Received: 02 November 2023 / Accepted: 21 December 2023 / Published online: 28 December 2023

DOI 10.34689/SH.2023.25.6.014

УДК 616.314-073.75

EVALUATION OF ROOT CANAL CONFIGURATION OF MANDIBULAR FIRST MOLARS IN A KAZAKHSTAN POPULATION BY USING CONE-BEAM COMPUTED TOMOGRAPHY

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Abstract

Relevance: Despite the emergence of advanced technologies and new approaches to endodontic treatment, chronic apical periodontitis continues to be a serious problem in the field of dentistry and is a frequent cause of tooth extraction. This topical issue highlights the importance of a deep understanding of root canal morphology, which serves as an important aspect for the success of both surgical and non-surgical endodontic procedures.

The aim: This study aimed to assess the prevalence of Distolingual Canals (DLC), Radix Entomolaris (RE), and Middle Mesial Canals (MMC) in Mandibular First Molars (M1M) among individuals of Kazakh nationality, using Cone Beam Computed Tomography (CBCT).

Material and methods: A retrospective review and cross-sectional study of cone beam computed tomography images from 500 patients was conducted, focusing on those that included bilateral M1Ms. Axial sections were evaluated from the coronal to the apical regions. Only healthy, previously untreated teeth were considered in order to obtain reliable data on root canal structure. The presence or absence of DLC, MMC, and RE in M1Ms was documented.

Results: Of the 500 patients, 20 (4%) exhibited a Middle Mesial Canal, 52 (10.4%) had a Distolingual Canal, and 30 (6%) presented with Radix Entomolaris.

Conclusion: There is a notable prevalence of RE, MMC, and DLC in M1M among the Kazakh population. Additionally, these anatomical variations demonstrated substantial bilateral occurrence. Endodontic clinicians should be aware of these variations to avoid potential complications during endodontic procedures.

Keywords: *Cone Beam Computed Tomography (CBCT), Middle Mesial Canal, Radix Entomolaris, Distolingual Canal, Morphology of Root Canal, Prevalence.*

Резюме

ОЦЕНКА МОРФОЛОГИИ КОРНЕВЫХ КАНАЛОВ ПЕРВЫХ МОЛЯРОВ НИЖНЕЙ ЧЕЛЮСТИ В КАЗАХСТАНСКОЙ ПОПУЛЯЦИИ С ПОМОЩЬЮ КОНУСНО-ЛУЧЕВОЙ КОМПЬЮТЕРНОЙ ТОМОГРАФИИ

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Актуальность. Несмотря на появление передовых технологий и новых подходов к эндодонтическому лечению, хронический апикальный периодонтит продолжает представлять собой серьезную проблему в области стоматологии и является частой причиной удаления зуба. Эта актуальная проблема подчеркивает важность глубокого понимания морфологии корневых каналов, которая служит важным аспектом для успеха как хирургических, так и нехирургических эндодонтических процедур.

Цель. В настоящем исследовании мы хотели оценить распространенность дистолингвальных каналов (DLC), Radix Entomolaris (RE) и средних мезиальных каналов (MMC) в первых молярах нижней челюсти (M1M) среди лиц казахской национальности с использованием конусно-лучевой компьютерной томографии (КЛКТ).

Материалы и методы. Был проведен ретроспективный обзор и поперечное исследование КЛКТ архивных снимков 500 зубов у пациентов, обращавшихся ранее с различными жалобами. Для получения достоверной информации критериями включения были ранее не леченные, здоровые, сформированными корнями зубы. Осевые или аксиальные срезы снимков КЛКТ оценивали от корональной до апикальной областей. Было документально подтверждено наличие или отсутствие DLC, MMC и RE у M1M.

Результаты: Из 500 пациентов у 20 (4%) был обнаружен среднемезиальный канал, у 52 (10,4%) — дистолингвальный канал и у 30 (6%) — Radix Entomolaris.

Вывод: Среди населения Казахстана среди M1M наблюдается заметная распространенность RE, MMC и DLC. Кроме того, эти анатомические вариации продемонстрировали значительную двустороннюю встречаемость. Врачи-эндодонтисты должны знать об этих различиях, чтобы избежать потенциальных осложнений во время эндодонтических процедур.

Ключевые слова: *конусно-лучевая компьютерная томография (КЛКТ), средний мезиальный канал, Radix Entomolaris, дистолингвальный канал, морфология корневого канала, распространенность.*

Түйіндеме

КОНУС-СӘУЛЕЛІК КОМПЬЮТЕР ТОМОГРАФИЯСЫ АРҚЫЛЫ ҚАЗАҚСТАН ПОПУЛЯЦИЯСЫНЫҢ ТӨМЕНГІ ЖАҚ БІРІНШІ МОЛЯРЛАРДЫҢ ТҮБІР КАНАЛЫНЫҢ МОРФОЛОГИЯСЫН ЗЕРТТЕУ

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Сәйкестігі: Созылмалы апикальды периодонтит эндодонтикалық емдеудің озық технологиялары мен жаңа тәсілдерінің пайда болуына қарамастан, стоматология саласында елеулі проблема болып табылады. Бұл өзекті мәселе тамыр арналарының морфологиясын терең түсінудің маңыздылығын көрсетеді, ол хирургиялық және хирургиялық емес эндодонтикалық процедуралардың табысты болуы үшін негізгі тас болып табылады.

Мақсат. Бұл зерттеуде біз конус сәулелік компьютерлік томография (КСКТ) арқылы қазақ ұлты өкілдерінің төменгі жақ бірінші азу тістеріндегі (M1M) дистолингвальды каналдар (DLC), Radix Entomolaris (RE) және ортаңғы мезиальдық каналдар (MMC) таралуын бағалауды мақсат еттік.

Материалдар мен тәсілдер. Бұрын әртүрлі шағымдармен жүгінген науқастардың 500 тісінің КСКТ мұрағаттық суреттеріне ретроспективті шолу жүргізілді. Сенімді ақпаратты алу үшін қосу критерийлері бұрын емделмеген, сау, түбірлі тістер болды. КСКТ кескіндерінің осьтік немесе осьтік кесінділері тәжден апикальды аймақтарға дейін бағаланды. M1M жүйесінде DLC, MMC және RE бар немесе жоқтығы құжатталған.

Нәтижелер: 500 науқастың 20-да (4%) ортаңғы мезиялық канал, 52-де (10,4%) дистолингуал каналы және 30-да (6%) Radix Entomolaris болды.

Қорытынды: Қазақ популяциясында M1M арасында RE, MMC және DLC-тің айтарлықтай таралуы байқалады. Сонымен қатар, бұл анатомиялық вариациялар маңызды екі жақты көрініс көрсетті. Эндодонтологтар эндодонтиялық процедуралар кезінде ықтимал асқынуларды болдырмау үшін осы айырмашылықтарды білуі керек.

Түйінді сөздер: *конус сәулелік компьютерлік томография (КСКТ), ортаңғы мезиальді канал, Radix Entomolaris, дистолингвальды канал, түбір өзектерінің морфологиясы, таралу.*

Bibliographic citation:

Tulegenova I.M., Kopbayeva M.T., Omarova B.A., Suleymeneva D.M., Sagatbayeva A.D. Evaluation of root canal configuration of mandibular first molars in a Kazakhstan population by using cone-beam computed tomography // *Nauka i Zdravookhranenie* [Science & Healthcare]. 2023, (Vol.25) 6, pp. 122-127. *DOI 10.34689/SH.2023.25.6.014*

Тулегенова И.М., Копбаева М.Т., Омарова Б.А., Сулейменева Д.М., Сагатбаева А.Д. Оценка морфологии корневых каналов первых моляров нижней челюсти в казахстанской популяции с помощью конусно-лучевой компьютерной томографии // Наука и Здравоохранение. 2023. 6 (Т.25). С. 122-127. *DOI 10.34689/SH.2023.25.6.014*

Тулегенова И.М., Копбаева М.Т., Омарова Б.А., Сулейменева Д.М., Сагатбаева А.Д. Конус-сәулелік компьютер томографиясы арқылы Қазақстан популяциясының төменгі жақ бірінші молярлардың түбір каналының морфологиясын зерттеу // Ғылым және Денсаулық сақтау. 2023. 6 (Т.25). Б. 122-127. *DOI 10.34689/SH.2023.25.6.014*

Introduction

Chronic apical periodontitis continues to pose a significant challenge in the field of dentistry, despite the advent of cutting-edge technologies and novel approaches to endodontic treatment [15,18,19,22]. This ongoing issue underscores the importance of having an in-depth understanding of the root canal morphology, which serves as a cornerstone for the success of both surgical and non-surgical endodontic procedures [2,4,7].

The anatomy of root canals is complex and can vary widely not just between different individuals but also among multiple teeth within the same person [11,12,14]. There has been extensive discourse regarding the importance of identifying all the canals present in the root canal system for optimal results. Adding to this complexity are various anatomical features such as lateral canals, anastomoses, and deltoid branches, which provide conducive environments for microbial growth and further complicate the treatment landscape [6].

Anatomical complexities of the root canal system, buffer effects of dentin and the physical barrier of the biofilm formed by the matrix create obstacles for medical treatment of root canals. Emerging complications in the form of chronic apical periodontitis necessitate the study of the dynamics of the variability of the morphology of the root canal before the start of endodontic treatment. Several variables, including gender, geographic location, and ethnicity, have been shown to influence root canal morphology [10,11,13]. These factors imply that endodontic treatments should be individualized and adapted to the population demographics to achieve optimal outcomes [20]. It has been noted in the literature[1,5] that there are notable disparities in the root and canal structure of the mandible first molar among various ethnicities, indicating individual and potentially hereditary differences.

With the emergence of 3D imaging technologies such as Cone Beam Computed Tomography (CBCT), clinicians now have an invaluable tool for in vivo studies of root canal anatomy [8]. This advancement offers promising avenues for more accurate diagnostic processes and treatment planning, making it possible to address the complexities associated with variable root canal morphologies. The utilization of CBCT enables a more precise evaluation of root canal anatomy, especially in situations where conventional approaches like radiographs or clinical examination are inadequate. The adoption of cone beam computed tomography in endodontic practice has surged in recent times due to its capability to pinpoint the precise position and morphology of canals and detect periapical lesions. Moreover, it can assist in treatment planning by determining the count, curvatures, and positions of canals, as well as locating accessory canals. The implementation of cone beam computed tomography in endodontics has resulted in enhanced treatment planning and a more comprehensive comprehension of root canal anatomy.

Furthermore, CBCT provides precise measurements owing to the isotropic nature of its voxels. Previous research has demonstrated that cone beam computed tomography is a dependable imaging technique for accurately visualizing root canal morphology and can be employed for cross-sectional analysis with a substantial sample size [16].

Thus, the search for rational methods of improving treatment methods, including drug treatment of infected root canals, as well as the study of possible variations of root canal changes in different groups of teeth remains an urgent problem and we know that mandibular molars in need of endodontic treatment exhibit multiple variations. Typically, mandibular molars possess two roots, although on occasion, supplementary roots and canals may also be present.

This cross-sectional study aimed to assess the prevalence of Distolingual Canals (DLC), Radix Entomolaris (RE), and Middle Mesial Canals (MMC)of roots in Mandibular First Molars (M1M) among individuals of Kazakh nationality, using Cone Beam Computed Tomography (CBCT).

Materials and Methods

Study Population and Data Collection

This cross-sectional study was conducted at Kazakh National Medical University, also in the private clinic «Rahat» where archival data from 500 patients were analyzed to identify the presence of additional middle mesial canals on three planes - axial, coronal and saggital in mandibular first molars using Cone-Beam Computed Tomography (CBCT). The inclusion criterion was that the teeth under examination should be intact, meaning they had not previously undergone any form of treatment and the roots must have a fully formed apex, without any trauma and defects. When an additional root was discovered on the distal and lingual side of the mandibular first molar (M1M), it was documented as "RE" (radix entomolaris), and additional canal were noticed as middle mesial canal, canalis distolingualis. The presense of DLC, RE and MMC we (yes/no) was identified and recorded.

Data were collected by reviewing pre-existing Cone-Beam Computed Tomography scans in accordance with the guidelines set forth by the American Association of Endodontists and the Oral and Maxillofacial Radiologists. Demographic details, such as patient age and gender, were also recorded.

CBCT Imaging and Evaluation

The methodology for Cone-Beam Computed Tomography image screening involved assessing the mesial and distal roots of mandibular first molars in three planes—coronal, sagittal, and axial—following the three-dimensional alignment of the long axes of the roots with the reference lines in the visualization software. Specifically, the following criteria were evaluated for each molar:

The presence or absence of radix entomolaris, middle mesial canal, and distolingual canal of first molar of mandible was documented. Identification was based on descriptions provided by Calberson et al [6].

Analysis was performed at 0.5 mm intervals and a 1 mm thickness in the axial plane, utilizing the software program i-Dixel by J Morita Manufacturing Corp, Kyoto, Japan. Examinations were conducted in axial sections ranging from the coronal to the apical regions of the teeth [Figures 1-2] and voxel size was 100 to 150.

Ethical Considerations

All procedures performed in this study were in compliance with the ethical standards of the institutional research committee. Patients' data were anonymized and treated confidentially to ensure privacy. The study receive an ethical approval, protocol number 6 (142) dated July 03, 2023.

Statistical Processing

To assess the statistical significance of the observed distributions, we utilized the Chi-square test. The formula for the Chi-square test is as follows: Chi-square ($\chi 2$) = $\sum$(Chi- square ($\chi 2$) = $\sum$ Expectedi (Observed$_i$−Expected$_i$) 2

In this equation, Observed$_i$ refers to the observed frequency for each category, and Expected$_i$ denotes the expected frequency based on the sample's overall proportions.

We categorized the patient data by age and gender. We then evaluated the prevalence of additional canals of roots such as the distolingual canal, radix entomolaris, and middle mesial canal in Mandibular First Molars (M1Ms) across different age groups and between the sexes.

The Chi-square value was then calculated, and a p-value less than 0.05 was considered indicative of statistical significance. All statistical calculations were carried out using SPSS Version 25.

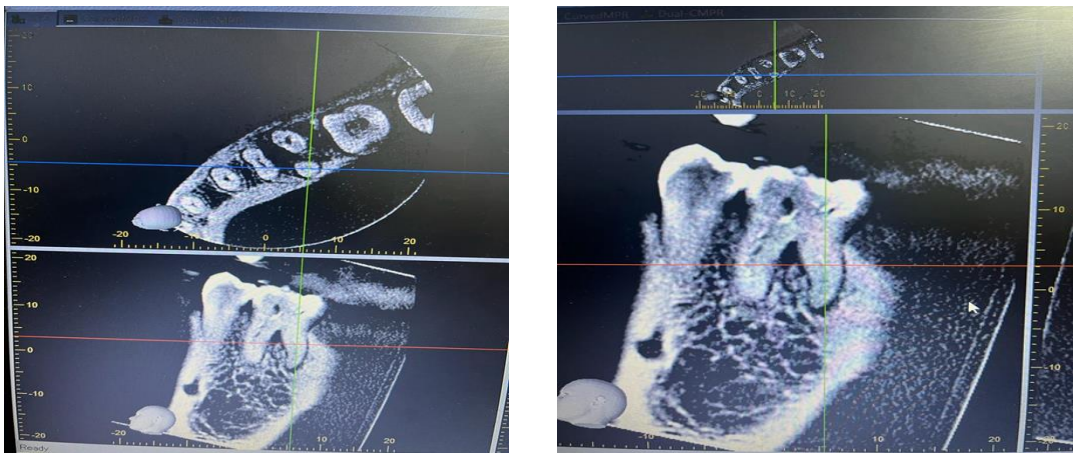

Figure 1. Axial cone-beam computed tomography sections of the mandibular first molar.

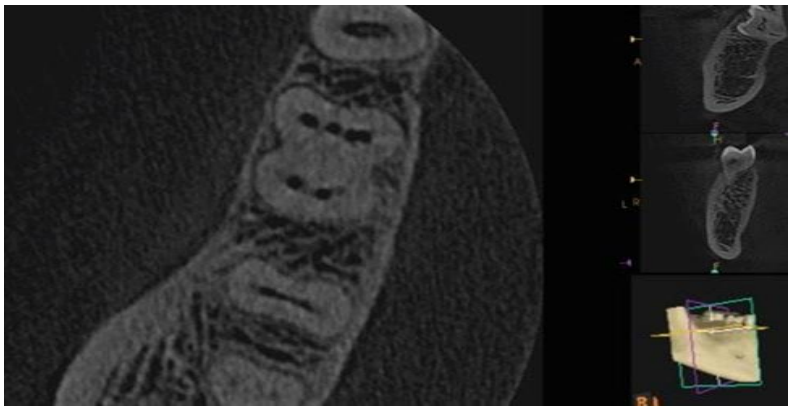

Figure 2. Axial cone beam computed tomography of the middle mesial canal of the first molar.

Results.

The age of the patients ranged from 13 to 56 years. Of these, 264 (52.8%) were male and 236 (47.2%) were female. The average age of the sample was 36.6 ± 3.7 years. The chi-square statistic calculated for this distribution is 1.568. The data in Table 1 indicate that there are no significant differences in the distribution of gender among the examined individuals, assuming an alpha level of 0.05 and 1 degree of freedom (df = 1), as the calculated chi-square value is below the critical chi-square value of 3.841

Table 1.

Demographic Distribution of Patients with Chi-Square Analysis.

Category	Observed (O)	Expected (E)	Percentage (%)	Chi-Square Contribution
Male Patients	264	250	52,8	0,784
Female Patients	236	250	47,2	0,784
Total	500	500	100,0	1,568

As shown in Table 2, the majority of the patients examined fell within the age range of 18 to 44 years, accounting for 376 individuals or 75.2% of the sample. This demographic primarily represents young adults in their most productive years. No significant gender differences were observed within this age group.

Table 2.

Age Distribution of Patients at the Time of Examination.

Age Range	Total	Female	Male	Percentage (%)
Under 18	56	36	20	11,2
18-44	376	191	185	75,2
45 and up	68	10	58	13,6
Total	500	-	-	100,0

As evident from Table 3, out of a total of 500 analysed patients' data, 245 (49%) were found to have additional dental canals. Of these, 151 (30.2%) were male patients and 94 (18.8%) were female patients. This suggests a clear male predominance with a higher likelihood of possessing additional dental canals in root system.

In terms of age distribution, particular attention was given to the age group 18-44 years, which constituted 196 (39.2%) of the surveyed population. Significant differences were found between patients both in terms of gender and age. Specifically, 30 (6%) male patients and 23 (4.6%) had a 46-distolingual canal. Additionally, 27 (5.4%) male and 19 (3.8%) female patients were found to have a 36-distolingual canal. Lastly, a radix entomolaris was identified in 20 (4%) male and 10 (2%) female patients in this age group.

Table 3.

Distribution of Patients Based on the Presence of Additional Dental Canals.

Observed Patients		Investigated Teeth and Canal Names						Number of Patients with Additional Canals (n/%)
		36-distolingual canal	36-Radix Entomolaris	36-Middle Mesial canal	46-distolingual canal	46-Radix Entomolaris	46-Middle Mesial canal	245/49%
Males (Under 18)	n	2	1	2	3	1	2	11
	%	10	5	10	15	5	10	2,2
Females (Under 18)	n	0	1	5	0	1	5	12
	%	0	2,7	13,8	0	2,7	13,5	2,4
Males (18-44)	n	27	19	9	30	20	11	116
	%	14,5	10,2	4,8	16,2	10,8	5,9	23,2
Females (18-44)	n	19	8	9	23	10	11	80
	%	10	4,2	4,7	12,1	5,2	5,7	16
Males (From 45 and above)	n	8	4	0	9	3	0	24
	%	13,8	6,8	0	15,5	5,1	0	4,8
Females (from 45 and above)	n	1	0	0	1	0	0	2
	%	10	0	0	10	0	0	0,4

Discussion

The present study aimed to investigate the prevalence of additional dental canals of roots, specifically the Distolingual Canal (DLC), Radix Entomolaris (RE), and Middle Mesial Canal (MMC) in Mandibular First Molars (M1Ms), among a population of Kazakh nationality using Cone Beam Computed Tomography (CBCT) images. A total of 500 patients were cross-sectional analyzed, including both males and females, across various age groups.

The study's findings suggest that additional dental canals are not uncommon. Specifically, 4% of the examined mandible first molar had middle mesial canal, 10.2% had canalis distolingualis, and 6% had radix entomolaris. The variations are particularly noteworthy and should be considered by endodontic clinicians for accurate diagnosis and effective treatment planning [23].

Our data show a slight gender disparity in the presence of additional canals. Males demonstrated a higher potential for additional dental canals with 30.2% of cases, compared to females at 18.8%. The age group of 18-44 was especially interesting as they represented 75.2% of the examined sample and also had the highest prevalence (39.2%) of additional dental canals of root system. These data imply that younger, working-age adults are more likely to require specialized endodontic treatment.

In terms of prevalence, our study found a lower percentage of middle mesial canal (4%) when compared to some previous studies, which reported a range of 5-15% for middle mesial canal [17]. The occurrence of middle mesial canals is relatively seldom. The prevalence of middle mesial canal of root is not affected by side, gender of the molar, or age. On the other hand, our figures for distolingual canal and radix entomolaris were generally higher; emphasizing the possibility that ethnicity could play a role in these anatomical variations. The variations between our study and previous works indicate the necessity of localized studies to better understand the epidemiology of these additional dental canals on morphology of the root system [9].

The gender disparity observed in our study corroborates findings from previous research, which also indicated a male predominance for certain dental anatomical features. However, most prior studies did not elaborate on age-based trends [21], making our findings in the 18-44 age group particularly significant for future research and clinical implications.

Interestingly, our study aligns with existing literature regarding the critical role of advanced imaging techniques like Cone-Beam Computed Tomography in identifying dental anatomical variations. Many studies have affirmed the superiority of CBCT over traditional X-ray imaging for endodontic applications, reinforcing our methodology and findings [3].

Clinical Implications

The high prevalence of additional canals of roots warrants a careful review by clinicians, as failure to identify and adequately treat these canals of root could lead to treatment failures and complications such as chronic apical periodontitis. Modern imaging techniques like Cone-Beam Computed Tomography are instrumental in identifying these variations, and the study underscores its utility in endodontic practice.

Limitations and Future Research

While the study provides valuable insights, it is limited by its retrospective nature and the focus on a specific ethnicity. Future research should consider a prospective study design and include a more diverse population for generalizable results.

Conclusion

In summary, our study has contributed significant findings to the field of endodontics by highlighting the prevalence of additional dental canals in Mandibular First Molars, with a specific focus on the Kazakh population and it is crucial for professionals to possess a comprehensive comprehension of root canal anatomy and account for possible anatomical deviations when formulating treatment strategies for their patients. Through taking these aspects into consideration, practitioners can enhance the caliber and effectiveness of their root canal therapies. The observed gender and age-based variations underscore the necessity for clinicians to employ advanced imaging techniques like Cone-Beam Computed Tomography for accurate diagnosis and treatment planning. Given the limitations of the study, future research is recommended to include a broader and more diverse population to enhance the generalizability of these findings.

Вклад авторов: *Все авторы принимали равноценное участие при написании статьи и заявляют об отсутствии конфликтов интересов.*

Финансирование: *при проведении данной работы не было финансирования сторонними организациями и медицинскими представительствами.*

Сведение о публикации*: результаты данного исследования не были опубликованы ранее в других журналах и не находятся на рассмотрении в других издательствах.*

Literature:

1. *Al-Maswary A.A. et al.* The Global Prevalence of Middle Mesial Canal in Mandibular First and Second Molars Assessed by Cone Beam Computed Tomography: A Systematic Review and Meta-Analysis // J Endod. 2023 Jun. 49(6):638-656. doi:10.1016/j.joen.2023.04.008.

2. *Bajoria A.A., Sarkar S., Sinha P.* Evaluation of Odontogenic Maxillary Sinusitis with Cone Beam Computed Tomography: A Retrospective Study with Review of Literature // J Int Soc Prev Community Dent. 2019. 9(2):194-20

3. *Barros-Costa M., Ferreira M.D. et al.* Middle mesial root canals in mandibular molars: prevalence and correlation to anatomical aspects based on CBCT imaging // Dentomaxillofac Radiol. 2022. 51(8):20220156.

4. *Braz-Silva P.H., Bergamini M.L., Mardegan A.P. et al.* Inflammatory profile of chronic apical periodontitis: a literature review // Acta Odontol Scand. 2019 Apr. 77(3):173-180. doi: 10.1080/00016357.2018.1521005. Epub 2018 Dec 26. PMID: 30585523.

5. *Bürklein S., Heck R., Schäfer E.* Evaluation of the Root Canal Anatomy of Maxillary and Mandibular Premolars in a Selected German Population Using Cone-beam Computed Tomographic Data // J Endod. 2017. 43(9):1448-1452.

6. *Calberson F.L., De Moor R.J., Deroose C.A.* The radix entomolaris and paramolaris: clinical approach in endodontics // J Endod. 2007. 33(1):58-63.

7. *Chugal N.M., Clive J.M., Spangberg LS.* Endodontic infection: some biologic and treatment factors associated with outcome // Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003 Jul. 96(1):81-90. doi: 10.1016/s1079-2104(02)91703-8. PMID: 12847449.

8. *De Paula-Silva F.W., Wu M.K., Leonardo M.R., da Silva L.A., Wesselink P.R.* Accuracy of periapical radiography and cone-beam computed tomography scans in diagnosing apical periodontitis using histopathological findings as a gold standard // J Endod. 2009. 35(7):1009-1012.

9. *Hasheminia M., Razavian H., Khorrami L., Mosleh H., Mohamadi S.* Prevalence of middle mesial canal in mandibular first molars using cone-beam computed tomography technique // Dent Res J (Isfahan). 2021.18:42.

10. *Martins J.N., Marques D., Francisco H., Carames J.* Gender influence on the number of roots and root canal system configuration in human permanent teeth of a Portuguese subpopulation // Quintessence Int. 2018.49(2):103-111.

11. *Marton I.J.* The influence of chronic apical periodontitis on oral and general health // Fogorv Sz. 2007 Oct.100(5):200-9, 193-9. English, Hungarian. PMID: 18078141.

12. *Mashyakhy M., Awawdeh M., Abu-Melha A. et al.* Anatomical Evaluation of Root and Root Canal Configuration of Permanent Maxillary Dentition in the Population of the Kingdom of Saudi Arabia // *Biomed Res Int.* 2022; 2022:3428229.

13. *Mashyakhy M.* Anatomical Evaluation of Maxillary Premolars in a Saudi Population: An In Vivo Cone-beam Computed Tomography Study // J Contemp Dent Pract. 2021. 22(3):284-289.

14. *Mohammadi Z., Jafarzadeh H., Shalavi S., Bandi S., Patil S.* Root and Root Canal Morphology of Human Third Molar Teeth // J Contemp Dent Pract. 2015.16(4):310-313.

15. *Nair P.N.* On the causes of persistent apical periodontitis: a review // Int Endod J. 2006 Apr.39(4):249-81. doi:10.1111/j.1365-2591.2006.01099.x. PMID:16584489.

16. *Patel S., Durack C., Abella F., et al.* Cone beam computed tomography in Endodontics - a review // Int Endod J. 2015 Jan.48(1):3-15. doi: 10.1111/iej.12270.

17. *Rödig T., Hülsmann M.* Diagnosis and root canal treatment of a mandibular second premolar with three root canals // Int Endod J. 2003. 36(12):912-919.

18. *Rouhani A., Aboutorabzadeh S.M., Reyhani M., et al.* Prevalence of missed canals in endodontically treated teeth: A cone-beam computed tomography study // J Clin Exp Dent. 2023 Aug 1. 15(8):e605-e611. doi: 10.4317/jced.60282. PMID: 37674603. PMCID: PMC10478193.

19. *Sobieszczański J., Mertowski S., Sarna-Boś K., et al.* Root Canal Infection and Its Impact on the Oral Cavity Microenvironment in the Context of Immune System Disorders in Selected Diseases: A Narrative Review // J Clin Med. 2023 Jun 17;12(12):4102. doi: 10.3390/jcm12124102.

20. *Salehrabi R., Rotstein I.* Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study // J Endod. 2004. 30(12):846-850.

21. *Tahmasbi M., Jalali P. et al.* Prevalence of Middle Mesial Canals and Isthmi in the Mesial Root of Mandibular Molars: An In Vivo Cone-beam Computed Tomographic Study // J Endod. 2017. 43(7):1080-1083.

22. *Tibúrcio-Machado C.S., Michelon C., Zanatta F.B., et al.* The global prevalence of apical periodontitis: a systematic review and meta-analysis // Int Endod J. 2021.54(5):712-735.

23. *Versiani M.A., Ordinola-Zapata R. et al.* Middle mesial canals in mandibular first molars: A micro-CT study in different populations // Arch Oral Biol. 2016.61:130-137.

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