International Journal of Research in Health and Allied Sciences
Journal home page: www.ijrhas.com
Official Publication of "Society for Scientific Research and Studies" [Regd.]
ISSN: 2455-7803

ORIGINAL RESEARH

Evaluation of root canal morphology of maxillary second premolars by clearing technique in Kashmiri population; an in –vitro study

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ABSTRACT
Introduction: The aim of this study was to investigate root canal morphology of maxillary second premolars in Kashmir population. **Materials and Methods**: Two hundred maxillary second premolars were collected, stained, decalcified, and cleared. Cleared teeth were examined in a steromicroscope under 7.5× magnification and the following observations were made: (1) length of the teeth, (2) number of root canals, (3) root canal configuration by Vertucci's classification, (4)number of isthmi between the canals, (5) frequency of apical deltas. **Results:** Of the two hundred maxillary second premolars, 61.5% had one root canal at the apex and 32.5 % had two root canals at the apex. The average length of the teeth was 20.5 mm. Concerning the canal morphology, 34% of the teeth exhibited Vertucci type II configuration followed by type I 29.5% and type IV pattern (27.5%). Isthmi and apical deltas was found in 14% and 12% of the cases, respectively. **Conclusion**: The root canal morphology of Maxillary second premolars can be complex and requires careful evaluation prior to endodontic therapy.
Key words: Apical delta; decalcification and staining; maxillary second premolar; root canal morphology; Vertucci's classification.

Received: 12 January 2019 Revised: 20 March 2019 Accepted: 24 March 2019

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This article may be cited as: Bhat SA, Misgar O, Zargar AW. Evaluation of root canal morphology of maxillary second premolars by clearing technique in Kashmiri population; an in –vitro study. Int J Res Health Allied Sci 2019; 5(3): 1-4.

INTRODUCTION

As we know the success of root canal therapy depends on a thorough knowledge of the root and root canal morphology so as to locate all existing canals and properly clean, shape, and obturate the root canal space three-dimensionally.[1] Studies on the internal and external anatomy of teeth have shown that anatomic variations can occur in all groups of teeth and can be extremely complex.[2,3] Numerous factors contribute to the variations found in the root canal studies including ethnicity,[4,5] age,[6] gender,[7] and study design (*in vitro* versus *in vivo*).[8] The maxillary second premolars are among the most difficult teeth to be treated endodontically.

This could be due to many factors namely the number of roots, the number of canals, the direction and longitudinal depressions of the roots, the various pulp cavity configurations, and the difficulties in visualizing the apical limit by radiographs.[9] In a study of North American patients, reported that 75% of maxillary second premolars exhibited one canal at the apex, with type I, II, and III canal configurations in 48%, 22%, and 5% of teeth, respectively. Two canals were present at the apex in 24% of maxillary second premolars, with type IV, V, VI, and VII configurations in 11%, 6%, 5%, and 2% of teeth, respectively[10]. Only 1% of teeth exhibited three canals at the apex. A Turkish study examining maxillary second premolars using light microscopy revealed a 50.64% incidence of type II to type VII (two canals) Vertucci configurations, with type I (one canal) and type VIII (three canals) configurations present in 48.66% and 0.66% of the total sample, respectively[11]. reported that 72.3% of maxillary second premolars possessed two canals with type II, IV, or VI canal configurations, whereas 27.7% of teeth exhibited one canal with a type I configuration[12]. In a stereomicroscopic study of maxillary second premolars from Indian patients, found that 64.1% of the teeth

sampled contained one canal at the apex; the remaining teeth (35.4%) exhibited two canals at the apex. In contrast to the previous studies[13], Vertucci type II canals were the most common (33.6%), followed by type IV and type I canals in 31.1% and 29.2% of the sample, respectively[13]. An additional canal configuration, type XIX, was found in one tooth [13] Hence, this study was undertaken to investigate the root canal anatomy of maxillary second premolar in an kashmiri population using Vertucci classification and to compare these findings with the published reports of different population. Two hundred extracted human adult maxillary second premolar were collected from the department of oral and maxilofacial surgery government dental college srinagar.

Teeth with fracture, incompletely formed roots, metallic restorations, and deep caries were not included. The teeth were stored in 10% formalin. ultrasonic scaler was used to remove Calculus and stains. The length of the teeth was measured using vernier caliper from the tip of the crown to the apex of the root. In case of a curved root, tangents were drawn to the curved portions of the tooth. The lengths were then measured by connecting the points of tangency. Access cavities were prepared using No. 2 round bur and the pulp tissue was dissolved by immersing the teeth in 2.5% sodium hypochlorite (Prevest denpro Pvt. Ltd., Mumbai, India) for 12 hours, followed by 20 minutes immersion in an ultrasonic bath. The teeth were then rinsed under running tap water for 2 hours and dried overnight. A syringe with a gauge 27 needle was used to inject the India Ink (Emichem Pvt. Ltd., Kolkata, India) into the root canal spaces coronally, assisted by vacuum suction apically. The teeth were air dried and decalcified in 5% nitric acid (George Chem, Vellore, Tamil Nadu, India) for 4–5 days. The acid solution was changed daily and the end point of decalcification was determined by periodic radiographs. The teeth were washed under running water to remove traces of nitric acid, dried and dehydrated using increasing concentrations of ethanol (70%, 95%, 100%) (Leonid Chemicals Pvt. Ltd., Bangalore, Karnataka, India) for 24 hours. Finally the teeth were rendered transparent by immersing in methyl salicylate (Jain General Traders, Chennai, Tamil Nadu, India). The cleared teeth were examined under stereomicroscope under 7.5× magnification.

The canal configurations were categorized into the first seven types of Vertucci's classification (1984) as follows:

1. type I. A single canal present from the pulp chamber to the apex;
2. type II. Two separate canals leave the pulp chamber and join short of the apex to form one canal;
3 type III. One canal leaves the pulp chamber, divides into two within the root, and then merges to exit in one canal;
4. type IV. Two separate and distinct canals are present from the pulp chamber to the apex;
5. type V. Single canal leaves the pulp chamber but divides into two separate canals with two separate apical foramina;
6. type VI. Two separate canals leave the pulp chamber but join at the midpoint and divides again into two separate canals with two separate apical foramina; and
7. type VII. One canal leaves the pulp chamber, divides and rejoins within the canal, and finally redivides into two distinct canals short of the apex.

RESULTS

Out of 200 studied maxillary second premolars, 61.5% had one root canal at the apex and 32.5% had two root canals at the apex. The average length of these teeth was 20.9 mm, ranging from 14.9 to 27.8 mm. In this study, variable root canal configurations were found in maxillary second premolars. Type II configuration was most prevalent (34%) followed by type I (29.5%), type IV (27.5%), type V (3.5%), type III (1.5%), type VI (2%), and type VII (2%)

Percent of root canal of maxillary second premolars in various studies

Author apex	No. of teeth	one canal at the apex	two canals at the apex	three canals at the apex
Pineda and Kuttler[2]	282	81.8	18.2	0
Vertucci[11]	200	75	24	1
Bellizzi and Hartwell[12]	630	40.3	58.6	1.1
Pecora *et al*.[9]	300	67.3	32.4	0.3
Caliskan *et al*.[13]	100	72	28	0
Chima[14]	26 females 20 males	30 30	73 70	0 0
Kartal *et al*.[11]	300	55	44.4	0.6
Sert and Bayirli[7]	100 females 100 males	75 49	24 48	1 3
Khurram *et al*.[15]	57 females 43 males	47 37	53 63	0 0
Weng *et al*.[10]	65	27.7	72.3	0
Present study	200	61.5	32.5	0

Root canal morphology of maxillary second premolars in various studies

			Canal Types							
Reference	**No. of teeth**	**type of study**	**I (%)**	**II (%)**	**III (%)**	**IV (%)**	**V (%)**	**VI (%)**	**VII (%)**	**VIII(%)**
Vertucci[3] (USA)	100	clearing	48	22	5	11	6	5	2	1
Caliskan *et al.*[13] (Turkey)	100	clearing	44	22	6	12	6	6	4	--
Kartal *et al.*[11]	300	clearing	48.6	6.3	-	37.99	4	.6	-	-
Sert and Bayirili[7] (Turkey)	200	clearing	32	20	10	25.5	6	1.5	3	1.5
Weng *et al.*[10] (China)	100	clearing	27.7	36.9	-	33.8	-	1.6	-	-
Present study	200	clearing	29.5	34	1.5	27.5	3.5	2	2	-

Number and percentage of Isthmi and apical deltas

Reference	Number of teeth	Transverse anastomosis (%)	Apical deltas %
Vertucci[3]	100	30.8	15.1
Caliskan *et al.*[13]	100	20	26
Kartal *et al.*[11]	300	37	15
Sert and Bayirili[7]	200	20.5	26.5
Weng *et al.*[10]	100	65	43.8
Present study	200	14	12

DISCUSSION

Studies on root canal morphology have been conducted by various methods like radiography,[14] decalcification and clearing,[3-5] direct observation with microscope,[12] sectioning and macroscopic observation,[16] and computer tomography.[17] Although various techniques have been used in these studies evaluating canal morphology, it has been reported that the most detailed information can be obtained ex vivo by demineralization and staining.[3] This technique also makes canal negotiation with instruments unnecessary, thereby maintaining the original form and relation of canals and provides a three-dimensional view of root canal.[3,4 The process of changing the tooth into a transparent object involves many physical and chemical changes. The inorganic constituents of the tooth are first dissolved by decalcification and further water, air, and lipid components are removed by dehydration and by subsequent immersion in the clearing agents.[18] The decalcifying agent 5% nitric acid is rapid in action, causes little damage to tissue if the time of decalcification is rapidly controlled. [19] After fixation in aqueous solutions, tooth tissue needs to be dehydrated slowly in order to prevent high degree of shrinkage due to the rapid removal of water.[19] When the dehydrating agent has been entirely replaced by methyl salicylate, the tissue has a transparent appearance, as the clearing agent increases the refractive index of the tooth. [19] The use of stereomicroscope for viewing the root canal pattern resulted in higher accuracy and magnification when compared to the magnifying glasses that were used in the previous studies. In 1993, Pecora et al. found that 90.3% of maxillary second premolars (n= 435) exhibited single roots, whereas 9.7% possessed two roots. This result differs from our finding that 65% of teeth have one root, and 33% have two roots. According to previous studies, the frequency of a single canal in maxillary second premolars varies between 27.70% and 48.66%, and the occurrence of two canals varies between 50.64% and 72.30% [11]. Other studies reported a high incidence (64.1% and 67.3%) of single canals at the apex of maxillary second premolars and a relatively lower incidence (35.4% and 32.4%) of two canals in this region [13,20]. In 2012, Al-nazhan et al. found that 59.4% of maxillary second premolars had two root canals, and this result is slightly higher than the present study (32.5%). A number of studies have reported on the absence or presence of three canals in maxillary second premolars, with incidences ranging from 0% to 2% of teeth[10]., The most common canal configuration observed in this study was type II , occurring in 34% of maxillary second premolars, followed by types I, IV,V, VI, VII and III (29.5%, 27.5%, 3.5%, 2%, 2%and 1.5%, respectively). Discrepancies in these findings may be explained by the

differences in sample size, ethnic population, and analysis technique among the different studies.

In the present study, one canal orifice was recorded in 61.5% of teeth, and two canal orifices were observed in 32.5% of teeth. An isthmus, which is a narrow ribbon-shaped communication between two root canals that may contain pulp or necrotic tissues, was only found in 14% of teeth. This result is low compared to previous studies, which have reported the incidence of isthmuses to vary between 19% and 65%.[10,12,13] An isthmus may affect the success rate of endodontic treatment because it is generally difficult to clean during root canal treatment, and it can act as a reservoir for microorganisms[21] Apical deltas were observed in 12% of teeth in this study. This result is comparable to the findings of[11] And[13] ; however, it is lower than that reported by other studies [7,10,12]. For example, Weng et al. reported apical deltas in 43% of second premolars[12]. Similar to isthmuses, the apical delta region is another important consideration during root resection and endodontic surgery because it can harbor microorganisms[22]. Intercanal communication was observed in 10% of teeth, with the highest incidence recorded in the middle third, followed by the coronal and apical thirds.

CONCLUSION

There was a high occurrence of single roots and two canals among the evaluated maxillary second premolars. The root canal morphology of maxillary second premolars in Kashmiri patients is complex and variable. Therefore, the external and internal morphology of maxillary second premolars requires cautious evaluation prior to endodontic treatment.

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