REVIEW ARTICLE

JRDMS

Prevalence of the C-shaped Root Canal Morphology in the Iranian Population: A Systematic Review and Meta-analysis

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Abstract

Background and Aim: This study reviewed the prevalence of C-shaped root canal morphology in different provinces of Iran.

Materials and Methods: This systematic review was conducted according to the PRISMA guidelines. Embase, Medline, PubMed, Scopus, Web of Knowledge, Google Scholar, Cochrane Library, Ovid, SID, CIVILICA, Magiran, IranMedex, and ISC electronic databases were searched for articles published from 2000 to 2021. The searched keywords included "C-shaped root canal system" and "prevalence", "molar teeth", "premolar teeth", and "Iranian population". Full-text assessment of the articles and critical appraisal were performed using the CONSORT and STROBE checklists. Gender, tooth type (first/second molar, first/second premolar), upper/lower jaw, and type of C-shaped classification were extracted from the eligible articles, pooled, and analyzed using forest plots with proportions and odds ratio with 95% confidence interval (CI). Meta-regression was performed to evaluate possible sources of heterogeneity.

Results: The prevalence of C-shaped canals was 0.06% (95% CI: 0.04-0.08). The prevalence of C-shaped canals was 0.08% (95% CI: 0.05-0.11) based on cone-beam computed tomography (CBCT) scans. The pooled prevalence of C-shaped root canal system was higher in Mazandaran (Sari and Babol) and East Azarbaijan (Tabriz) (0.10%) than other provinces. There was no significant difference between the pooled prevalence of C-shaped root canal system in males (0.26%) and females (0.36%). The pooled prevalence of C-shaped morphology was 0.03% in first molars and 0.12% in second molars.

Conclusion: The prevalence of C-shaped morphology is high in the Iranian population. Tooth type has a significant effect on the prevalence of C-shaped canals.

Keywords: Tooth root; Prevalence; Molar; Bicuspid; Iranian people

Introduction

The aim of non-surgical root canal treatment is to remove microorganisms and necrotic or inflamed pulp tissue from the root canal system [1]. Identification of all root canals and their complete debridement are necessary for a

successful root canal treatment [2]. Missing a canal due to anatomical variations or complexity of the root canal system can lead to root canal treatment failure [3]. Many studies have been conducted on the internal and external tooth anatomy [4]. Some anatomical variations of the root canal system such as root fusion, merged canals, and C-shaped root canal system can complicate root canal treatment.

The C-shaped root canal morphology was first identified by Cooke and Cox [4]. This canal shape results from the fusion of mesial and distal roots in the buccal or lingual aspect [5]. Melton et al. described three categories (I-III) of C-shaped canals [6]. Fan and his colleagues also provided another classification with 5 groups (C1-C5) for C-shaped canals [7]. Evaluation of the root canal anatomy may be performed by root sectioning, canal staining, tooth clearing, stereomicroscopy, two-dimensional radio-graphy, and three-dimensional cone-beam computed tomography (CBCT) and micro-computed tomography [7,8].

Since adequate knowledge about the presence of this anatomical variation can help dentists that confront this root canal configuration in their daily endodontic practice, this study aimed to systematically review the prevalence of C-shaped root canal configuration in different provinces of Iran and its correlation with gender, tooth type, and ethnicity.

Materials and Methods

This systematic review was approved by the ethics committee of Mazandaran University of Medical Sciences (IR.MAZUMS.REC.1400.13690). This review was conducted according to the "Preferred Reporting Items for Systematic Reviews and Meta-analyses" (PRISMA) guidelines and the Condition, Context, Population (CoCoPop) criteria, and was registered in PROSPERO (CRD42021291725) [9]. A structured question was designed for the study as follows: What is the prevalence of C-Shaped root canal configuration (Condition) in molar and premolar teeth (Context) of the Iranian population (Population)?

Search Strategy

An electronic search was performed in PubMed, Embase, Scopus, Web of Knowledge, Google Scholar, Cochrane Library, Ovid, SID, Magiran, IranMedex, CIVILICA, and ISC databases about the prevalence of C-shaped root canals from 2000 to 2021. The following keywords were searched according to MeSH: "C-shaped root canal system", "prevalence", "molar teeth", "premolar teeth", and "Iranian population" and connected with OR and AND. Dissertations were also reviewed and the bibliographic references were hand-searched.

Eligibility Criteria

The inclusion criteria were descriptive cross-sectional studies on the prevalence of C-shaped canals in mature maxillary and/or mandibular molar or premolar teeth published in Persian or English from the beginning of 2000 to the end of 2021.

Study Selection

Articles were screened in terms of title and abstract, and then imported to EndNote X20.0 software. Duplicate articles were deleted. The remaining articles underwent full-text assessment according to the structure and components of the prevalence question (CoCoPop) by two reviewers. Articles that met the inclusion criteria and had at least one of the three variables of "gender", "province" or "C-Shaped canal" were included in the review. Disagreements between the reviewers were resolved through discussion.

Quality Assessment

Studies that were included in the present study were descriptive cross-sectional studies. Critical appraisal and quality assessment of the studies were performed by two evaluators using CONSORT and STROBE checklists [10]. The CONSORT is a 25-item checklist for reporting

how a clinical trial is designed, analyzed, and interpreted [10]. The STROBE statement is an authoritative tool consisting of a 22-item checklist, which focuses on reporting or evaluating different sections of observational studies [11].

Data Extraction and Meta-Analysis

Level of evidence of articles was determined, and risk of bias was assessed using the CONSORT and STROBE tools. The following information was then extracted from the included studies in the final analysis: First author's name, publication year, study design, sample size, and country. The method of assessment of C-shaped canals, the overall prevalence of C-shaped canals, the prevalence of C-shaped canals in males and females, the type of teeth studied, the prevalence of C-shaped canals according to gender and tooth type, and the prevalence of C-shaped canal types according to the Fan classification [7].

The C-shaped canal morphology prevalence was measured according to the grouping mentioned in the articles. The homogeneity index was used to determine the need for a meta-analysis. The Cochran's tests (Q) and the Chi-square test (I2) were used to detect heterogeneity. Wherever the homogeneity index showed I2 greater than 50% and P<0.1 among the studies, a meta-analysis was performed. Otherwise, the results were reported only qualitatively and descriptively. Data analysis was done through STATA11 software. A heterogeneity test was first conducted for the prevalence of C-shaped canals. An I2 of less than 25% is usually viewed as low heterogeneity, between 25% and 50% as moderate, and over 50% as high heterogeneity [12]. Considering the significance of the Chi-square test (Chi square=370.6, P<0.001) and I2>0.6, the random method was used. Moreover, the Begg's test was used to assess the publication bias.

The adopted search strategy yielded 107 papers; of which, 92 were original articles, and the remaining were case reports or letter to editors. Of all retrieved articles, 15 were from PubMed, 33 were from IranMedex and MagIran, 23 were from SID, 35 were from Google Scholar, 1 was a conference paper, and 6 were theses and dissertations. The articles were imported to EndNote 20.0 software, and after elimination of duplicates, 71 studies remained. The remaining articles were reviewed in terms of eligibility criteria, and 24 studies were excluded. Next, the full-texts were examined for eligibility and 14 were excluded. Of the remaining 33 articles, 3 were excluded due to incomplete information, leaving 30 studies. The search strategy flow diagram is presented in Figure 1.
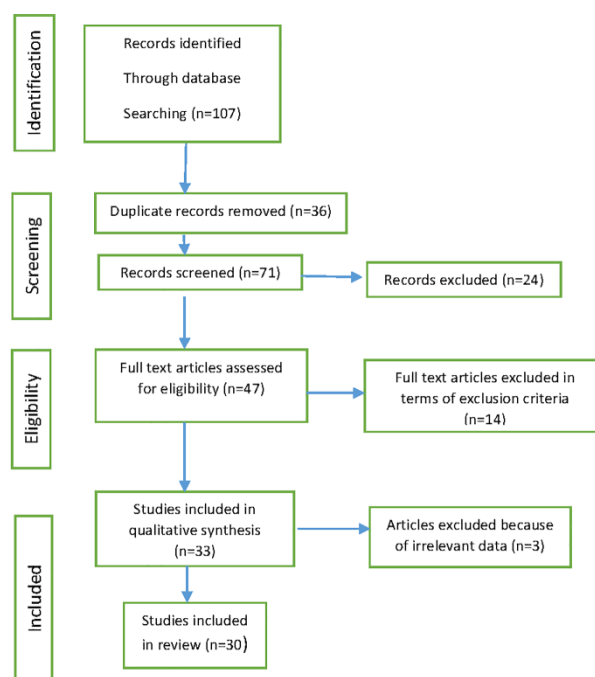

Figure 1. Search strategy

Results

All included studies were about the root canal anatomy of molar or premolar teeth. A total of 8,865 teeth were evaluated. Table 1 presents detailed information about the included studies.

Table 1. Detailed information about the included studies

First author	Publication year	Sample size	Province of Iran	Evaluation Method	Tooth Type	Overall Prevalence	Prevalence By Gender	Prevalence by C-shape classification	Prevalence by tooth type
Haddadi [13]	2018	260	Mazandaran (Sari)	CBCT	Mandibular second molar	11.5%	3.3% in males 16.4% in females	C1:43.3% C4:26.66% C2:16.66% C3:10% C5:3.3%	----
Ashraf [14]	2004	123	Tehran	Transverse section	Mandibular second molar	13.8%	Not reported	Not reported	----
Noormandi poor [15]	2007	368	Zahedan	Stereomicroscope (x40)	Mandibular second molar	3%	----	C1: 1.35% C2: 1.08% C3: 0.57%	
Rahimi [16]	2008	139	Tabriz	Indian Ink Injection Clearing	Mandibular second molar	7.2%			6.25% in mandibular second molars 0% in mandibular molar molar
Hasheminia [17]	2009	160	Isfahan	Clearing	Mandibular first & second molars	5%		Melton class 1: 1% Class 2:2.5% Class 3: 0.5%	
Kuzekanani [18]	2011	200	Kerman	Stereomicroscoe (x4)	Mandibular second molars	5%			
Janani [19]	2018	384	384	CBCT	Mandibular second molars	21.4%	No correlation	Fan Coronal: C1 Middle: C3b Apical: C3b	Bilateral C-shaped canals: 15.6%
Madani [20]	2017	301	Mazandaran (Babol)	CBCT	Mandibular first & second molars	9.3%	Females: 78.5% Males: 21.5%	Melton In 6 sections	First molar: 1.2% Second molar:17.6%
Zare Jahromi[21]	2018	456	Isfahan	CBCT	Mandibular first & second premolars	0.44%	Females: 0% Males: 0.8%		First premolar: 0.44% Second premolar: 0.44%
Rad [22]	2020	1408	Guilan (Rasht)	CBCT	All teeth	7.81%	Females: 77.38% Males:35.75%	Fan: C1: 57.27% C2: 42.73% C3 :0 C4: 0 C5: 0	Mand. teeth: 10.04% Max. teeth: 5.81%

First author	Publication year	Sample size	Province of Iran	Evaluation Method	Tooth Type	Overall Prevalence	Prevalence By Gender	Prevalence by C-shape classification	Prevalence by tooth type
Khedmat [23]	2010	217	Golestan (Gorgan)	Radiography & sectioning (x40)	Mandibular first premolars	1.38%	--	Fan: C3: only classification found	---
Akhlaghi [8]	2016	150	Tehran & Marand	India Ink & clearing technique Stereomicroscope (x10)	Mandibular second molars	6.7%	---	---	---
Zarrabi [24]	2003	100	Mashhad	Stereomicroscope	Mandibular first premolars	1%	---	---	---
Khademi [25]	2017	182	Isfahan	CBCT & Clearing	Mandibular first & second premolars	3.2%	---	---	First premolar: CBCT: 6.6% Clearing: 4.4% Second premolar: 0
Sobhani [26]	2013	400	Tehran	CBCT	Mandibular first & second premolars	0%	---	---	---
Gharechahi [27]	2021	50	Mashhad	CBCT	Maxillary second molars with fused roots	6%	---	---	---
Zarei [28]	2009	103	Mashhad	Clearing	Maxillary second molars	1.94%	---	---	---
Sarraf [29]	2021	638	Tehran	CBCT	Mandibular first & second molars	3.76%	First molar: Females:9.6% Males:90.4% Second molar: Females: 0% Males:100%	---	Mandibular first molar: 1.12% Mandibular second molar: 5.64%
Salem Milani [30]	2019	313	Tabriz	CBCT	Maxillary first & second molars	2.85%	Females: First molar:1.47% Second molar: .5% Males: First molar:2.34% Second molar:2.9%	Melton C1	First molar: 3.2% Second molar:5.4%
Haeri Tabatabaei [31]	2017	316	Tehran	CBCT	Mandibular second molars	18%	----	----	----

First author	Publication year	Sample size	Province of Iran	Evaluation Method	Tooth Type	Overall Prevalence	Prevalence By Gender	Prevalence by C-shape classification	Prevalence by tooth type
Kolahdouzan [32]	2014	282	Ghazvin	CBCT	Mandibular first & second molars	7.4%	---	---	Second molar: 13.1% First molar: 0%
Hajihassani [33]	2017	145	Ghazvin	CBCT	Mandibular first & second premolars	0%	---	---	---
Farqani [34]	2018	450	Zahedan	CBCT	Maxillary molars	5.33%	---	Highest prevalence:B1	---
Nooroleini [35]	2020	369	Ardebil	CBCT	Mandibular first & second molars	---	Females < males: Statistically significant	---	First molar: 6% Second molar: 5.45%
Rahimi [36]	2014	384	Tabriz	CBCT	Mandibular second molars	15.6%	No correlation	Fan	---
Rahimi [37]	2007	266	Tabriz	Clearing, Ink	Mandibular first & second premolars	2.25%			First premolar: 2.4% Second premolar: 2%
Kuzekanani [38]	2014	150	Kerman	Clearing India ink	Maxillary third molars	3.5%	---	---	---
Zare Jahromi [39]	2013	100	Isfahan	Clearing	Maxillary second molars	3%	---	---	---
Bolhari [40]	2013	217	Tehran	Cross-sectioning (x40)	Mandibular second premolars	0.9%	---	---	---
Shakuei [41]	2013	234	Tabriz	CBCT	Mandibular first & second molars	---	----	---	First molar: 6.7% second molar: 34.6%

A total of 30 studies were evaluated. All studies had a cross-sectional quasi-experimental design. Two studies had been conducted in Mazandaran Province [13,20], 2 in Qazvin Province [32,33], 6 in Tehran Province [14,8,26,29,31,40], 2 in Zahedan in Sistan and Baluchistan Province [15,34], 6 in Tabriz in East Azerbaijan province [41,37,36,30,19,16], 4 In Isfahan Province [17,21,25,39], 2 in Kerman Province [18,38], 1 in Rasht in Guilan Province [22], 3 in Mashhad in Khorasan Province [24,27,28], 1 in Gorgan in Golestan Province [23], and 1 was conducted in Ardabil Province [35].

The prevalence of C-shaped canal was estimated to be 0.06% (95% CI: 0.04-0.08) (Table 2). Moreover, the results of the sensitivity analysis indicated that none of the studies had a significant effect on the prevalence of C-shaped canals.

P<0.001 indicated possible publication bias; thus, the results must be interpreted cautiously. Figure 2 shows the funnel plot of the publication bias.
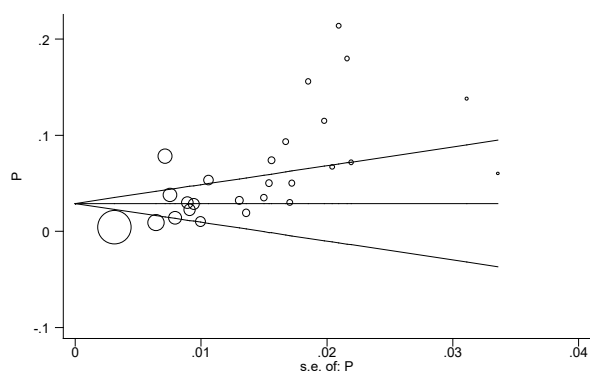

Figure 2. Begg's funnel plot with pseudo 95% confidence interval

Thirteen studies reported the prevalence of C-shaped canals based on CBCT scans [13,19,20,21,22,25,27,29,30,31,32,34,36]. Considering the significance of the Chi-square test (Chi square=331.8, P<0.001) and I2>0.6, the random method was used. The prevalence of C-shaped canals was estimated to be 0.08% (95% CI: 0.05-0.11). Moreover, publication bias was assessed, and P=0.028 indicated the probability of publication bias; thus, caution must be taken when interpreting the results.

Table 2 shows the prevalence of C-shaped canals based on gender, tooth type, and classification. The prevalence of C-shaped canals was 0.36% and 0.26% in females and males, respectively. According to the reported CI values, no significant difference existed between males and females in this regard. The prevalence of C-shaped canals was significantly higher in second molars (0.12%; 95% CI: 0.07-0.17) than other teeth (P=0.002). Moreover, the prevalence of C1 class was 0.26% (95% CI: 0-0.53) and it was insignificantly higher than other groups (C2 to C5) based on the Fan's classification (P=0.174).

As the prevalence of C-shaped canals may vary depending on several factors such as province (ethnicity), tooth type, etc., meta-regression was performed. The results showed a difference in prevalence of C-shaped canals based on province. Table 3 reports the prevalence of C-shaped canals in different provinces of Iran. The highest prevalence rate was observed in Mazandaran and East Azerbaijan Provinces. The study conducted in Ardabil Province was omitted in this section because it did not report the overall prevalence of C-shaped canals.

Discussion

It is believed that root canal anatomy, root morphology, and their anatomical variations are strongly correlated with race and ethnicity [42,43]. This systematic review aimed to systematically evaluate the prevalence of C-Shaped root canal anatomy in different cities of Iran to find a pattern of frequency among people of different cities. The overall prevalence of C-shaped canal configuration was 6%. The highest prevalence was recorded in Mazandaran and East Azerbaijan Provinces (10%) followed by Guilan (8%) and Tehran (6%). These provinces are located in south and south west of Iran. Kerman, Qazvin and Zahedan showed the same prevalence rate for this anatomical variation (approximately 4%). Kerman and Zahedan are located north-east of Iran. Isfahan showed a lower prevalence rate of 3% followed by Mashhad (2%) and Gorgan (1%).

Table 2. Prevalence of C-shaped canals according to gender, tooth type and C-shaped canal classification

Variable	Category	Number of studies	Model	I2	Prevalence (95% CI)	P-value of the Begg test
Gender	Male	6	Random	0.99	0.26(0-0.60)	0.348
	Female	6	Random	0.99	0.36(0.24-0.70)	0.142
Tooth Type	First molar	5	Random	0.85	0.03(0.01-0.05)	0.050
	Second molar	7	Random	0.95	0.12(0.07-0.17)	0.002
	First premolar	3	Random	0.83	0.02(0-0.05)	0.117
	Second premolar	2	Random	0.66	0.01(0-0.03)	0.317
Class	1	4	Random	0.99	0.26(0-0.53)	0.174
	2	4	Random	0.99	0.16(0-0.36)	0.174
	3	3	Random	0.93	0.03(0-0.06)	0.117

Table 3. Prevalence of C-shaped canals in different provinces of Iran

Province	Number of studies	Model	I2	Prevalence (95% CI)	P-value of Begg test
East Azerbaijan	5	Random	0.96	0.10 (0.03, 0.16)	0.142
Isfahan	4	Random	0.76	0.03 (0, 0.05)	0.174
Guilan	1	-	-	0.08	-
Golestan	1	-	-	0.01	-
Kerman	2	Fixed	0	0.04 (0.02, 0.06)	0.317
Khorasan Razavi	3	Fixed	0.02	0.02 (0, 0.03)	0.117
Mazandaran	2	Fixed	0	0.10 (0.08, 0.13)	0.317
Qazvin	2	Random	0.96	0.04 (0, 0.11)	0.317
Sistan	2	Random	0.65	0.04 (0.02, 0.06)	0.317
Tehran	6	Random	0.96	0.06 (0.03, 0.09)	0.091

Gorgan and Mashhad are located in the southeast of Iran. Thus, the prevalence of C-shaped canal configuration is different in different geographical regions of Iran, and it was the highest in the south and southwest, and the lowest in the south east.

Naseri et al. [44] studied the prevalence of C-shaped root canals in an Iranian population. Their systematic review included 6 papers and they reported that the total incidence of C-shaped canals in the Iranian population was 6.96%, which was close to the rate obtained in the present study. Slight difference may be related to the type of teeth evaluated. They only selected the studies that had been conducted on mandibular second molars, but in the present study, all maxillary and mandibular teeth were evaluated. Thus, the mean prevalence rate was slightly lower in the present study.

Different prevalence rates have been reported for this anatomical variation in different geographical regions. Martins et al. [45] in their systematic review about the prevalence of C-shaped canal morphology using CBCT, reported that the pooled proportion of C-shaped anatomy in mandibular second molars in East Asian countries (39.6%; 36.0–43.1%) was significantly higher compared with other regions (Europe, Latin America, Africa, west Asia).

Mashyakhy et al. [46] published a systematic review about the root canal morphology of permanent mandibular dentition in a Saudi Arabian Population. They reported the prevalence of different root canal anatomies in different parts of Saudi Arabia. They evaluated the prevalence of C-shaped canal morphology in first and second premolars and molars and revealed that this anatomical variant was found in second molars significantly more than in other teeth (12%). They added that it is an uncommon canal configuration in first molars and first and second premolars (3%, 2%, and 1%, respectively). Mashyakhy et al. in their systematic review in Saudi Arabia reported the prevalence of C-shaped canals to be 8% in first premolars and 9.8% in second molars [46].

The prevalence of C-shaped canals in each gender was evaluated in 6 studies, which were

subjected to a meta-analysis. It was reported that the prevalence of C-shaped root canal morphology was higher in females (36%) than males (26%), but this difference was not statistically significant.

Martins et al. [45] in their systematic review about the prevalence of C-shaped canal morphology reported that C-shaped canal configuration in mandibular first molars was not affected by gender. They found no significant difference regarding the prevalence of C-shaped root canal morphology between males (8.8%–18.3%) and females (13.7–27.4%).

Some studies reported a significant difference in the prevalence of C-shaped canal morphology between males and females [47-50]. Martins et al. showed significantly higher prevalence of C-shaped root canal morphology in maxillary molars of females [51] and mandibular premolars of males [52]. However, it should be mentioned that in the present study, the number of studies included in the meta-analysis was small, and therefore, the results should be interpreted with caution.

In the present review, only 10 studies evaluated the prevalence of C-shaped root canal morphology according to its classification. Each study used a different classification system of C-shaped root canal anatomy, and the Fan's classification followed by the Melton's classification were used most commonly. The pooled prevalence of C1 classification was the highest. The prevalence of different classes of C-shaped anatomy was not mentioned by Martins et al [45].

Evidence shows variations in tooth morphology in different races [53-56]. Also, changes in environmental conditions can change the size and morphology of the jaw and teeth; for example, softer diet and food can decrease the size of jaw and teeth [57]. Therefore, it may be stated that fusion of the roots which results in formation of C-shaped canals, may be a response to environmental changes.

One limitation of the present study was the differences in diagnostic accuracy of different methods of assessment of root canal morphology such as CBCT, stereomicroscopy, radiography, staining with ink, and clearing technique [58]. This study included all the relevant available studies irrespective of the adopted technique for assessment of root canal morphology in order to have a larger selection of the available studies on this topic. Resultantly, the prevalence of C-shaped canals was investigated without standardizing the method of assessment of the C-shaped anatomy. Another limitation was that the number of studies for meta-analysis was small. Thus, future multicenter studies are recommended to be performed in different parts of Iran.

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