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RESEARCH ARTICLE

EVALUATION OF ROOT CANAL MORPHOLOGY OF MAXILLARY PERMANENT SECOND MOLARS USING CONE BEAM COMPUTED TOMOGRAPHY IN CHENNAI – A CROSS SECTIONAL STUDY.

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Abstract

Aim: To study the variation in the root canal morphology of maxillary permanent second molars in the Chennai population based on Vertucci classification by using cone beam computed tomography.

Background: The success of endodontic treatment is mainly attributed to the understanding of the root canal morphology, proper cleaning and shaping, followed by obturation of the prepared root canals. Certain distinct features of the teeth may complicate an endodontic treatment due to the complex morphology and various individual variations of the teeth. Hence, It is important for a dentist to evaluate the root canal morphology of the teeth, which can be done using Cone Beam Computed Tomography (CBCT) prior to any treatment involving the tooth pulp in order to ensure the success and effectiveness of the dental treatment.

Materials and Methods: One hundred Cone Beam Computed Tomography (CBCT) images are randomly selected from the Department of Oral Medicine and Radiology in Saveetha Dental College and Hospital, Chennai, India. The selected CBCT images are examined for the inclusion criteria in maxillary permanent second molars based on Vertucci classification.

Results: A total of 170 permanent maxillary second molars were examined in this study. Type 1 is commonly seen in males (90.59%), followed by Type 3 (4.31%), Type 5 (2.75%), Type 2 (1.96%) and Type 8 (0.39%) based on the Vertucci's classification. In females, most of the root canal morphology is of Type 1 (87.84%), followed by Type 5 (3.53%), Type 3 (2.35%) and Type 4 (0.78%) respectively.

The mean values of the length of mesiobuccal root of permanent maxillary second molars are 11.6997 mm in males and 11.0313 mm in females with standard deviations of 0.9541 and 0.9371 in males and females respectively. As for the length of distobuccal root, the mean values are 11.5302 mm with standard deviation of 0.8823 in males and 10.7267 mm in females with standard deviation of 0.5867. The mean values of the palatal root are 12.0041 mm in males and 11.0693 in females with standard deviations of 0.9714 and 0.6965 in males and

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females respectively.

The mean distance between the occlusal pit and pulp chamber are 4.3681 mm with standard deviation of 0.5769 in males and 4.3728 mm with standard deviation of 0.7828 in females. The distance between the pulpal floor and furcation are reported to have a mean value of 3.3034 mm in males and 2.5493 mm in females with standard deviations of 0.6509 and 0.3765 in males and females respectively. The mean distance between the cement-enamel junction (CEJ) and pulp chamber is 3.2283 mm in males with standard deviation of 0.5708 and 2.6727 mm in females with standard deviation of 0.3853.

Conclusion: Based on the findings in this study, it can be concluded that there is no significant variation in the root canal morphology of permanent maxillary second molars between males and females, particularly in the Chennai population as most of them commonly exhibit Type 1 in the permanent maxillary second molars. CBCT is one of the best methods to help dentists in proper evaluation of the root canal configurations in order to ensure the success of an endodontic treatment.

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Introduction:-

Despite being largely preventable, dental caries remains the most common chronic disease reported by dental patients, especially in children due to the thin mineralized layer between the external and internal surfaces of the teeth, which leads to rapid progression of caries towards the dental pulp.^{1 2 3} Pulp therapy is considered to be one of the commonly performed treatments in a routine dental practice in order to ensure the normal function of the teeth and maintain the integrity of the dental arch.⁴

It is important for a dentist to analyze the root canal morphology of the teeth before performing any treatment involving the tooth pulp such as pulpectomy and pulpotomy in order to ensure the success and effectiveness of the dental treatment. Certain distinct features of the teeth, which vary from the normal morphology of the specific teeth, may complicate the dental treatment such as pulp therapy that involves cleaning, shaping and obturation of the root canals.^{4 5 6}

Various methods have been introduced for the study of root canal morphology including ground sectioning of the teeth and three-dimensional (3D) models of the teeth and root canal systems, which involves the injection of dyes or other materials into the root canal.^{7 8 9} Newer methods such as the use of radiographs have been introduced in order to replace the previous methods due to their side effects such as alteration of the dental tissues from the use of dyes as a result of demineralization of the teeth.^{10 11 12 13 14} Routine radiographs such as intraoral periapical radiographs (IOPA) are rarely used for the study of root canal morphology due to certain limitations such as the production of two-dimensional (2D) images, which makes it difficult to analyze the root canal structures in the presence of blind spaces.¹⁵

Cone beam computed tomography (CBCT) is therefore considered to be a better choice in the study of root canal morphology due to their ability to visualize the overall structure of the root canal in the form of three-dimensional images with more accuracy and precision without altering the tooth structures.^{16 17 18 19} This study focuses on the evaluation of the number of root canals and 3D characteristics of root canal systems of the permanent second maxillary molars using CBCT in Chennai, which are later compared with those in the Vertucci classification.

Vertucci's Classification of Root Canal Morphology (20)

Various studies have provided different methods of classifying root canal configurations, which may be based on various factors such as the number of canals and intracanal branching and fusion. One of the common classifications of root canal morphology is the Vertucci's classification that involves 8 different types of root canal configurations.

Advantages and Disadvantages of Cone Beam Computed Tomography (CBCT)^{22 23}

Cone Beam Computed Tomography (CBCT) was first indicated for endodontics in the 1990s and has since become one of the commonly used radiographic methods in dentistry due to its accurate 3-dimensional (3D) imaging modality.²⁴ The following features represent some of the advantages and disadvantages of CBCT imaging used in dentistry today.

Advantages of CBCT imaging

1. High resolution and quality of scanned images
2. Less time consuming due to immediate action
3. Reduction in patient's exposure to radiation
4. Low cost and affordable for patients

Disadvantages of CBCT imaging

1. Presence of metal artifacts which may result in inaccurate diagnosis
2. Inability to be used as a routine procedure in a clinical practice due to patient's exposure to radiation

Materials And Methods:-

The study was approved by Human Ethical committee, Saveetha University (SRB-2019/092). One hundred Cone Beam Computed Tomography (CBCT) images of different patients were randomly selected from the Department of Oral Medicine and Radiology at Saveetha Dental College and Hospital, Chennai, India dated from September 2018 to January 2019. The CBCT images were collected from patients between 20 to 50 years of age indicated for the assessment of impacted teeth, implant placement, root canal treatment and other conditions that were not specifically mentioned. The CBCT scans were first downloaded in the form of compact discs from the patient's data collection in the department, followed by assessment of the CBCT images using the Galileos Viewer 1.9 software for the evaluation of root canal morphology and other features of the maxillary permanent second molars based on the manufacturer's guidelines.

In order to obtain a proper diagnosis, the CBCT images were required to follow certain criteria such as the presence of fully erupted maxillary permanent molars, intact tooth with completely formed root apices and absence of lesions and artifacts. Certain features of the teeth such as incomplete, fractured and resorbed roots, root canal treated teeth, incomplete root apices and perforated and obliterated tooth may interfere with the diagnosis and thus excluded from the study.

The selected CBCT images were examined for various features of the maxillary permanent second molars, which include the number of canals, root canal configurations based on Vertucci's classification, length of each root, distance between the occlusal pit and pulp chamber, distance between the pulp floor and furcation and distance between the cement-enamel junction and pulp chamber. The results obtained for each parameter were later tabulated in the form of descriptive analysis that include the mean values, standard deviation and significance of result for each feature of the tooth being evaluated, followed by comparison of each data between males and females.

Inclusion Criteria for CBCT scans^{20 24}

The following criteria should be considered in the evaluation of CBCT images in order to obtain a proper diagnosis.

1. The complete height of maxilla from the alveolar crest to the vestibular depth should be clearly visible on the CBCT scans.
2. Presence of full erupted maxillary second molars
3. Absence of lesions or defects in the maxilla
4. Absence of coronal or root restoration, post and core build up or crown prosthesis
5. Absence of root canals with open apices, root resorption or calcification
6. Presence of fully developed root without any defect
7. High quality CBCT images

Results And Explanation:-

A total of 100 Cone Beam Computed Tomography (CBCT) images were collected from the Department of Oral Medicine and Radiology at Saveetha Dental College and Hospital, Chennai, India, out of which, only 96 CBCT images were qualified for this study while the remaining 4 CBCT images did not fulfill the ideal criteria for the

evaluation of root canal morphology based on Vertucci's classification and other features of permanent maxillary second molars. From the 96 CBCT scans, a total of 170 permanent maxillary second molars were qualified for the examination while the remaining teeth were not included due to certain factors such as extracted or root canal treated teeth. The results obtained from the evaluation of root canal morphology and other features of the permanent maxillary second molar were tabulated in the form of descriptive analysis, which include mean value and standard deviation, followed by comparison of the results between males and females.

In **Table 2**, it is stated that the mean values of the number of root canals in the permanent maxillary second molars are 3mm in males 3.0465 mm in females with standard deviations of 0 and 0.2118 in males and females respectively. Based on **Table 3**, it can be seen that Type 1 is commonly seen in males as it is found in 90.59% of the teeth being examined in this study, predominantly in the distobuccal root (96.47%), followed by mesiobuccal (88.24%) and palatal (87.06%) roots respectively. Following Type 1, Type 3 is seen in approximately 4.31% of the teeth, which makes it the second most common type of root canal morphology seen in males based on Vertucci's classification. In addition, Type 5 is seen in 2.75% of the teeth, followed by 1.96% of Type 2 and 0.39% of Type 8 respectively. None of the Type 4, Type 6 and Type 7 were reported in this study, which indicates that they are not commonly seen in the permanent maxillary second molars in males. Comparatively, the results in **Table 4** shows that 87.84% of the teeth being examined in females acquired Type 1, mainly seen in the distobuccal root (94.12%), followed by mesiobuccal (88.24%) and palatal (81.17%) roots respectively. Following Type 1, the second most common type of root canal morphology in females based on Vertucci's classification is Type 5, as seen in 3.53% of the teeth being examined for this study. Other types of root canal morphology seen in females include Type 3 (2.35%) and Type 4 (0.78%) respectively. Since most of the root canal morphology are of Type 1, other forms such as Type 2, Type 6, Type 7 and Type 8 are less commonly seen in females as none of these types of root canal morphology is seen in this study.

According to the descriptive analysis of the results obtained in **Table 5**, it can be seen that the mean values of the length of the mesiobuccal root of permanent maxillary second molars are 11.6997 mm in males and 11.0313 mm in females with standard deviations of 0.9541 in males and 0.9371 in females. The descriptive analysis of the length of the distobuccal root of permanent maxillary second molars indicates a mean value of 11.5302 mm with a standard deviation of 0.8823 in males and a mean value of 10.7267 mm with a standard deviation of 0.5867 in females for the teeth being examined in this study. The descriptive analysis of the length of the palatal root of permanent maxillary second molars include the mean values of 12.0041 mm in males and 11.0693 mm in females with standard deviations of 0.9714 and 0.6965 seen in males and females respectively.

As for the distance between the occlusal pit and pulp chamber of permanent maxillary second molars, the descriptive analysis in **Table 6** shows the mean value of 4.3681 mm in males with a standard deviation of 0.5769 in males, while in females, the mean value for the distance between the occlusal pit and pulp chamber is 4.3728 mm with a standard deviation of 0.7828. The descriptive analysis of the distance between the pulpal floor and furcation of permanent maxillary second molars in **Table 7** is described in terms of its mean value of 3.3034 mm in males and 2.5493 mm in females and its standard deviations of 0.6509 in males and 0.3765 in females. According to the descriptive analysis of the results in **Table 8**, the distance between the cemento-enamel junction (CEJ) and pulp chamber of permanent maxillary second molars are expressed in terms of its mean value of 3.2283 mm in males and 2.6727 mm in females with standard deviations of 0.5708 and 0.3853 in males and females respectively.

Discussion:-

Cone Beam Computed Tomography (CBCT) is considered to be a non-invasive method of diagnosis in endodontics as it helps in the detection of various pathological conditions such as periapical lesions or defects and increases the success rate of an endodontic treatment.²³ Root canal treatment could be challenging for a dentist especially in the presence of complex morphology and wide individual variations of the root canals that may complicate any step of the procedure such as cleaning and shaping.²⁵ Inadequate knowledge about root canal morphology may interfere with the success of endodontic treatment.²³ This study was conducted on 170 teeth of permanent maxillary second molars, in which 85 teeth are from males and the other 85 teeth are from females obtained from a total of 96 CBCT images at the Department of Oral Medicine and Radiology, Saveetha Dental College and Hospital, Chennai, India. All teeth are examined for the morphology of root canals, length of the roots and other features of the permanent maxillary second molars. The root canal configurations are later recorded and classified based on the Vertucci's classification.

In terms of the number of canals present, **Table 2** states that the mean values of the number of root canals in the permanent maxillary second molars are 3mm in males with standard deviation of 0, in which all the teeth being studied have three canals (100%) and 3.0465 mm in females with standard deviation of 0.2118 as 95.3% of the teeth acquired three canals while the remaining 4.7% have four canals due to the presence of MB2 canals. The presence of MB2 canals in the permanent maxillary second molars has been reported in various studies done previously. A study by Nikoloudaki et al. reveals the prevalence of MB2 canals (30.29%) in the upper second molars.²⁶ A similar study by Tanvi et al. reported the presence of MB2 canals in 17.39% of permanent maxillary second molars in the study done among an Indian subpopulation in Mumbai with equal distribution between males and females. The study further explained the relationship between the prevalence of three separated roots in permanent maxillary second molars and genders, in which the incidence of three-rooted maxillary permanent second molars is more common in males compared to females.²⁴

Various studies have indicated the presence of three canals in the permanent maxillary second molars, which basically confirm the findings in this study. A study by Nikoloudaki et al. reported the frequent presence of three canals in the permanent maxillary second molars (49.5%) as compared to permanent maxillary first molars.²⁶ A similar study by Ghoncheh et al. reported the prevalence of three roots of mesiobuccal, distobuccal and palatal in the permanent maxillary second molars with one canal in each root (86%) seen in an Iranian population.²³

Based on the descriptive analysis of root canal morphology of permanent maxillary second molars in **Table 3**, it can be seen that 90.59% of the teeth being examined in males acquired Type 1 of the Vertucci's classification, mainly in the distobuccal root (96.47%), followed by mesiobuccal (88.24%) and palatal (87.06%) roots respectively. Similarly, the results in **Table 4** shows a significantly high percentage (87.84%) of Type 1 seen in females, predominantly in the distobuccal root (94.12%), followed by mesiobuccal (88.24%) and palatal (81.17%) roots respectively, although the percentage of Type 1 in females is slightly lower than the percentage in males.

In comparison, a study by Neelakantan et al. reveals that Type 1 is commonly seen in the mesiobuccal root (62%) followed by Type 4 (38.6%).²⁷ Similarly, distobuccal and palatal roots also consist of predominantly Type 1 and the other canal types are seen in 9.3% of the teeth being examined. Another study by Ghoncheh et al. reported the prevalence of Type 1 morphology in three-rooted permanent maxillary second molars, especially in the distobuccal and palatal roots (100%) while the mesiobuccal roots show Type 2 (2.54%) and Type 4 (11.3%), following Type 1 (86.2%).²³

Following Type 1, the other common types of root canal morphology seen in the permanent maxillary second molars in males are Type 3 (4.31%), Type 5 (2.75%), Type 2 (1.96%) and Type 8 (0.39%). On the other hand, different types of root canal morphology are also seen in females such as Type 5 (3.53%), Type 3 (2.35%) and Type 4 (0.78%) other than Type 1. None of the Type 4, Type 6 and Type 7 is reported in males, indicating that they are less commonly seen in the permanent maxillary second molars in males. In comparison, Type 2, Type 6, Type 7 and Type 8 are not observed in the permanent maxillary molars in females.

The results in **Table 5** show the length of the mesiobuccal root of permanent maxillary second molars in terms of its mean value and standard deviation in males and females. The mean values of the length of mesiobuccal root of permanent maxillary second molars are 11.6997 mm and 11.0313 mm in males and females respectively, while the standard deviations are 0.9541 in males and 0.9371 in females. Based on the results, it can be seen that the length of mesiobuccal root of permanent maxillary second molars in males are almost similar in males and females, although the values in males are slightly higher than those in females.

As for the length of the distobuccal root of permanent maxillary second molars expressed in **Table 5**, the results indicate a mean value of 11.5302 mm with a standard deviation of 0.8823 in males and a mean value of 10.7267 mm with a standard deviation of 0.5867 in females for the teeth being examined in this study. Examination of the palatal root of permanent maxillary second molars reveals the mean values of 12.0041 mm in males and 11.0693 mm in females with standard deviations of 0.9714 and 0.6965 seen in males and females respectively. By comparison, it can be seen that the lengths of distobuccal and palatal roots of permanent maxillary second molars in males are slightly higher than those in females.

Based on the descriptive analysis of the distance between the occlusal pit and pulp chamber of permanent maxillary second molars in **Table 6**, it can be seen that the mean values are calculated to be 4.3681 mm with a standard

deviation of 0.5769 in males and 4.3728 mm with a standard deviation of 0.7828 in females. It can be said that there is no significant difference in the distance between the occlusal pit and pulp chamber of permanent maxillary second molars seen in males and females.

As for the distance between the pulpal floor and furcation of permanent maxillary second molars described in **Table 7**, the mean values are shown to be 3.3034 mm in males and 2.5493 mm in females, while its standard deviations are 0.6509 in males and 0.3765 in females. The results in **Table 8** indicate the distance between the cemento-enamel junction (CEJ) and pulp chamber of permanent maxillary second molars, in which its mean values are 3.2283 mm in males and 2.6727 mm in females with standard deviations of 0.5708 and 0.3853 in males and females. According to the results obtained in **Table 7** and **Table 8**, it can be observed that the distance between the pulpal floor and furcation, along with the distance between the cement-enamel junction (CEJ) and pulp chamber of permanent maxillary second molars in males are higher than the values seen in females.

Conclusion:-

From this study, it can be concluded that the Indian subpopulation in Chennai has a higher prevalence of 3 canals in the permanent maxillary second molars, in which most of the canals exhibit Type 1 morphology based on the Vertucci's classification. Most of the Type 1 morphology is seen in the distobuccal root, followed by mesiobuccal and palatal roots in both males and females. Although CBCT has been one of the commonly used radiographic imaging techniques in dentistry, its use should be limited to certain conditions instead of using it as a routine procedure in daily clinical practice due to the risk of patient's exposure to radiation that may lead to various adverse side effects to the patient.

Conflict Of Interest

The authors of this study confirm that there is no conflict of interests in the publication of this paper.

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Table 1:-Root canal morphology based on Vertucci's classification

TYPES	FEATURES
Type 1	Single canal extending from the pulp chamber to the apex (1)
Type 2	Two separate canals from the pulp chamber → join together short of the apex → form a single canal (2 – 1)
Type 3	One canal from the pulp → divides into two separate canals → merge before exiting as a single canal (1 – 2 – 1)
Type 4	Two separate canals extending from the pulp chamber to the apex (2)
Types 5	Single canal from pulp chamber → divides short of the apex → two separate canals with separate apical foramina (1 – 2)
Type 6	Two separate canals from pulp chamber → merge in the body of the root → divides short of the apex → exit as two separate canals (2 – 1 – 2)
Type 7	Single canal from pulp chamber → divides → merge in the body of the root → divides into two separate canals short of the apex (1 – 2 – 1 – 2)
Type 8	Three separate canals extending from the pulp chamber to the apex (3)

Table 2:-Descriptive analysis of number of root canals of permanent maxillary second molars

GENDER	MEAN VALUE (mm)	STANDARD DEVIATION
Males	3	0
Females	3.0465	0.2118

Table 3:-Descriptive analysis of the root canal morphology of maxillary permanent second molars based on Vertucci's classification in males

VERTUCCI'S CLASSIFICATION	MB, n (%)	DB, n (%)	P, n (%)	TOTAL, n (%)
Type 1	75 (88.24)	82 (96.47)	74 (87.06)	231 (90.59)
Type 2	0	0	5 (5.88)	5 (1.96)
Type 3	3 (3.53)	3 (3.53)	5 (5.88)	11 (4.31)
Type 4	0	0	0	0
Type 5	6 (7.06)	0	1 (1.18)	7 (2.75)
Type 6	0	0	0	0
Type 7	0	0	0	0
Type 8	1 (1.18)	0	0	1 (0.39)

Table 4:-Descriptive analysis of the root canal morphology of maxillary permanent second molars based on Vertucci's classification in females

VERTUCCI'S CLASSIFICATION	MB, n (%)	DB, n (%)	P, n (%)	Total, n (%)
Type 1	75 (88.24)	80 (94.12)	69 (81.17)	224 (87.84)
Type 2	0	0	0	0
Type 3	6 (7.06)	0	0	6 (2.35)
Type 4	2 (2.35)	0	0	2 (0.78)
Type 5	2 (2.35)	5 (5.88)	2 (2.35)	9 (3.53)
Type 6	0	0	0	0
Type 7	0	0	0	0
Type 8	0	0	0	0

Table 5:-Descriptive analysis of the length of mesiobuccal, distobuccal and palatal roots of permanent maxillary second molars in males and females

GENDER	MEAN VALUE (mm)			STANDARD DEVIATION		
ROOTS	MB	DB	P	MB	DB	P
Males	11.6997	11.5302	12.0041	0.9541	0.8823	0.9714
Females	11.0313	10.7267	11.0693	0.9371	0.5867	0.6965

Table 6:-Descriptive analysis of the distance between occlusal pit and pulp chamber of permanent maxillary second molars in males and females

GENDER	MEAN VALUE (mm)	STANDARD DEVIATION
Males	4.3681	0.5769
Females	4.3728	0.7828

Table 7:-Descriptive analysis of the distance between pulpal floor and furcation of permanent maxillary second molars in males and females

GENDER	MEAN VALUE (mm)	STANDARD DEVIATION
Males	3.3034	0.6509
Females	2.5493	0.3765

Table 8:-Descriptive analysis of the distance between cement-enamel junction (CEJ) and pulp chamber of permanent maxillary second molars in males and females

GENDER	MEAN VALUE (mm)	STANDARD DEVIATION
Males	3.2283	0.5708
Females	2.6727	0.3853

References:-

1. Reich E, Lussi A, Newbrun E, 1999. Caries-risk assessment. International dental journal, 49(1), pp.15-26.

2. Yang R, Yang C, Liu Y, Hu Y, Zou J, 2013. Evaluate root and canal morphology of primary mandibular second molars in Chinese individuals by using cone-beam computed tomography. *Journal of the Formosan Medical Association*, 112(7), pp.390-395.
3. Aminabadi NA, Farahani RM, Gajan EB, 2008. Study of root canal accessibility in human primary molars. *Journal of oral science*, 50(1), pp.69-74.
4. Goerig, A.C. and Camp, J.H., 1983. Root canal treatment in primary teeth: a review. *Pediatric dentistry*, 5(1), pp.33-37.
5. Kim Y, Lee SJ, Woo J, 2012. Morphology of maxillary first and second molars analyzed by cone-beam computed tomography in a Korean population: variations in the number of roots and canals and the incidence of fusion. *Journal of endodontics*, 38(8), pp.1063-1068.
6. Razumova S, Brago A, Khaskhanova L, Barakat H, Howijieh A, 2018. Evaluation of anatomy and root canal morphology of the maxillary first molar using the cone-beam computed tomography among residents of the moscow region. *Contemporary clinical dentistry*, 9(Suppl 1), p.S133.
7. Tu M.G, Liu JF, Dai PW, Chen SY, Hsu JT, Huang HL, 2010. Prevalence of three-rooted primary mandibular first molars in Taiwan. *Journal of the Formosan Medical Association*, 109(1), pp.69-74.
8. Liu JF, Dai PW, Chen SY, Huang HL, Hsu JT, Chen WL, Tu MG, 2010. Prevalence of 3-rooted primary mandibular second molars among Chinese patients. *Pediatric dentistry*, 32(2), pp.123-126.
9. Piesco NP, 1994. Histology of dentin. *Oral development and histology*, pp.98-110.
10. Hibbaed ED, 1957. Morphology of the root canals of the primary molar teeth. *J. Dent. Child.*, 24, pp.250-257.
11. Davis SR, Brayton SM, Goldman M, 1972. The morphology of the prepared root canal: a study utilizing injectable silicone. *Oral Surgery, Oral Medicine, Oral Pathology*, 34(4), pp.642-648.
12. Sidow SJ, West LA, Liewehr FR, Loushine RJ, 2000. Root canal morphology of human maxillary and mandibular third molars. *Journal of endodontics*, 26(11), pp.675-678.
13. Mesbahi M, Talei Z, Mollaverdi F, Kadkhodazadeh M, 2010. Comparison of root canal system configuration in primary teeth. *Res J Biol Sci*, 5(7), pp.488-91.
14. Salama FS, Anderson RW, McKnight-Hanes C, Barenie JT, Myers DR, 1992. Anatomy of primary incisor and molar root canals. *Pediatr Dent*, 14(2), pp.117-8.
15. Wang YL, Chang HH, Kuo CI, Chen SK, Guo MK, Huang GF, Lin CP, 2013. A study on the root canal morphology of primary molars by high-resolution computed tomography. *Journal of Dental Sciences*, 8(3), pp.321-327.
16. Dowker SE, Davis GR, Elliott JC, 1997. X-ray microtomography: nondestructive three-dimensional imaging for in vitro endodontic studies. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, 83(4), pp.510-516.
17. Rhodes JS, Ford TP, Lynch JA, Liepins PJ, Curtis RV, 1999. Micro-computed tomography: a new tool for experimental endodontology. *International Endodontic Journal*, 32(3), pp.165-170.
18. Peters OA, Laib A, Rügsegger P, Barbakow F, 2000. Three-dimensional analysis of root canal geometry by high-resolution computed tomography. *Journal of Dental Research*, 79(6), pp.1405-1409.
19. Peters OA, Laib A, Göhring TN, Barbakow F, 2001. Changes in root canal geometry after preparation assessed by high-resolution computed tomography. *Journal of Endodontics*, 27(1), pp.1-6.
20. Chandra B S, Gopikrishna V, Grossman L I (2014). *Grossmans endodontic practice*. Wolters Kluwer (India).
21. Zheng QH, Wang Y, Zhou XD, Wang Q, Zheng GN, Huang DM, 2010. A cone-beam computed tomography study of maxillary first permanent molar root and canal morphology in a Chinese population. *Journal of endodontics*, 36(9), pp.1480-1484.
22. Yu X, Guo B, Li KZ, Zhang R, Tian YY, Wang H, Hu T, 2012. Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. *BMC medical imaging*, 12(1), p.18.
23. Ghoncheh Z, Zade BM, Kharazifard MJ, 2017. Root morphology of the maxillary first and second molars in an Iranian population using cone beam computed tomography. *Journal of dentistry (Tehran, Iran)*, 14(3), p.115.
24. Tanvi M, Vimala N, Lalitagauri M, 2016. Evaluation of the root morphology of maxillary permanent first and second molars in an Indian subpopulation using cone beam computed tomography. *J Dent Med Sci*, 15, pp.51-6.
25. Alrahabi M, Zafar MS, 2015. Evaluation of root canal morphology of maxillary molars using cone beam computed tomography. *Pakistan journal of medical sciences*, 31(2), p.426.
26. Nikoloudaki GE, Kontogiannis TG, Kerezoudis NP, 2015. Suppl 2: M3: Evaluation of the Root and Canal Morphology of Maxillary Permanent Molars and the Incidence of the Second Mesiobuccal Root Canal in Greek Population Using Cone-beam Computed Tomography. *The open dentistry journal*, 9, p.267.
27. Neelakantan P, Subbarao C, Ahuja R, Subbarao CV, Gutmann, JL, 2010. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. *Journal of endodontics*, 36(10), pp.1622-1627.