

# Root Morphology and Canal Configuration of Permanent Canines Among Saudi Population: Systematic Review and Comparison with Worldwide Studies

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**Aim:** The root morphology and canal configuration (RMCC) of mandibular and maxillary canines among Saudi population is systematically reviewed and compared with international studies in this research.

**Methods:** This study was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations. The electronic databases of PubMed, Science Direct, Scopus, Wiley Library, Google website search, and Web of Science were searched. Only local and international cross-sectional, comparative, evaluation, and validation studies or case reports published between 2016 and 2022 that directly evaluated canine RMCC and assessed participants using cone beam computed tomography were included.

**Results:** Forty-three studies that investigated RMCCs (17 local and 26 international) were involved in this review. The original Saudi research recorded that almost 100% of maxillary canines had one root and one canal, whereas 98.4% and 94.1% had one root and one canal in the mandibular arch. Vertucci's class I had the highest percentages in the maxillary and mandibular arches at 98.3% and 95.8%, respectively, followed by class III with 0.7% and 1.9% for the same arches, respectively. International studies recorded that 100% of maxillary canines had one canal and root; the percentages of the mandibular arch were 92.3 and 98% for single canal and root, respectively; and the highest percentage was obtained by Vertucci's class I (91.1%), followed by class III (4.7%).

**Conclusion:** This review reports and confirmed the symmetry of the RMCCs of maxillary and mandibular canines between Saudi studies and other populations. Moreover, Vertucci's classes I and III were the most frequent RMCCs, and two-rooted canines in both arches were considerably less frequently than single-rooted ones.

**Keywords:** Vertucci's classification, mandibular canine, maxillary canine, root morphology, canal configuration, number of canals, number of roots, Saudi population

## Background

The preservation of natural teeth in function and aesthetics is the golden goal of endodontic treatment; achieving this objective depends on many stages, starting from the proper selection of the case and treatment plan up to the final restoration.<sup>1-3</sup> Root canal (RC) preparation is considered the most critical step owing to its direct effect on the subsequent stages of the procedure.<sup>4</sup> The success of root canal therapy (RCT) is attributed to the correct shaping, cleaning, and filling

of the RC system, which requires thorough knowledge of the external and internal anatomy of the canal system and its morphological variations.<sup>5,6</sup>

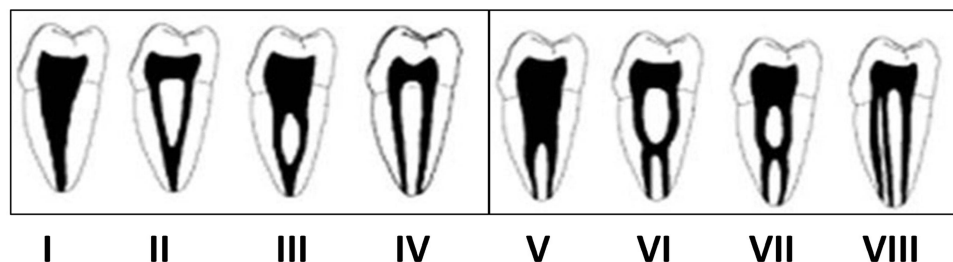
Failure due to incomplete RCT may lead to postoperative disease, pain, and complications.<sup>7</sup> One of the major causes of RCT failure is the clinician's inability to detect additional canals because of the unexpected anatomy of some RC systems.<sup>8</sup> An unexpected anatomy is known as an anatomical variation.<sup>3,9</sup> These variations are common because the internal morphology of the RC is more complex than the external morphology of the tooth.<sup>10-13</sup> Negligence to treat a few millimeters of tissue pulp can lead to an unsuccessful RCT.<sup>10</sup> Likewise, if not all existing RCs are treated, microbes and dead tissue will remain in the RCs, affecting the treatment results and the long-term prognosis of the tooth.<sup>13</sup> A dentist must be familiar with the root morphology and canal configuration (RMCC) of the tooth before starting treatment to avoid these failures.<sup>2,5</sup>

Therefore, a broad knowledge of RMCC and its variations is imperative to improve the prognosis of RCT.<sup>14,15</sup> Researchers have used a variety of methods and techniques to evaluate RMCC, including serial sectioning,<sup>16,17</sup> canal staining and clearing,<sup>18,19</sup> and radiographs, such as periapical or digital radiograph<sup>5,19</sup> and cone beam computed tomography.<sup>2,3,20-28</sup> CBCT is a highly useful tool for noninvasive, 3D imaging. It is an accurate diagnostic tool for the effective diagnosis of RC morphology, including the length and number of roots and curvatures in sagittal and axial planes.<sup>22,29-31</sup>

Many researchers proposed different classifications of RMCC.<sup>17,19,34,35</sup> Other classifications used other ways for RMCC classification.<sup>36,37</sup> The most common classification used as the standard is Vertucci's classification, in which RMCC is categorized into eight types<sup>19,34</sup> as follows (Figure 1):

- o Type I (1-1): A single canal runs from the orifice to the apex.
- o Type II (2-1): Two canals arise from the pulp chamber and unite in its course into one.
- o Type III (1-2-1): One canal arises from the pulp chamber and splits into two during its course. The two canals unite again into one before exiting from apex.
- o Type IV (2-2): Two canals run separately from the orifice to the apex.
- o Type V (1-2): One canal arises from the floor of the pulp chamber and divides into two during its course.
- o Type VI (2-1-2): Two canals start from the pulp chamber, unite into one during the course, and then divide again into two before exiting the root apex.
- o Type VII (1-2-1-2): One canal leaves the pulp chamber, divide, unite again into in its course, and finally divide into two before exiting from the apex.
- o Type VIII (3-3): Three canals leave the pulp chamber and run independently toward the apex.

Several studies have demonstrated that RMCC varies with race and ethnic group,<sup>38,39</sup> as well as with gender.<sup>3,40</sup> Therefore, these variations must be involved in the pretreatment analysis for RCT. Previously published research has described the RMCCs of several permanent teeth, including the anterior teeth. Maxillary anterior teeth often have a straightforward morphology that presents with one root and one canal.<sup>6,29-31</sup> However, mandibular anterior teeth have a more complex anatomy and often have two canals.<sup>19,41-44</sup> Mandibular canines usually have a single root with a single RC.<sup>7,8</sup> Several studies of anatomical variations in mandibular canines have been reported in the literature, in which



**Figure 1** Vertucci's classification of canal configuration.

single-root and two-root canals account for about 15%,<sup>43,45–48</sup> and double roots and double canals account for 5%.<sup>41,49,50</sup> Conversely, few local original studies have investigated canine morphology.<sup>2,3,29–33</sup> Maxillary canines usually have one root and one canal and rarely have two roots or two channels. This condition explains local or/and international case reports involving maxillary canines with double roots or canals are few.<sup>50,51</sup> Mandibular canines with two canals and one root were recorded in many published Saudi case reports.<sup>43,45–48</sup> Other studies reported mandibular canines with two canals and two roots.<sup>41,42,44,49,50</sup>

Among the Saudi population, quite a few number of peer-reviewed original studies and research<sup>2,3,29–33</sup> or case reports<sup>41–50</sup> have investigated the RMCC of permanent canine as shown in Table 1. Most other original research studies that investigated the canine has been conducted outside the Saudi population<sup>20–26,52–60</sup> as presented in Table 2. Other papers, such as case report studies,<sup>51,61–67</sup> studied the RMCC among Western populations. Therefore, this review aimed to search studies in the form of original research and/or case reports on canine RMCC on the basis of Vertucci's classification<sup>19,34</sup> among Saudis. Then, the results were compared with studies from other countries. This study contributes to the structural knowledge prerequisite for a successful RCT.

## Materials and Methods

The current systematic review was constructed and designed according to the Preferred Reporting Items for Systematic Review and Meta-analysis.<sup>68–70</sup>

### Research Protocols and Eligible Criteria

The authors conducted the search plan using the state, context, and population framework to systematically review the RMCC of maxillary and mandibular canines among the Saudi population and compared the results with other international studies. The questions were “what is the root canal morphology and configuration of canines among the Saudi population?” and “is the canine RMCC among the Saudi population similar or different from the international schema in published research?” Hence, only local, or international cross-sectional studies or case reports that directly evaluated canine RCMC and data by CBCT were included. The inclusive criteria were studies published as original research and/or case report(s) from 2016 until January 2022 and conducted among Saudis; papers comparing the site/arch, sides, and data collected from CBCT technique; and studies published in English. Then, these papers were compared with international original studies and case reports.

### Search Method for Identification and Screening of Studies

All peer-reviewed original research articles on RMCCs were selected. PubMed, Science Direct, Scopus, Wiley Library, Google website search, and Web of Science were searched to identify the most relevant cross-sectional studies that assessed and measured the RMCC using CBCT. The first research question was “what is the root morphology and canal configuration of the canine tooth among the Saudi and international populations according to Vertucci's classification?” The second question was “what are the numbers of canals and roots in the maxillary and mandibular canines among the Saudi and international studies?” The search terms used were “maxillary and/or mandibular canine”, “root morphology”, “canal configuration”, “canal morphology”, “root and canal numbers”, “CBCT”, “dental colleges”, and “medical colleges.” The keywords were used individually or in combination using the Boolean operators “AND”, “OR”, and “NOT” to search for the terms “root morphology” and “canal configuration” independently. Two reviewers manually completed the search by assessing the selected journals that focus on dentistry, particularly on the RMCC of canines.

### Study Selection, Data Collection, and Data Items

Aside from the aforementioned criteria, this study also assessed papers published in English that used CBCT for data collection and any study that investigated the RMCCs according to Vertucci's classifications, as well as root and canal numbers among Saudi subjects. Then, the findings were compare with the findings of international studies, including original studies or case reports. Moreover, the site of the tooth/teeth and the numbers of canal(s) and root(s) were assessed. A researcher evaluated the validity and duplications of the studies. Studies that did not assess the RMCC, longitudinal studies, case-control studies, and systemic reviews were excluded. Articles that did not indicate the number

**Table 1** Original Articles of Canines with Variations in Arch, Gender, Root and Canal Numbers, and RMCC According to Vertucci's Classification Conducted at Saudi Arabia (n=7)

Researcher(S), Year/City	Sample Size & Arch	Gender	Number of Roots		Number of Canals		Canal Configuration According to Vertucci's Classifications					
			One Root N %	Two Roots N %	One Canal N %	Two Canals N %	I N %	II N %	III N %	IV N %	V N %	Others N %
Alshayban et al, 2022/ Riyadh <sup>32</sup>	592 Mandibular	Male	-	-	271 (95.8)	12 (4.2)	271 (95.8)	-	7 (2.5)	I (0.3)	4 (1.4)	-
		Female	-	-	295 (95.8)	14 (4.2)	296 (95.8)	-	9 (2.9)	I (0.3)	3 (1)	-
Iqbal et al, 2022/ Jouf <sup>33</sup>	570 Mandibular	Male	-	-	-	-	320 (56.1)	-	8 (1.4)	10 (1.8)	-	Missing I (0.1)
		Female	-	-	-	-	195 (34.2)	-	32 (5.6)	4 (0.7)	-	-
	570 Maxillary	Male	-	-	-	-	336 (58.9)	-	6 (1)	-	-	-
		Female	-	-	-	-	222 (38.9)	-	6 (1)	-	-	-
Almohaimede et al, 2021/ Riyadh <sup>29</sup>	694 Mandibular 634 Maxillary	Male	1328 (100.0)	-	1237 (93.2)	81 (6.8)	542 (95.9)	I (0.2)	7 (1.2)	-	10 (1.8)	-
		Female	-	-	-	-	718 (94.1)	13 (1.7)	16 (2.1)	-	14 (1.8)	-
	Mandibula	Mandibula	674 (97.1)	20 (2.9)	625 (90.0)	69 (10.0)	639 (92.1)	11 (1.6)	20 (2.9)	5 (0.7)	17 (2.4)	VII:2 (0.3)
		Maxillary	634 (100)	-	622 (98.1)	12 (1.9)	621 (97.7)	3 (0.5)	3 (0.5)	-	7 (1.1)	-
Alkahtany et al, 2020/ Riyadh <sup>30</sup>	298 Mandibular/Right	-	593 (99.1)	3 (0.9)	583 (97.8)	13 (2.2)	292 (98.0)	4 (1.3)	-	I (0.3)	I (0.3)	-
	298 Mandibular/Left	-	-	-	-	-	291 (97.7)	4 (1.3)	-	3 (1.0)	-	-
Al-Dahman,et al, 2019/Riyadh <sup>31</sup>	454 Mandibular	Male	209 (99.5)	I (0.5)	194 (92.4)	16 (7.6)	433 (95.4)	13 (2.6)	7 (1.8)	I (0.2)	-	-
		Female	244 (100)	-	239 (98.0)	5 (2.0)	-	-	-	-	-	-
Mashyakhy, 2019/ Jazan <sup>3</sup>	384 Maxillary	Male	184 (100.0)	-	180 (97.8)	4 (2.2)	180 (97.8)	-	4 (2.2)	-	-	-
		Female	200 (100.0)	-	200 (100.0)	-	200 (100.0)	-	0 (0.0)	-	-	-
Mashyakhy and Gambarini, 2019/ Jazan <sup>2</sup>	410 Mandibular	Male	195 (99.0)	2 (1.0)	184 (93.4)	13 (6.6)	184 (93.4)	-	11 (5.6)	-	-	V: 2(1.0)
		Female	204 (95.8)	9 (4.2)	188 (88.3)	25 (11.7)	188 (88.3)	-	14 (6.6)	-	-	V: 1(5.2)

**Table 2** Original Articles of Canines with Variations in Arch, Root, and Canal Numbers, and RMCC According to Vertucci's Classification Conducted Internationally (n=17)

Researcher(S), Year/Country	Sample Size and Arch	Number of Roots		Number of Canals		Canal Configuration According to Vertucci's Classifications					
		I Root N (%)	2 Roots N (%)	1 Canal N (%)	2 Canals N (%)	I N (%)	II N (%)	III N (%)	IV N (%)	V N (%)	Others N (%)
Yang et al, 2016/China <sup>20</sup>	3014 Mandibular	2988(99.2)	26 (0.8)	2972 (98.6)	42 (1.4)	2887 (95.8)	22 (0.7)	63 (2.1)	4 (0.1)	12 (0.4)	26(0.86)
da Silva et al, 2016/Brazil <sup>21</sup>	200 Mandibular	191 (95.5)	9 (4.5)	181 (90.5)	19 (9.5)	181 (90.5)	2 (1)	8 (4)	5 (2.5)	4 (2)	-
	200 Maxillary	200 (100)	-	200 (100)	-	200 (100)	-	-	-	-	-
Popovic et al, 2016/Serbia <sup>27</sup>	312 Mandibular	294 (94.2)	18 (5.8)	290 (92.9)	22 (7.1)	290 (92.9)	2 (0.6)	2 (0.6)	-	18 (5.8)	-
Soleymani et al, 2017/Iran <sup>22</sup>	300 Mandibular	269 (98.7)	4 (1.3)	297 (99)	3 (1)	269 (89.7)	11 (3.6)	17 (5.7)	-	-	3 (1)
Plascencia, 2017/Mexico <sup>23</sup>	32 Mandibular	30 (93.7)	2 (6.3)	18 (56.3)	14 (43.7)	30 (93.7)	-	1 (3.1)	-	1 (3.1)	-
Haghanifar et al, 2017/Iran <sup>24</sup>	368 Mandibular	365 (99.2)	3 (0.8)	356 (96.7)	12 (3.3)	359 (97.6)	-	-	-	9 (2.4)	-
Martins et al, 2017/Portugal <sup>25</sup>	1200 Mandibular	1166 (97.2)	34 (2.8)	1082 (90.2)	118 (9.8)	40 (3.3)	17 (1.4)	32 (2.7)	-	28 (2.3)	Other: 1 (0.1)
Raman et al, 2017/India <sup>26</sup>	50 Mandibular/Left	39 (78)	10 (20)	39 (78)	10 (20)	39 (78)	39 (78)	-	10 (20)	-	Missing: 1 (2)
	50 Mandibular/Right	42 (84)	7 (14)	42 (84)	7 (14)	-	-	7 (14)	-	-	Missing: 1 (2)
Basha S, 2018/Egypt <sup>28</sup>	100 Mandibular	-	-	-	-	92 (92)	-	3 (3)	-	5 (5)	-
Naseri et al, 2019/Iran <sup>53</sup>	33 Mandibular	31 (93.9)	2 (6.1)	31 (93.9)	2 (6.1)	31 (93.9)	-	2 (6.1)	-	-	-
Pan et al, 2019/Malaysia <sup>54</sup>	411 Mandibular	406 (98.8)	5 (1.2)	386 (93.9)	25 (6.1)	386 (95.1)	20 (4.9)	-	-	-	-
Doumani et al, 2020/Syria <sup>55</sup>	418 Mandibular	409 (97.9)	9 (2.1)	401 (95.9)	17 (4.1)	401 (95.8)	3 (0.8)	13 (3.2)	-	1 (0.2)	-
Karobari et al, 2020/Malaysia <sup>56</sup>	1702 Mandibular	1696 (99.6)	6 (0.4)	1544 (90.7)	158 (9.3)	1544 (90.7)	3 (0.2)	140 (8.2)	-	12 (0.7)	Other: 3 (0.2)
Kulkarni et al, 2020/USA <sup>57</sup>	259 Mandibular	259 (100)	-	220 (85)	39 (15)	220 (85)	36 (14.0)	3 (1.0)	-	-	-
Sroczyk-Jaszczynska et al, 2020/Poland <sup>58</sup>	100 Mandibular/left	92 (92)	8 (8)	83 (83)	17 (17)	82 (82)	4 (4.0)	4 (4.0)	1 (1.0)	8 (8.0)	-
	104 Mandibular/right	100 (96.2)	4 (3.8)	90 (88.2)	11 (10.8)	90 (88.3)	-	4 (3.8)	-	6 (5.9)	VI: 4 (0.98)
				3 roots: 1 (0.98)							
Leal Silva et al, 2021/Brazil <sup>59</sup>	4805 Mandibular	4690 (97.6)	115 (2.4)	4290 (89.3)	515 (10.7)	4282 (89.1)	76 (1.6)	320 (6.7)	5 (0.1)	116 (2.4)	VII: 6 (0.1)
Talabani et al, 2021/Iraq <sup>60</sup>	299 Mandibular/Left	293 (97.9)	6 (2)	266 (88.9)	33 (11)	266 (88.4)	14 (4.6)	12 (4)	-	7 (2.3)	-
	299 Mandibular/Right	292 (97.6)	7 (2.3)	264 (88.2)	35 (11.7)	263 (87.9)	15 (5)	12 (4)	-	9 (3)	-

of subjects and participants or whose specimens had been partly evaluated in other clinical or laboratory studies were also excluded. Two investigators (Al M.M and M.Y) individually read all the titles and abstracts and carefully evaluated them. The researchers had to agree whether each study was related to the study questions. Finally, 38 studies were included, including 15 locally published papers and 18 international studies.

## Data Extraction and Analysis

The data from each study were extracted using unique tables designed by the investigators. The information included the author(s)' name(s), year of publication, name of city or country, sample size, gender, arch, number of roots, number of canals, RMCC according to Vertucci's classification, side, and clinical findings.

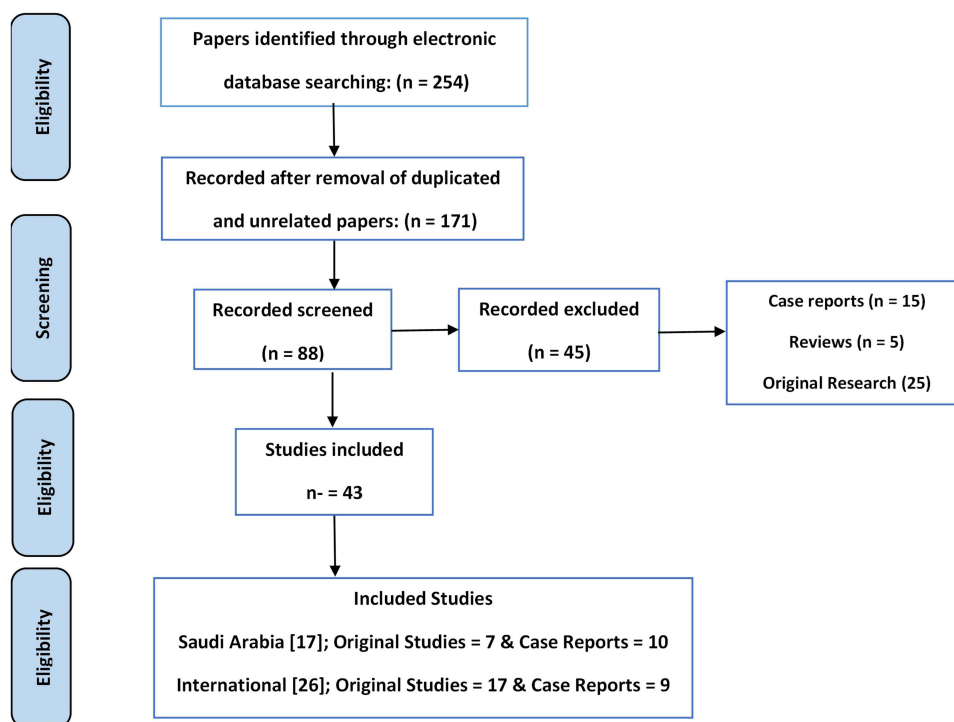
## Results

### Study Selection

A total of 254 studies were gathered and analyzed, of which 171 were excluded because they were duplicates or not related to the present systematic review. Among the 88 remaining papers, 50 were further excluded, because they were not related to the question of the review. Finally, 42 studies (17 local studies [7 original studies and 10 case reports] and 26 international studies [17 original studies and 9 case reports]) were involved in this review (Figure 2). All extracted data are summarized in Tables 1 and 2.

### Study Characteristics and Quality of the Included Studies

The value of the involved published original research and case reports studies was evaluated using the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology.<sup>68–70</sup> For the Saudi studies, five studies had good quality, whereas most of the case reports were had low or fair quality. The international studies in both forms as original and/or case reports papers were good quality reports. All of the original studies used CBCT in studying RMCC, whereas 80% and 70% of the local and international case studies were diagnosed with CBCT, respectively. All studies



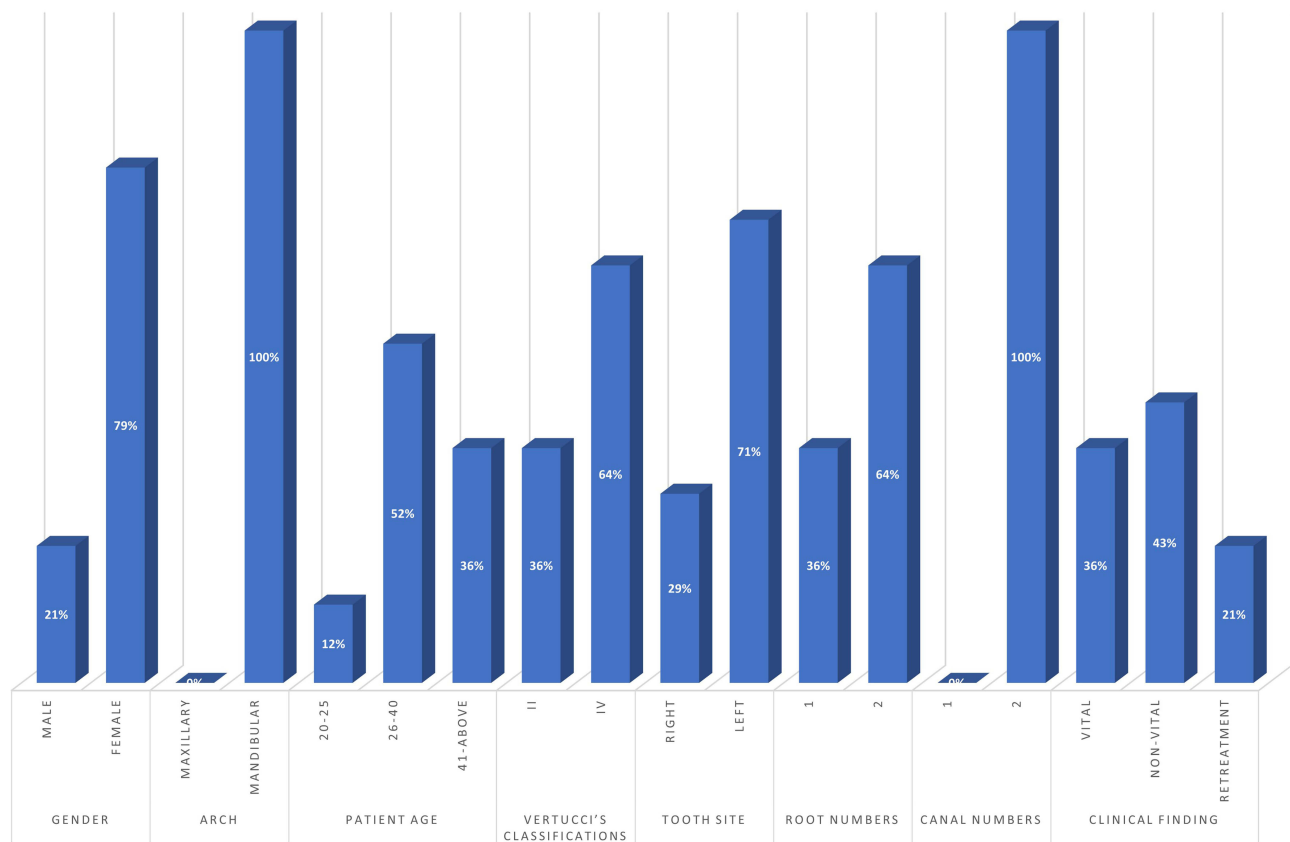
**Figure 2** Flowchart of the study selection process based on the Preferred Reporting Items for Systematic Review and Meta-Analyses.

were assessed and checked by two investigators (Al M. M and M. Y) who independently screened the published articles and assessed the risk of bias.

## Data Synthesis of Results

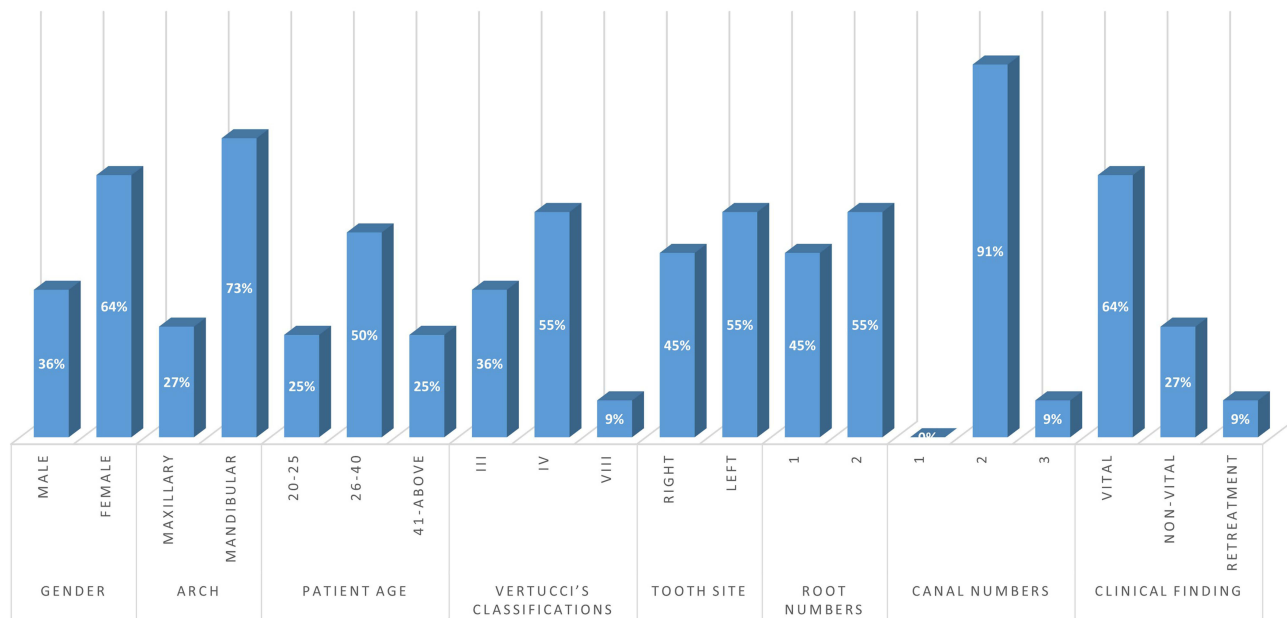
All the papers and research included herein were cross-sectional in nature, studied *in vivo*, and in the form of case reports, and most of them used CBCT. The Saudi original research recorded that 100% of cases had one root and one canal in the maxillary arch, but the percentages of mandibular canines with one root and one canal were 98.4% and 94.1%, respectively. According to Vertucci's classification, Class I had the highest percentages in the maxillary and mandibular arches at 98.3% and 95.8%, respectively followed by class III at 0.7% and 1.9% for the same arches, respectively (Table 1).

The Saudi case reports revealed that 79% of cases were recorded in females, 100% were found in the mandibular arch, 64% were Vertucci's class IV, whereas the remaining cases were class II. Among the reported cases in the mandibular arches, 71% were in the left side, 64% had two roots, and 100% had one canal; the non-vital was the common cause of RCT of canine and documented in 43%, followed by 36% of teeth with vital pulp (Figure 3). All maxillary canines had one canal and root and classified as Vertucci's class I in the international studies. The percentages of the canines with one canal and root were 92.3% and 98%, respectively; Vertucci's class I had the highest percentage (91.1%), followed by class III (4.7%) (Table 2). In the international case reports, the percentage of males to females were 36%–64%. Among the mandibular canines, 73% were found on the left side, 55% had two roots, 91% had two canals, and 64% were vitally treated. The frequency of Vertucci's classes III, IV, and VIII were 36%, 55%, and 9%, respectively (Figure 4).



**Figure 3** Previous published Saudi case reports of canines with variations in gender, arch, root and canal numbers, and RMCC according to Vertucci's classification (n=10).





**Figure 4** Case reports of canines with variations in gender, tooth type, side, root and canal numbers, and RMCC according to Vertucci's classification in other countries (9 studies and 11 tooth).

## Discussion

Populations with different demographic origins may have variations in tooth morphology.<sup>71,72</sup> Since the 1870s, the literature has documented various studies on the anatomy of the RCS of teeth in different populations using various and improved analytical techniques.<sup>73,74</sup> Most of these methods involve an invasive procedure that can alter the actual morphology of the canal.<sup>75</sup> Recent studies have used computed tomography, a noninvasive 3D imaging, as it is an accurate diagnostic means for the effective diagnosis of RCMCs.<sup>22,29-31</sup> Dentists must be aware of the anatomical changes of the RCSs to avoid procedural errors caused by a lack of knowledge and to ensure the success of RCT.<sup>73,74</sup> Therefore, knowledge of RMCC is one of the most important keys to successful RCTs. Each type of tooth has common characteristics through which the operator can determine the initial access position and the size of the first file to be used; this approach could be used to deal with any problems that arise during treatment. The canine's role in mastication is tearing, mediating between the incision of the anterior teeth and the grinding of the posterior teeth.<sup>76</sup> CBCT was chosen as the assessment tool in the present study, because it is a reliable resource for analyzing the prevalence of RC configuration and is currently considered the most reliable clinical approach for estimating the proportion of individuals presenting a specific RMCC.<sup>77,78</sup>

Canines are very long and stable teeth with two canines each in the maxilla and mandible at the corner of the mouth, which is why they are called the "cornerstones" of the dentition. Typically, a canine has a single pointed cusp, also called a cuspid, and presents with a single root and RC; canines have the most number of dens invaginatus or dens in dente variations.<sup>79</sup> The present study was designed and conducted as a systematic review aimed at analyzing the root and RC configuration of maxillary and mandibular canines in the Saudi population based on available anatomic prevalence studies using CBCT and then compared the findings with international studies.

Mandibular canines usually have a single root with a single RC.<sup>7,8</sup> However, they can have double roots.<sup>43,45-48,56</sup> After a qualitative summary of the included studies, the results identified similarities and differences among the subpopulations analyzed. The results of the current systematic review showed that 98.4% and 100% of maxillary and mandibular canines respectively have a single root, whereas double root was observed only in 1.6% of mandibular canines. However, the prevalence of two-rooted maxillary canines in the Saudi population in this study was 0%. This finding suggests that the existence of two roots in maxillary canines is infrequent. In Iranian populations, the rates of



mandibular canines with two roots found by Aminsobhani et al and Rahimi et al that were 4.7% and 12.08% higher than those observed in the present study, respectively.<sup>80,81</sup> However, our rates were higher than those of Zhao et al (0.7%) among the Chinese population,<sup>82</sup> Singh and Pawar in the South Asian Indian population (0%),<sup>83</sup> Zhengyan et al (0.8%) in the Chongqing population,<sup>20</sup> Pan et al (1.21%) in the Malaysian population,<sup>54</sup> and Soleymani et al (1.3%) among the Iranian population.<sup>22</sup>

Concerning Vertucci's classification among maxillary canines, our study showed that type I canal configuration was observed in 98.3%, followed by types III and V (0.7%). These results differ from a study conducted by Amardeepet et al in the Indian population, in which type I was found in 74.5% of cases, followed by type III (11.6%).<sup>75</sup> In another study among the Malaysian population, a type I canal configuration was found in all maxillary canines examined (100%).<sup>54</sup> The present study recorded that type I canal configuration was found in most mandibular canines (95.8%), followed by type III (1.9%) and Type II (1.1%). Our findings are inconsistent with a study by Wolf et al in the German population, in which type I was presented as 74.5%, followed by 14.3% for the type II class.<sup>84</sup> These results differed from other studies, in which type I prevalence was reported as 81.5% in the Mexican population,<sup>1</sup> 80.4% in the Turkish population,<sup>66</sup> 95.4% in the Hamadani population in Iran,<sup>85</sup> and 92% in the South Asian Indian population.<sup>83</sup> These differences in RMCC can be attributed to racial differences in patients even within the same population, which is considered an important factor that can affect clinicians' perceptions of anatomical suspicion about RMCCs.<sup>39</sup>

The present study reported differences in root and canal numbers between genders. Notably, 79% of case reports conducted in the Saudi population that are reported in this review were females with two roots and two canals in mandibular canines. Interestingly, Martinns et al and Mancino and Kharouf reported findings that coincide with these results, that is, females have considerably more roots and RCs in mandibular canines than males.<sup>40,52</sup> On the contrary, Soleimani et al<sup>22</sup> reported that mandibular canines with two roots and two canals are much more common in male than in females. The differences and inconsistencies in the results can be explained by regional differences and differences due to anonymous analysis, race, and the populations investigated.

The present review also investigated bilateral symmetry, as 71% of the two canals were located on the left side in comparison with 29% on the right side in all local case reports, which indicates asymmetry in canal number. These findings are inconsistent with studies carried out among Iranian populations, which reported a high probability of bilateral symmetry of 95.4% in the number of roots and canal configuration.<sup>22</sup> Moreover, similarities in RCMC were recorded in a local study conducted by Alkahtany et al<sup>30</sup> and among studies conducted outside Saudi Arabia by Raman et al and Sroczyk-Jaszczynska et al in India and Poland, respectively.<sup>26,58</sup> Finally, no similarities were documented in the clinical findings among the local (36%) and international case reports (64%). This finding could be explained by the regularity of dental check-up and follow-up appointments, as well as proper charting, diagnosis, and treatment plan for each patient during the first visit to dental clinics.

We could not make a comparison between gender in relation to canals or root number and Vertucci's classification because published research and case reports locally and internationally that deal with gender specification are limited. Other drawbacks may be related to the similarity of the root and canal numbers between the right and left sites and sides of the face.

## Conclusions

The following conclusions can be drawn within the limitation of this systematic review. Saudi original research recorded that almost 100% of maxillary canines had one root and one canal, whereas 98.4% and 94.1% of mandibular canines had one root and one canal, respectively. Vertucci's class I had the highest percentages in the maxillary and mandibular arches at 98.3% and 95.8%, respectively, followed by class III at 0.7% and 1.9%, respectively. International studies recorded that 100% of maxillary canines had one canal and root, and the percentages for single canal and single root in the mandibular arch were 92.3% and 98%, respectively. Vertucci's class I was found in 100% of the maxillary arches, and Vertucci's classes I and III had percentages of 91.1% and 4.7% in the mandibular arches, respectively. This review reports and confirms the symmetry in the RMCCs of maxillary and mandibular canines between Saudi studies and other populations. Moreover, Vertucci's classes I and III were the most frequent RMCCs, and two-rooted canines were considerably less frequently than single-rooted ones in both arches.

## Disclosure

The authors report no conflicts of interest in this work.

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