(e) ISSN Online: 2321-9599

(p) ISSN Print: 2348-6805

ORIGINAL ARTICLE

Evaluation of Root canal morphology of mandibular canines by CBCT in Kashmiri population- An in vitro study

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ABSTRACT

Introduction: This study was conducted to assess the morphology of mandibular canines using cone-beam computed tomography (CBCT) in a Kashmiri population. **Methodology:** A total of 200 permanent mandibular canines were selected and scanned using CBCT. The anatomy of root was evaluated for the following parameters: the pattern of the root canals, anatomic length of the crown and the root, the presence of accessory canals, the shape of the access cavity, the position of the apical foramina. ***Results***: In present study the mandibular canines showed various canal patterns like Type I (82.2%), Type II (4.2%), Type III (10%), and Type V (2%) based on Vertucci's [2] classification. In addition to this, four of the mandibular canines (1.6%) had a (2-1-2-1) canal configuration which is Type XIX. **Conclusion**: The root canal anatomy of permanent mandibular canines varied widely in an Kashmiri population.
Key words: Mandibular canines, Root canal.

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This article may be cited as: Bhat SA, Bhagat RK, Misgar OH. Evaluation of Root canal morphology of mandibular canines by CBCT in Kashmiri population- An in vitro study. J Adv Med Dent Scie Res 2016;4(6):321-324.

INTRODUCTION

A thorough knowledge of the root canal morphology and its variations is an indispensable prerequisite for the success of the root canal treatment. Many roots have additional canals and a variety of canal configurations. Occasionally during the formation of a root, a break develops in Hertwig's epithelial root sheath producing a small gap. This results in "accessory canals" and can be formed anywhere in the root, leading to periodontal-endodontic communication [1]. From the past to more recent, studies on root canal anatomy and its variations has been often reported [2–3]. Hence, a comprehensive understanding of the root canal morphology and its aberrations dictates the final results of the root canal procedures.[4, 5]

Canines are universally referred to as the "cornerstone" of the dental arches. Both maxillary and mandibular canines have canine eminence on their labial portion of the teeth which has a cosmetic value. Aesthetically, they help in normal facial expressions at the "corners" of the mouth. Functionally, the shape and position of the canines play a major role in intercuspal positioning by "canine guidance" [6]. Usually a single-rooted permanent canine is considered to have a single canal. Recently, researchers have shown that the root canal anatomy of permanent canines shows variations.[7, 8]

The morphological study of root canals can be performed through different ways, including staining and tooth clearing, tooth sectioning, conventional radiography, digital radiography and conventional computed tomography (CT) [9, 10]. The ideal technique is the one that is accurate, simple, non-invasive and capable of in vivo application [9]. Cone-beam computed tomography (CBCT) has become a successful tool to explore the root canal anatomy [11, 12]. Neelakantan et al. [13] had concluded that CBCT is an accurate as modified canal staining and clearing technique which is a gold standard in identifying root canal anatomy. The main benefits of this technique include producing three-dimensional images compared to conventional radiography, being non-invasive, reducing superimpositions in intra oral and extra oral anatomies and their surrounding structures and lower radiation doses and costs compared to conventional CT [14-17]. Many studies have noted the effect of ethnicity on the anatomic diversity of root canals, and since studies on morphological assessment of mandibular canines on Kashmiri population using CBCT are limited, the present study was conducted to investigate the morphological diversity of mandibular canines using CBCT in a Kashmiri population.

MATERIALS AND METHODS:

The present study evaluated the three dimensional CBCT images of 200 completely erupted mandibular canines belonging to 200 patients with a mean age of 37.5 years that visted dental section of District hospital Kulgam Kashmir over a one-year period. Only the canines with no endodontic treatments were examined. CBCT images that fulfilled the following criteria were selected: high-quality CBCT images that showed mandibular canines with completely erupted roots, untreated root canals, absence of coronal or post-coronal restorations, absence of periapical lesions and root resorptions.

All the teeth were dried and mounted longitudinally on a modeling wax sheet (The Hindustan Dental Products Pvt Ltd. India). Then, the teeth were scanned by a CBCT scanner (Sirona Dental System) using SICAT Galileo

Implant version 1.8 software. The three-dimensional (3D) resolution (isotropic voxel size) was about 0.3 mm, and the spherical imaging volume was 15 cm with a magnification set at 1:1 ratio along with a reconstruction time of 2.5–4.5 s. The scan setting was done at 85 kVp, 42 mAs with an exposure time of 14 s. The software was also used for volumetric rendering of the 3D images through selective integration and measurement of adjacent voxels (all voxels are isotropic) in the display. The objects within the volume were then accurately measured in different directions.

The anatomic length of the root was measured in sagittal and axial planes from the CEJ to the apex. The position of each apical foramen was classified as central (at the tip of the root apex) or lateral (away from the tip of the root apex or off-centered). The root curvatures were evaluated in three plans. The inter orifice distance between two canals or two roots was measured from the edge of one canal to the other in the axial plane using a ruler software. The prevalence of each Vertucci type was determined through evaluating the sagittal and axial planes. The following information was recorded and analyzed: The root canal pattern, the number of canals and roots for each canine, the possibility of morphological bilateral symmetry, the foramen and root curvature positions, the distance between two root canal orifices of the mandibular canines with two root canals and the anatomical length of the root.

The data were analyzed in SPSS software (SPSS version 20.0, SPSS, Chicago, IL, USA) using the Chi-squared test and the t test. The level of statistical significance was set at 0.05.

RESULTS

Root Canal Patter: In present study the mandibular canines showed various canal patterns like Type I (82.2%), Type II (4.2%), Type III (10%), and Type V (2%) based on Vertucci's [2] classification. In addition to this, four of the mandibular canines (1.6%) had a (2-1-2-1) canal configuration which is Type XIX as per Sert and Bayirli's [4] classification (Figure 1). Results are tabulated in Tables 1 and 2 in comparison with earlier studies on maxillary and mandibular canines

Anatomic Length of Crown and Root. The average anatomical length of the crown and root of mandibular canines, was 10.1mm and 16.9 mm, respectively

Apical Foramina. In mandibular canines, the apical foramina were centrally located in 36.2% of the samples and laterally located in 63.8% of the samples.

Table 1

Position of the accessory canals from the root apex.

Distance from the apex	Mandibular canine (n = 200)
<0.5mm	8
0.5mm to 1mm	15
1mmto 1.5mm	2
1.5mm to 2mm	2
Total number of teeth with accessory canals	27(13.5)
Total number of teeth without accessory canals	173(86.5)

Shape of the access cavity at cementoenamel junction in cross-sectional view.

Shape	Mandibular canine (n = 200)	
	number	percentage
Round	38	19
Oval	92	46
Long Oval	37	18.5
Flattened	33	16.5

Root canal patterns in mandibular canines in % (n = 200)

Authors	Population	Technique	No of Teeth	Type I	Type II	Type III	Type IV	Type V	Additional Type
Vertucci [2]	USA	Clearing and staining	100	78	14	2	6	-	-
Pineda and Kuttler [3]	MEXICO	Radiographs	187	81.5	13.5	-	5	-	-
Çalış kan et al. [11]	TURKEY	Clearing and staining	100	80.39	3.92	13.73	-	1.96	-
Sert and Bayirli [4] (Men) (Women)	TURKEY	Clearing and staining	100	90 62	9 22	- 13	- 3	- -	- -
P'ecora et al. [12]	BRAZIL	Clearing and staining	830	92.2	4.9	-	9.2	-	-
Present study	INDIA	CBCT	200	82.2	4.2	10	-	2	1.6

DISCUSSION

The very important thing is to identify and manage root canal variations. A complete knowledge of tooth morphology, careful interpretation, adequate access, and exploration of the tooth are prerequisites for successful root canal treatment [19]. The present in vitro study focuses on the root canal anatomy of human permanent mandibular canines to overcome problems relating to cleaning and shaping.

Differences in methodologies to study the morphology of the teeth account for highly variable results. In the past, various methodologies used to study canal anatomy were histopathological studies [18], intraoral periapical radiographs [20], clearing and demineralising method [21], and surgical operating microscopy [22].Most of these methods involve an invasive procedure which might alter the actual canal morphology. Images captured by intraoral radiographs are only two-dimensional. Recently, studies have been reported using computed tomography, which is a noninvasive technique and provides three-dimensional imaging. Studies have been reported in the literature using spiral computed tomography [23].Whilst it had drastically reduced scan time and effective dosages, they were not as accurate and did not limit the dosage as low as could be reasonably achieved [24]. To overcome the drawbacks of these methods CBCT, which is a relatively newer diagnostic imaging, was used to study the root canal anatomy [8, 25]. Among the various studies on mandibular canines, P´ecora et al. [26] had reported a maximum incidence of Type

I in 92.2% of the teeth (Table 2). In this study the second most common canal pattern was Type III in 10% of the samples which is similar to that reported by C¸ alis¸kan et al. [27]. On the contrary, in Vertucci's study [2], the second most commonly occurring canal pattern was Type II (14%) followed by Type III which was present only in 2% of the teeth. The Type IV canal pattern was reported by P´ecora et al. [26] in 1.2% of mandibular canines which was not present in our study. In the Iranian population, Aminsobhani et al. [8] reported single canal in 71.8%and two canals in 28.2%inmandibular canines

In the present study, the 4 (1.6%) of the samples in mandibular canine had Sert and Bayirli's [4] Type XIX canal configuration (i.e., two canals leave the pulp chamber, join as a single canal in the middle third, divide again into two canals, and finally exist as single canal. In this study, the average length of the crown of mandibular canine was 10.1 mm, whereas the average length of the crown in Ash and Nelson's [6] study was 11 mm. Versiani et al. [7] reported that the average length of the root of mandibular canine ranged from 12.53mm to 18.08 mm, which was similar to the present findings.In the present study all the accessory canals in mandibular canines were found in the apical one-third region within 2mm from the root apex.

In the study by Green [22] (12%). Versiani et al. [7] used microcomputed tomography and reported a higher incidence of accessory canals. In their study [7], 69% of the mandibular canines had accessory canals which were located in the middle third ($n = 4$) and in apical third ($n = 65$). However, in the present study only 13.5% ($n = 27$) of the mandibular canines had accessory canals. Likewise, Green [22] reported the presence of accessory canals in mandibular canine to be 10%.

The Advanced modes of imaging techniques have allowed for indepth knowledge of root canal anatomy in three-dimensional view. Versiani et al. [7] used microcomputed tomography whereas Green [28] used ground section and microscopy to study the presence of accessory canals. Differences in methodologies to evaluate the accessory canals may account for highly variable results which needs further analysis. In mandibular canines 33 teeth had flattened access cavity, amongst which 16.5% of the teeth had more than one canal.

From this study one can infer that if the shape of the access cavity is flattened, one can expect more than one canal pattern in mandibular canine during root canal treatment. In mandibular canines the position of the apical foramina was 59.9% laterally and 40.1% centrally placed. Similar results were reported in the literature amongst different populations [18, 7, 29]. Based on the present study in an Kashmiri population, it is evident that the majority of the apical foramina in mandibular canines were laterally positioned. Therefore, care should be taken during working length determination and cleaning and shaping of permanent canine.

CONCLUSION

In this study the mandibular canines showed various canal patterns like Type I (82.2%), Type II (4.2%), Type III (10%), and Type V (2%) based on Vertucci's [2] classification. In addition to this, four of the mandibular canines (1.6%) had a (2-1-2-1) These findings emphasize the importance of clinician's knowledge of morphological diversity of root canals. Since leaving a canal untreated is one of the main causes of root canal treatment failure, the presence of a second canal must always be considered by the dentist in mandibular canine root canal treatments. Cone-beam computed tomography provides an accurate tool for the morphological assessment of canines.

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