19**	16.28	0.00
Sert et al. [41]	n/a*	n/a*	n/a*	n/a*	n/a*
Tomaszewska et al. [50]	23.08	15.38	**46.15**	15.38	0.00
Faramarzi et al. [13]	12.85	10.61	**68.72**	8.94	0.00
Sidow et al. [43]	n/a*	n/a*	n/a*	n/a*	n/a*
Razumova et al. [37]	13.87	11.76	**72.27**	2.10	0.00
Al-Qudah et al. [3]	5.91	11.49	**52.36**	28.21	2.03
Todor et al. [49]	n/a*	n/a*	n/a*	n/a*	n/a*
Average	14.92	11.93	**47.28**	14.32	0.60

Table 4. Frequency (%) of root canal classification according to Vertucci [51] and Sert & Bayrili [40] in single rooted third maxillary molar teeth

Author	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VIII	Type XV (3–2)	Type XVIII (3–1)	Type XXIII (3–4)
Rawtiya et al. [36]	**47.06**	17.65	11.76	5.88	11.76	5.88	0.00	0.00	0.00	0.00
Ng et al. [29]	14.29	**42.86**	0.00	14.29	7.14	0.00	0.00	21.43	0.00	0.00
Alavi et al. [2]	**40.00**	0.00	0.00	0.00	0.00	0.00	20.00	20.00	0.00	20.00
Singh and Pawar [45]	**90.00**	0.00	5.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
Weng et al. [54]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sert et	72.8	9.71	3.88	7.77	3.88	0.97	0.00	0.00	0.97	0.00

al. [41]	2									
Average	**52.83**	14.04	4.13	5.59	5.56	1.37	4.00	8.29	0.19	4.00

Table 5. Frequency (%) of root canal classification according to Vertucci [51] and Sert & Bayrili [40] in 2-rooted third maxillary molar

Author	**Buccal root**					**Palatal root**		
	Type I	Type II	Type III	Type IV	Type V	Type I	Type II	Type IV
Rawtiya et al. [36]	**42.86**	14.29	0.00	**42.86**	0.00	**62.50**	0.00	37.50
Ng et al. [29]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Alavi et al. [2]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Singh and Pawar [45]	**93.94**	0.00	3.03	3.03	0.00	**96.97**	0.00	3.03
Weng et al. [54]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sert et al. [41]	**78.15**	20.48	3.61	6.02	4.82	**98.80**	1.20	0.00
Average	**71.65**	11.59	2.21	17.30	1.61	**86.09**	0.40	13.51

Table 6. Frequency (%) of root canal classification according to Vertucci [51] and Sert and Bayrili [40] in 2-rooted fused third maxillary molar

Author	**Type I**	**Type II**	**Type IV**	**Type VIII**	**Type XV (3–2)**
Rawtiya et al. [36]	n/a	n/a	n/a	n/a	n/a
Ng et al. [29]	14.29	14.29	**42.86**	14.29	14.29
Alavi et al. [2]	20.00	20.00	**60.00**	0.00	0.00
Singh and Pawar [45]	n/a	n/a	n/a	n/a	n/a
Weng et al. [54]	n/a	n/a	n/a	n/a	n/a
Sert et al. [41]	n/a	n/a	n/a	n/a	n/a
Average	17.14	17.14	**51.43**	7.14	7.14

Table 7. Frequency (%) of root canal classification according to Vertucci [51] and Sert and Bayirli [40] in 3-rooted third maxillary molar

a. mesiobuccal root

Author	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type IX	Type XV
Rawtiya et al. [36]	**43.80**	15.60	0.00	40.60	0.00	0.00	0.00	0.00	0.00
Ng et al. [29]	**61.11**	11.11	0.00	22.22	0.00	5.56	0.00	0.00	0.00
Alavi et al. [2]	**54.55**	12.99	3.90	12.99	9.09	2.60	2.60	0.00	1.30
Singh and Pawar [45]	**57.45**	31.91	2.13	8.51	0.00	0.00	0.00	0.00	0.00
Weng et al. [54]	**62.50**	20.83	4.17	8.33	4.17	0.00	0.00	0.00	0.00
Sert et al. [41]	**77.78**	13.13	0.00	5.05	0.00	0.00	0.00	0.00	0.00
Average	**59.53**	17.60	1.70	16.28	2.21	1.36	0.43	0.00	0.22

b. distobuccal and palatal root

Author	Distobuccal root					Palatal root		
	Type I	Type II	Type III	Type IV	Type V	Type I	Type III	Type V
Rawtiya et al. [36]	**87.50**	3.10	0.00	9.40	0.00	**100.00**	0	0
Ng et al. [29]	**100.00**	0.00	0.00	0.00	0.00	**100.00**	0.00	0.00
Alavi et al. [2]	**100.00**	0.00	0.00	0.00	0.00	**100.00**	0.00	0.00
Singh and Pawar [45]	**100.00**	0.00	0.00	0.00	0.00	**100.00**	0.00	0.00
Weng et al. [54]	**87.50**	0.00	4.17	0.00	8.33	**91.67**	4.17	4.17
Sert et al. [41]	**100.00**	0.00	0.00	0.00	0.00	**100.00**	0.00	0.00
Average	**95.83**	0.52	0.69	1.57	1.39	**98.61**	0.69	0.69

Table 8. Frequency (%) of root canal classification according to Vertucci [51] and Sert & Bayirli [40] in fused 3-rooted maxillary third molar

Author	Type I	Type II	Type IV	Type VI	Type VIII	Type XV (3–	Type XVI (2–	Type XVIII (3–	Type XX (4)	Type XXI (4–	Type XXIII (3–

						2)	3)	1)		1)	4)
Rawtiya et al. [36]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ng et al. [29]	0.00	0.00	4.55	0.00	**45.45**	22.73	0.00	0.00	18.18	4.55	4.55
Alavi et al. [2]	**27.50**	7.50	12.50	0.00	20.00	12.50	5.00	5.00	0.00	0.00	10.00
Singh, Pawar [45]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Weng et al. [54]	**63.16**	21.05	0.00	5.26	10.53	0.00	0.00	0.00	0.00	0.00	0.00
Sert et al. [41]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average	**30.22**	9.52	5.68	1.75	25.33	11.74	1.67	1.67	6.06	1.52	4.85

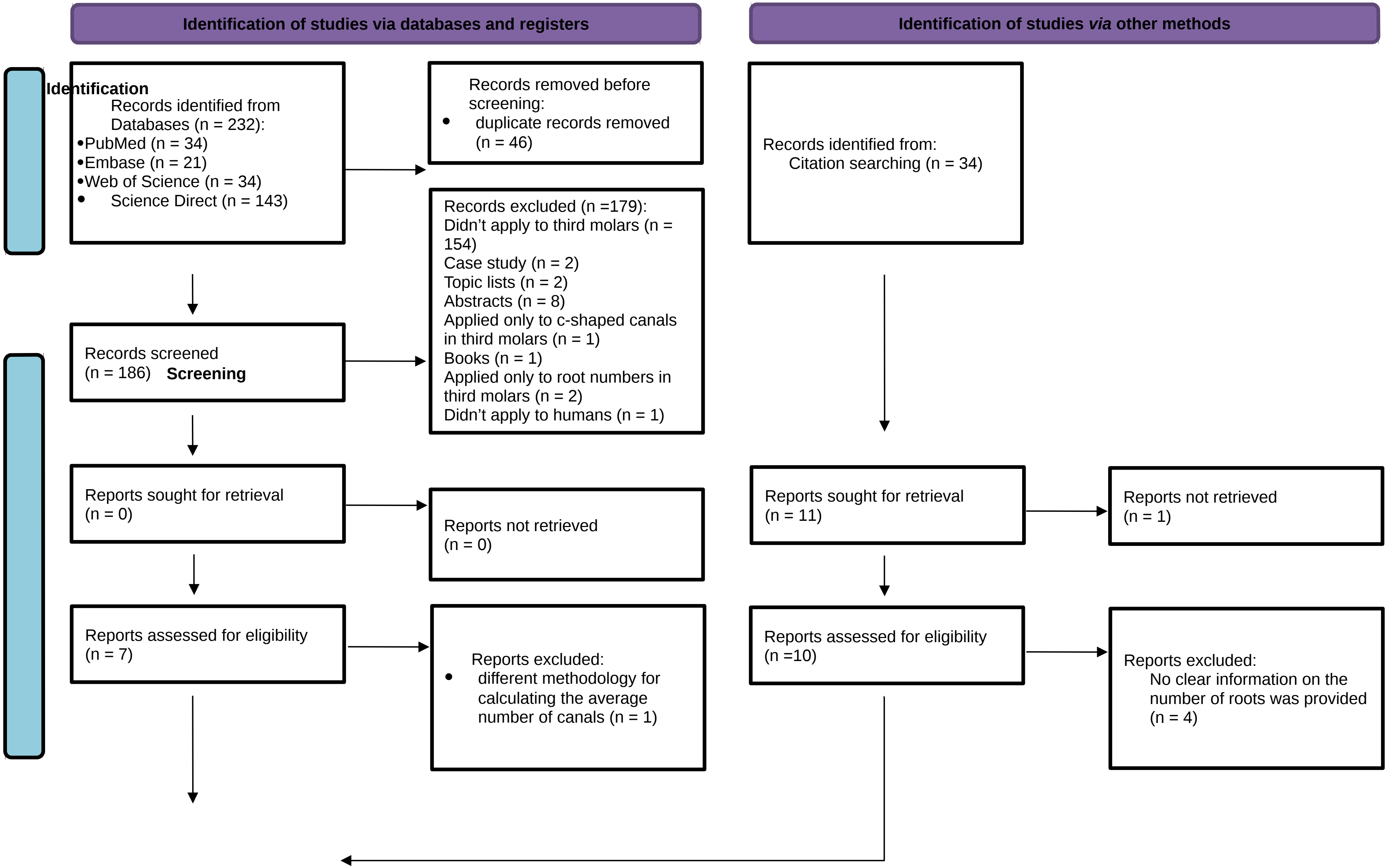
Table 9. Frequency (%) of root canal classification according to Vertucci [51] and Sert & Bayirli [40] in 3-rooted maxillary third molar with fused MB and DB roots

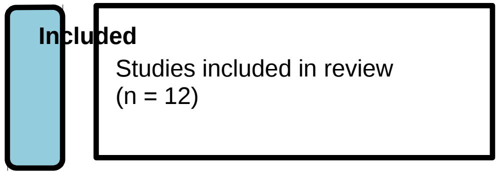
Author	**Fused MB and DB roots**							**Palatal root**
	Type I	Type II	Type IV	Type VI	Type XV (3-2)	Type XVI (2-3)	Type XXIII (3-4)	Type I
Rawtiya et al. [36]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ng et al. [29]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Alavi et al. [2]	6.25	**31.25**	**31.25**	12.50	6.25	6.25	6.25	**100.00**
Singh and Pawar [45]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Weng et al. [54]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sert et al. [41]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average	6.25	**31.25**	**31.25**	12.50	6.25	6.25	6.25	**100.00**

Table 10. Frequency (%) of root canal classification according to Vertucci [51] and Sert & Bayirli [40] in 4-rooted maxillary third molar

Author	**Fused roots**			**Mesiobuccal root**	**Mesiobuccal 2 root**	**Distobuccal root**	**Palatal root**
	Type XV (3–2)	Type XXIII (3–4)	Type XX (4)	Type I	Type I	Type I	Type I
Rawtiya et al. [36]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ng et al. [29]	25	25	**50**	n/a	n/a	n/a	n/a
Alavi et al. [2]	0.00	**100.00**	0.00	n/a	n/a	n/a	n/a
Singh, Pawar [45]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Weng et al. [54]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sert et al. [41]	n/a	n/a	n/a	**100.00**	**100.00**	**100.00**	**100.00**
Average	12.50	**62.50**	25.00	**100.00**	**100.00**	**100.00**	**100.00**

Figure 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources





(Source: [33]. For more information, visit: http://www.prisma-statement.org/)

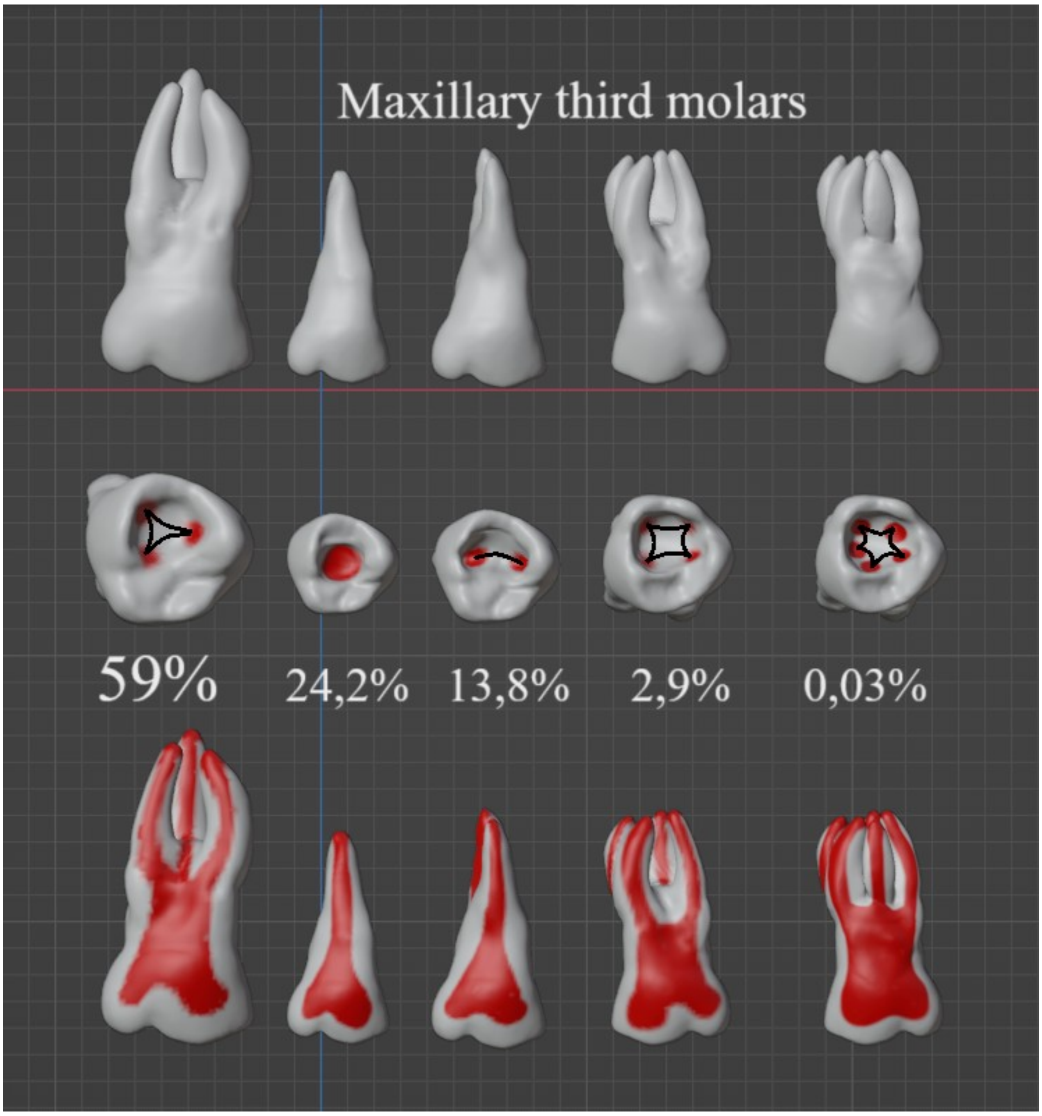


Figure 2.