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INVESTIGATION OF ROOT CANAL ANATOMY OF MANDIBULAR PERMANENT CANINE IN EGYPTIAN SUBPOPULATION: A CONE-BEAM COMPUTED TOMOGRAPHY STUDY

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ABSTRACT

Introduction: The aim of this study was to investigate the root and root canal anatomy of mandibular canine in Egyptian subpopulation.

Methods: 1000 CBCT scans of completely erupted mandibular permanent canines were acquired from Egyptian patients, The number and percentages of roots, canals, and types of canal morphology were then examined in teeth utilizing Vertucci's classification**.**

Results: the percentage for mandibular canine with two roots was very small (1.2%), the percentages for a two root canals mandibular canine was 21%, Vertucci type V recorded the highest percentage (7.8%), followed by type II (6.6%), then type IV(4.9%) and the least percentage configuration was type III (1.7%).

Conclusion: Different studies on different population and even on the same populations yielded variable results, therefore the existence of all possibilities for extra roots and extra canals should be always kept in mind. CBCT scan is a must in any case with suspected unusual anatomy, to avoid any mishaps.

Clinical implications: Even though one root mandibular canine with Vertucci type I recorded the highest prevalence, two rooted mandibular canine and one root with two root canals does occur and should be considered during root canal treatment of this tooth.

KEY WORDS: root canal anatomy, mandibular canine, CBCT, Egyptian subpopulation.

INTRODUCTION

Human teeth have a vast range of forms and anatomical configurations that are closely linked to genetic aspects, ethnicity, and geographical origin[1]. It is critical to understand the internal morphology of all teeth, as many roots with very simple exterior surfaces may conceal a more complex root canal structure. Therefore, in order to attain effective

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results, comprehensive thorough knowledge of the complexity of tooth anatomy and root canal system morphology is crucial to achieve successful root canal debriding, shaping, and filling during endodontic treatment[2]. Indeed, a lack of awareness of the three-dimensional (3D) root canal system morphology can lead to an inability to recognize or treat all root canals, jeopardizing comprehensive pulp removal and thorough disinfection, and ultimately leading to treatment failure[3].

For the examination of internal root canal anatomy of teeth, practitioners typically rely on intraoral radiographs, which only offer a two-dimensional representation of a three-dimensional object and are also known to have several drawbacks such film distortion and superimposition[4]. Numerous approaches, such as tooth clearing and staining techniques, tooth sectioning, and microscopic viewing, have all been employed for the analysis of root canal anatomy over the past years[5]. All of these invasive techniques are only used for in vitro investigations on extracted teeth. Recently, research on root canal morphology have used micro computed tomography (micro-CT), which offers amazing internal anatomical imaging and reproduction[6]. Indeed, Micro-CT itself is only suitable for lab research due to the high radiation dose and therefore is not appropriate for daily endodontics or studies which aim to assess differences in root canal morphologies among different populations of different ethnicities, also it requires a very long processing time which limits the inclusion of a large sample size required for prevalence studies[7]. Cone beam computed tomography (CBCT) instead, is a precise non-invasive radiographic machine for assessment of the external and internal anatomy of the jaw and teeth in three planes without artifacts of the overlying anatomical structures. It offers numerous advantages, including lower radiation exposure when compared to conventional or medical CT, greater accuracy than standard 2D radiography, better picture resolution, automated image processing and documentation, and ergonomics[8].

Permanent mandibular canines usually have a single root and a single canal. However, there is variation in canal anatomy, with additional canals or roots in the mandibular canine located in the buccal and lingual orientations, with diverse canal configurations that can vary greatly depending on ethnicity, race, and gender[9]. If a second canal is present, the success of the endodontic procedure will be compromised by negligence to locate, debride, and seal it. As a result, improper management of the second canal, which is typically the lingual canal, is one of the leading causes of endodontic treatment failure in the mandibular canine[10]. Several studies in various populations have shown that there are many variations in the predominance of the two canals in mandibular canines. Therefore, the purpose of this study was to use cone beam computed tomography (CBCT) to document the in vivo prevalence of the number of roots, root canals, and root canal morphology according to vertucci classification for mandibular canines in an Egyptian subpopulation.

MATERIALS AND METHODS

This research was approved by the research ethics committee at Suez Canal University(666/2023).

Overall,1000 CBCT scans of completely erupted mandibular permanent canines were acquired from Egyptian patients (619 men and 381 women) who visited the Suez Canal University Faculty of Dentistry in Ismailia, Egypt, between 2020 and 2023. For a variety of dental treatment plans (orthodontics, endodontics, surgery, and implant). The patient's age ranged from 18y to 74y.

The exclusion criteria for teeth were previously treated root canals, calcification, internal or external resorption, caries or restoration, intracanal post, and distorted CBCT images.

For image assessment using CBCT, CS9300 3D digital imaging system was used. Technical specifications were as follows: voxel size was 75–600 μm, with small or large field of view (FOVs), the slice thickness was 0.2mm viewed from the coronal to apical region, and the exposure time was 3–15

seconds according to the manufacture (Carestream Dental LLC, USA).

The number of roots, canals, and types of canal morphology were then examined in teeth utilizing Vertucci's classification[11]:

Type I: From the pulp chamber to the apex, a single canal extends.

Type II: After leaving the pulp chamber on their own, two independent canals combine to exit as a single canal.

Type III: One canal exits the pulp chamber, splits into two within the root, then reunites to exit as a single canal.

Type IV: Two unique canals emerge from the pulp chamber as two distinct canals.

Type V: One canal exits the pulp chamber and splits into two distinct canals before emerging from the body of the root.

Type VI: Two canals split apart after joining within the body of the root and exiting as two separate canals.

Type VII: A single canal emerges from the pulp chamber, splits, reunites, and then redivides to form two distinct canals.

Type VIII: 3 distinct canals emerge from the pulp chamber as three independent canals.

RESULTS

Data were collected and arranged according to each type of Vertucci classification**.** The percentage for the number of roots and types of root canals were recorded. Single rooted mandibular canine recorded 98.8%, while two rooted canine recorded 1.2%. Regarding the number of canals within one root according to Vertucci, Type I revealed 79%, and 21% for the two canalled mandibular canine represented as type V 7.8%, type II 6.6%, type III 1.7% and type IV 4.9%. **Tables (1-3) & Figures (1-5).**

TABLE (1) Showing the number/percentage of roots in mandibular canine

Total of 1000 patients	**One Root**	**Two Roots**
	988 (98.8%)	12 (1.2%)

TABLE (2) Showing Root canal configuration of mandibular canine

Canal type (Vertucci)	**Numbers/1000**	**Percentage**
I	790	79%
II	66	6.6%
III	17	1.7%
IV	49	4.9%
V	78	7.8%
Total	**1000**	**100 %**

TABLE (3) Showing the number/percentage of Female/Male in this study

Total of 1000 patients	**Female**	**Male**
	619	381

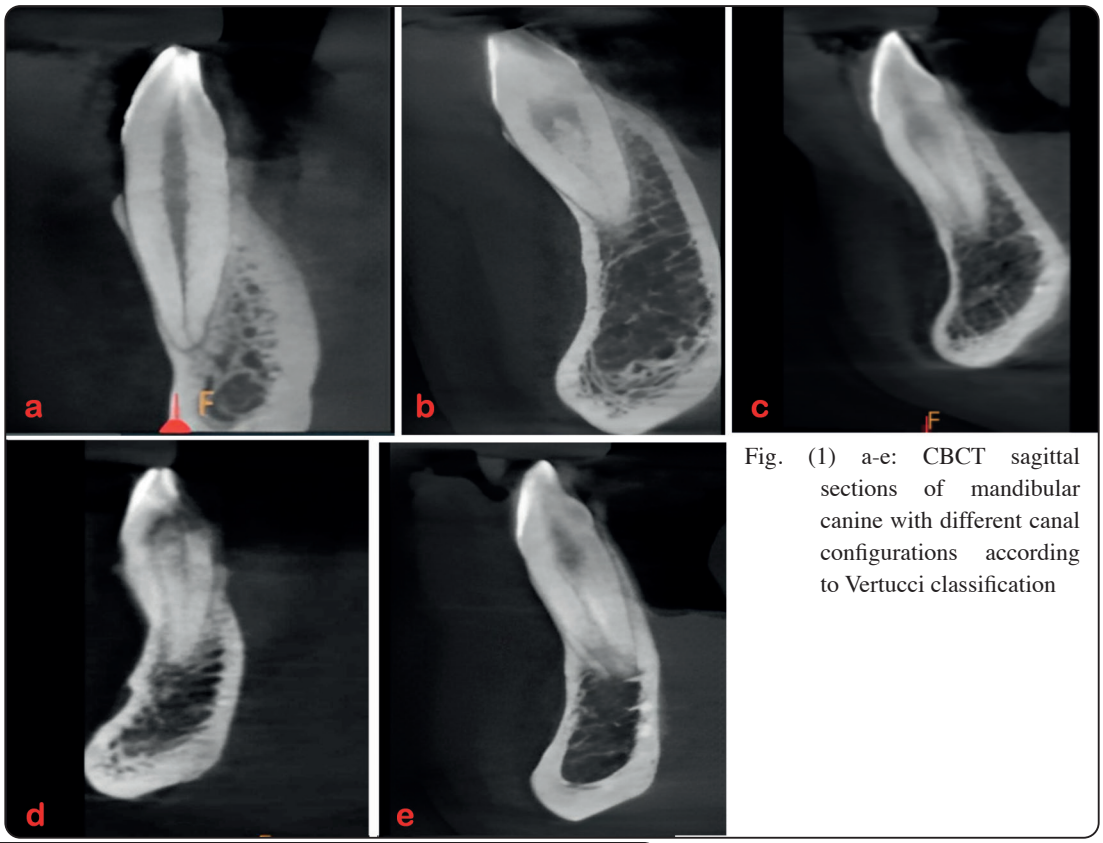

Fig. (1) a-e: CBCT sagittal sections of mandibular canine with different canal configurations according to Vertucci classification

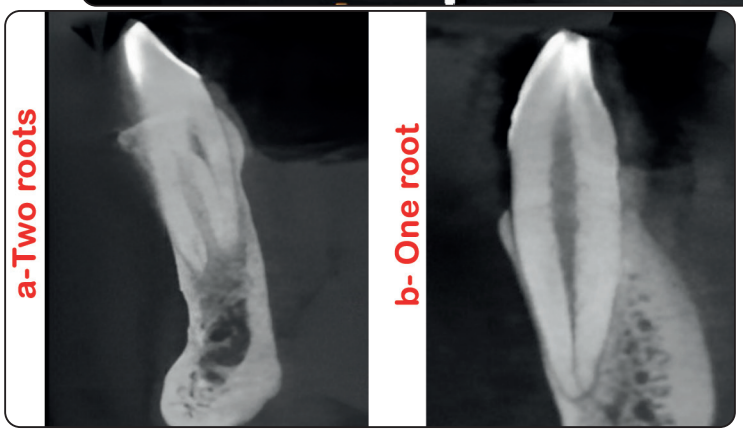

Fig. (2): CBCT Sagittal sections of mandibular canine showing two roots (a), & one root (b)

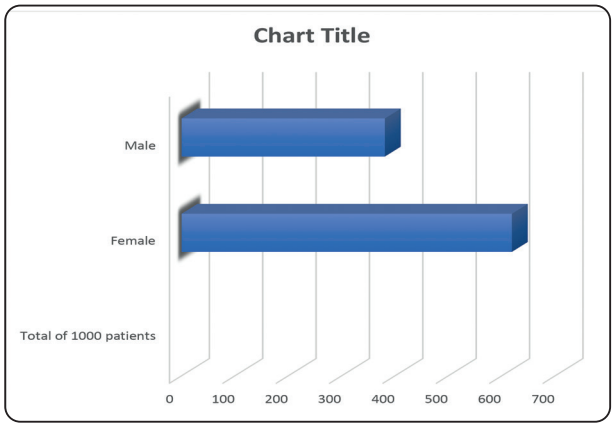

Fig. (3): Bar chart Showing the number of Female/Male in this study

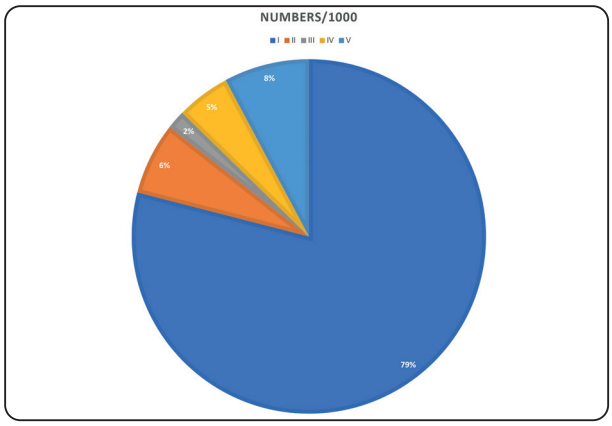

Fig. (4) pie chart showing percentage of different Root canal configurations of mandibular canine

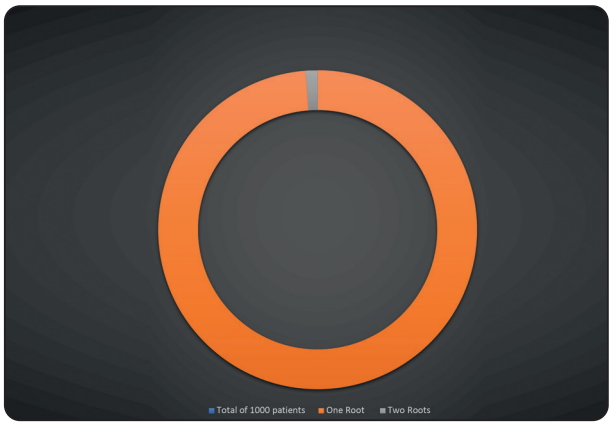

Fig. (5) bar chart showing the number of roots in mandibular canine

DISCUSSION

External and internal root canal anatomy of teeth is one of the complex structures of the human body, the same tooth represents different internal anatomical configuration with variable percentages. The prevalence of certain root canal configuration seems to be similar among people of the same ethnicity[12]. Thorough recognition of all the possible configurations of root canal anatomy specific for each tooth is the cornerstone for achieving successful root canal treatment. Missed lingual canal is a common cause of failure of root canal treatment of mandibular canine [13], as the second lingual canal is usually a narrow slit lying under the lingual shoulder, therefore a proper lingual extension is a must to gain access to this canal[14].

The prevalence of two roots in mandibular canine in Egyptian subpopulation in the current investigation was very small (1.2%), which is comparable to other studies on different ethnicities : 2.6% in Saudi Arabian subopulation[15], 2.8% in a Portuguese study[16], 1.2 % in Malaysian study[17], 1.3% in Iranian study[18], 0.8% in Chinese subpopulation[19], and 1.7% in Indian subpopulation[20]. While a North American study reported 100% for one root mandibular canines[21]

Mandibular canines were mostly taken for granted as one canal before the wide spread of CBCT and the presence of a second canal was the odd, and cases with two canals were most often published as case reports[22]. CBCT is a reliable noninvasive tool for identification of the complex root canal anatomy as it allows three-dimensional visualization of the tooth in sections which is highly correlated to histological tooth sections[23].

The results of the current investigation demonstrated a relatively high percentage 21% for an overall two-root canals anatomy in mandibular canines in this Egyptian subpopulation compared to other CBCT studies on different populations, where a study on 200 Iranian subjects showed overall 2.4% for a second canal[24]& 10.3% in 300 Iranian subjects[18], another study on 2828 Turkish subpopulation had a 6.1%[25] , while martin et al 2018[26] disclosed 9.8% in a Portuguese study with sample size 670 with similar percentage of 9.5% in a Brazilian study by Silva et al., 2016[27] & 10.9% in another Brazilian study[28] , 22.2% in Iraqi 1794 subpopulation[29]. In a micro–Ct Swiss German study on 101 mandibular canines of which 98 single rooted mandibular canines had 7.84% two canals and 3 teeth had two roots[30], 4.3% in 592 Saudi subpopulation[31] and 2.52% in another 952 Saudi subpopulation[32], 10.2% in 697 Saudi subpopulation[33], 15% in 259 north

American sub population[21]. 4.9% of 411 Malaysian subpopulation[17] & 9.3% in1702 Malaysian subpopulation[34]. However, a study on a Brazilian subpopulation showed 22% for a second canal in mandibular canine[35] and another study on Georgian populations reported 31.8 % for a second canal[36].

Two root canals in one root can exist with different configuration which requires special attention from the operator, as the two canals can start the journey inside the root canal at the floor of the pulp chamber from one or two orifices and can exit the root from one or two foramina, the percentage of different configurations in the current study according to vertucci classification was the greatest for type V (7.8%), followed by type II (6.6%), then type IV(4.9%) and the least percentage configuration was type III (1.7%). This comes in harmony with polish[37], Serbian[38], Iranian[24], and Iraqi[39] studies, in which each population respectively recorded the highest percentage for type V. On the other hand, Type V was the least in a study on Syrian population[40], and in other studies on Indian[41], Chinese[19], Portuguese[16],Iranian[18], Malaysian[34], Saudi Arabian[42] and Brazilian[27] populations type III recorded the highest percentage.

Studies on root canal anatomy of mandibular canine in Egyptian population is scarce, one study[43] examined a very small sample size (15 mandibular canines), even though they showed approximated percentage to our study for a second canal 33.3% with 13.3% for Vertucci type III, 13.3% IV and 6.7% V, this sample size cannot reflect a prevalence in a subpopulation. Another study[44] evaluated mandibular anterior teeth bilaterally in 100 patients with contradictory results to the present study as they concluded a 100% for Vertucci type I for mandibular canines with total absence of a second canal[44], this could be attributed to the sample size which is one tenth of the current study sample size.

It could be noticed that different studies on different population and even on the same populations yielded variable results, therefore the existence of all possibilities for extra roots and extra canals should be always kept in mind and not excluded even if it was not previously reported. CBCT scan is a must in any case with suspected unusual anatomy to avoid any mishaps such as missed canal, overextension, perforation and fractured instrument[45].

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