

Retreatment Of Root Canals In Maxillary Molars Due To Missing Second Mesiobuccal Canals And Its Association With Gender

Research Article

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Abstract

The knowledge of root canal morphology determines the success of endodontically treated teeth, especially the anatomy of the maxillary molars as its mesiobuccal root has two distinct canals. Majority of failures in maxillary molars result from missing the second mesiobuccal (MB2) canal, as it is present in 50% to 90% of maxillary molars. The aim of the study was to evaluate the association between retreatment of root canals in maxillary molars due to missing second mesiobuccal canal and gender. This study was conducted among patients visiting the outpatient department of a private dental college from June 2019 to March 2020. The data was formulated by reviewing the case sheets of patients and the data was statistically analysed using Statistical Package for Social Sciences (SPSS) software. The current study shows retreatment of root canals in maxillary molars due to missed second mesiobuccal canal was 9.7%. It was more prevalent in the right maxillary first molars (6.5%) compared to left maxillary first molars (3.2%) in which males (6.5%) had higher occurrence rate than females (3.2%). Pearson's Chi Square value: 3.389, p value: 0.06 (>0.05). No significant association was found between gender and retreatment due to missed second mesiobuccal canal.

Keywords: Maxillary Molar; Second Mesiobuccal Canal; Retreatment; Gender.

Introduction

Anatomical variations impose certain limitations to the chemico-mechanical preparation of the root canal causing certain areas of the root canal to not be accessed by the instrument, leading to failure of cases. These anatomical variations are of utmost importance, especially in maxillary molars as they present a number of main canals. Previous studies have reported variations in palatal, mesiobuccal and distobuccal canals of maxillary molars [1-3]. Most often, these variations are seen in the mesiobuccal root when compared to the palatal root. This canal is known as the second mesiobuccal canal or MB2, as a simplified name [3]. In 1925, Hess was the first to report the presence of these canals [4].

When a root canal treatment becomes unsuccessful, the clinician is challenged to make a decision that solves the problem. Hence, a proper diagnosis is required to deal with the clinical management

of the situation [5, 6]. In instances where the failure occurred due to short fillings in straight canals or under-instrumented roots, it can be managed easily [7, 8]. However, failure of treatment that occurs due to missed canals can be managed either by microsurgery or non-surgical root canal retreatment [9, 10].

It is essential to know the root and canal morphology of each tooth as the knowledge of this is important for the planning of endodontic treatment and its success [11]. The presence of a MB2 in maxillary molars is said to range from 50% to 90% of cases [3, 12]. The success of the treatment relies on detecting all canals that can then be disinfected, cleaned, shaped, and obturated [13-15]. Most of the failed root canal treatments are due to missed MB2 canals, in maxillary first second molar [16-19]. The mesiobuccal root of the maxillary first molar has led to more research [20], because it consists of an extra root canal, known as the MB2 canal [21]. In the maxillary first molars, the MB2 canal departs the

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chamber at a sharp mesial inclination, then bending distally, making its detection very challenging [22, 23]. The difficulty to detect the second mesiobuccal canal is one of the main reasons for endodontic failure in maxillary first molars [24, 25]. Endodontically retreated teeth were found to contain more undetected MB2 canals, suggesting that failure of endodontic treatment has occurred due to missing out on the existing MB2 canals which eventually leads to a poorer prognosis of that tooth [26, 27].

When the MB2 canal is not found in the initial treatment, several retreatments are performed, aiming to address the cases of missed second mesiobuccal canals [28]. Therefore, the clinician should approach in the best possible manner [29], as it is important to access the proper location of MB2 canals and they are essential for the successful treatment of maxillary molars [30]. The clinician should be able to locate and manage these cases in the initial treatment and also choose the best option when the initial treatment fails. Previously our team has a rich experience in working on various research projects across multiple disciplines [31-45].

In our study we aim to evaluate the association between retreatment of root canals in maxillary molars due to missing second mesiobuccal canal and gender.

Materials and Methods

Study Setting

The present retrospective study was conducted in a University setting with an advantage of a wide range of availability of data. Ethical clearance for this study was obtained from the Institutional Ethical Committee - SDC/SIHEC/2020/DIASDA-TA/0619-0320. The population included in the study were 31 patients who underwent retreatment of root canal in maxillary molars due to missed MB2 canal at the Conservative dentistry and Endodontics Department. Two examiners were involved in the study.

Study design

The study was designed based on the set inclusion criteria of patients from the out patient department who underwent retreatment of root canals in maxillary molars due to missed MB2 canal. Cases which did not fall under this inclusion criteria were excluded from the study.

Sampling

The study was based on non probability convenience sampling. To minimize the sampling bias, all the case sheets of patients who underwent retreatment of root canals in maxillary molars due to missed MB2 canal were reviewed and included.

Data Collection and Tabulation

This study is a retrospective study where the data was collected by reviewing the case records of the patients visiting the out patient department of a private dental college from June 2019 to March 2020. The collected data included the following parameters: Patients details: Name, Age, Gender, Patient identification number and the presence of retreatment of root canals in maxillary molars due to missed MB2 canal were recorded. A total of 86,000 case sheets and radiographs associated with the case sheets were reviewed and the data of 31 patients who underwent retreatment of root canals in maxillary molars due to missed MB2 canal was further analysed. Cross verification of the data was done by a reviewer.

Results and Discussion

This study shows that 9.7% of retreatment was due to missed MB2 canals. (Figure 1) Retreatment in right maxillary first molar (16) - 54.8%, right maxillary second molar (17) - 3.2%, left maxillary first molar (26) - 38.7%, left maxillary second molar (27) - 3.2%. (Figure 2) Retreatment due to a missed MB2 canal in the right maxillary first molar (16) is 6.5% and left maxillary first molar (26) is 3.2% respectively. (Figure 3) Retreatment was more prevalent in males, 71% than in females 29%. (Figure 4) Retreatment due to missed MB2 canal was more prevalent in males, 6.5% than in females. (Figure 5)

Based on the results of this study we can see that retreatment of root canals in maxillary molars due to missed MB2 is 9.7%. Similar studies were done by Wolcott et al.,(26)[46] Sempira et al.,[47] Baruwa et al., [48] Costa et al., [49] and Nascimento et al. [50]. Wolcott et al. [46] states that the incidence of second mesiobuccal canal in first maxillary molar retreatment was 67% and the incidence of second mesiobuccal canal in maxillary second molar retreatment was 44% when compared to initial treatment. Sempira et al. [47] stated in his study that two hundred maxillary first molars and maxillary second molars were evaluated with the help

Figure 1. Bar chart represents the prevalence of retreatment due to missed MB2 canal in maxillary molars. X axis represents retreatment due to missed MB2 canals and Y axis represents the percentage of patients undergoing retreatment. The prevalence of retreatment in maxillary molars due to missed MB2 canal was less (9.7%) compared to the overall retreatment cases (90.3%).

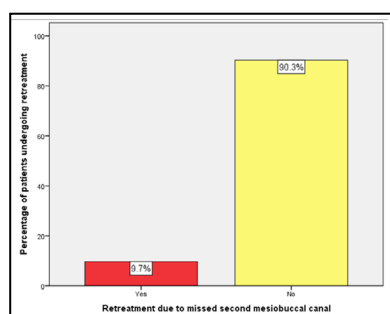


Figure 2. Bar chart represents the prevalence of overall retreatment in various maxillary molars. X axis represents the various tooth numbers and Y axis represents the percentage of teeth undergoing overall retreatment. The prevalence of overall retreatment in maxillary molars was higher in tooth number 16 (54.8%) compared to others.

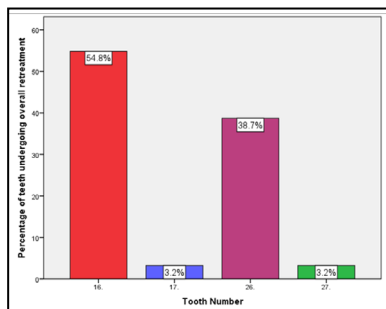


Figure 3. Bar chart represents the association between various teeth and retreatment due to missed MB2 canal compared to other reasons. X axis represents the various teeth and Y axis represents the number of teeth undergoing retreatment. [Pearson’s Chi Square value = 0.324a , df = 3, p value = 0.955 (>0.05), hence statistically not significant]. The prevalence of retreatment due to missed MB2 canal was higher in tooth number 16 (6.5%) when compared to others and the difference was statistically not significant.

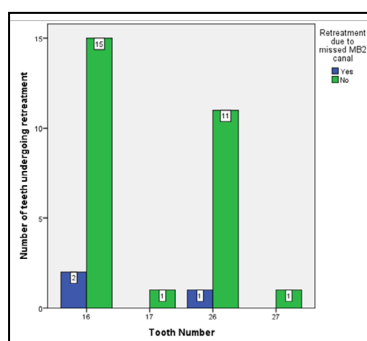


Figure 4. Bar chart represents the prevalence of overall retreatment among males and females. X axis represents the gender and Y axis represents the percentage of patients undergoing retreatment. The prevalence of overall retreatment was higher in males (71.0%) when compared to females (29.0%).

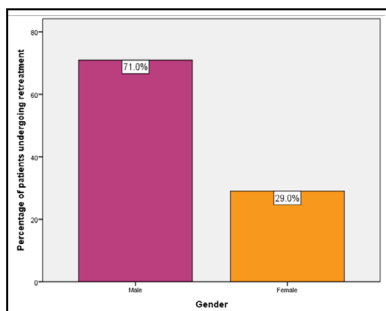
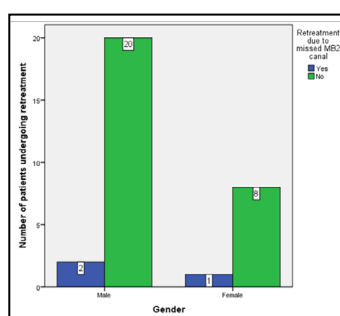


Figure 5. Bar chart represents the association between gender and retreatment due to missed MB2 canal compared to other reasons. X axis represents the gender and Y axis represents the number of patients undergoing retreatment. [Pearson’s Chi Square value = 0.030a , df = 1, p value = 0.863 (>0.05), hence statistically not significant] Retreatment due to missed MB2 canal was more in males (6.5%) when compared to females (3.2%) which shows the results are statistically not significant.



of a microscope, in which MB2 canal was present in 30% percent of all maxillary molars. When evaluated separately, 33.1% of the maxillary first molars and 24.3% of the maxillary second molars had MB2 canal. In a study by Costa et al. [49] 2294 teeth with evidence of root fillings were identified, out of which two hundred and eighty one teeth were assessed and 12% had at least one untreated missed canal. The mesiobuccal roots of maxillary first molars had the greatest frequency of untreated canals, with the

second mesiobuccal canal being the most frequently missed canal. Six hundred eighteen endodontically treated teeth were evaluated and 59.3% root canals showed failure in a study conducted by Nascimento et al. [50]. Underfilling was the most frequent technical error for failure in all root canals, except for the second mesiobuccal root canal of maxillary molars which were missed in 78.4% of the cases. Baruwa et al. [48] states that the root presenting with the highest percentage of 62.8% of missed canals was

the second mesiobuccal root of the maxillary first molar.

Based on prevalence of retreatment of root canals and its association with gender, our study shows male predilection. 71% of males had retreatment when compared to females. Retreatment of root canals due to missed second mesiobuccal canal was also more prevalent in males (6.5%). This is in line with the studies conducted by [51-53] except [54], where Al-Rahabi states that his study had more female predilection than male predilection.

Loupes, microscopes, radiographs and cone beam computed tomography (CBCT) have been used for better access, detection and treatment of the second mesiobuccal canal of maxillary first molars [55, 56]. By using better access techniques, Weller et al [55] recorded a MB2 canal in 39% of his sample of maxillary first molars and 21.4% in the maxillary second molars. This technique helped to prepare a rhomboidal shape access and a thorough probing of the groove between the mesial and palatal canals with a sharp endodontic explorer [57]. MB2 is typically located under a layer of dentin that sits on the pulp floor, known as the “dentin shelf” [58]. This needs to be removed in order to uncover the MB2 orifice. These techniques will eventually lead to higher endodontic quality treatment and better outcomes [59]. Our institution is passionate about high quality evidence based research and has excelled in various fields [60-70].

The limitations of the study include small sample size, single centered study and cannot be generated into a larger population. For future scope, a larger sample size along with further diagnosis and treatment plan will be beneficial.

Conclusion

Within the limits of the study, we observed that retreatment of root canals in maxillary molars due to missed MB2 was 9.7% and it was more prevalent in the maxillary first molars. Incidence of overall retreatment and retreatment due to missed MB2 canals was more prevalent in males than in females.

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Author's Contribution

First author (Fathima Bareera Rezvi) performed the analysis, and interpretation and wrote the manuscript. Second author (Dr. Adimalapu Hima Sandeep) contributed to conception, data design analysis, interpretation and critically revised the manuscript. Third author (Dr. Manjary Chaudhary) participated in the study and revised the manuscript. All the authors have discussed the results and contributed to the final manuscript.

References

- Christie WH, Peikoff MD, Fogel HM. Maxillary molars with two palatal roots: a retrospective clinical study. *J Endod.* 1991 Feb;17(2):80-4. Pubmed PMID: 1919407.
- Fogel HM, Cunha RS. Maxillary First Molars with 2 Distobuccal Canals: A Case Series. *J Endod.* 2017 Nov;43(11):1925-1928. Pubmed PMID: 28967494.
- Kulid JC, Peters DD. Incidence and configuration of canal systems in the mesiobuccal root of maxillary first and second molars. *J Endod.* 1990 Jul 1;16(7):311-7.
- Ibarrola JL, Knowles KI, Ludlow MO, McKinley IB Jr. Factors affecting the negotiability of second mesiobuccal canals in maxillary molars. *J Endod.* 1997 Apr;23(4):236-8. Pubmed PMID: 9594773.
- Ramamoorthi S, Nivedhitha MS, Divyanand MJ. Comparative evaluation of postoperative pain after using endodontic needle and EndoActivator during root canal irrigation: A randomized controlled trial. *Aust Endod J.* 2015 Aug;41(2):78-87. Pubmed PMID: 25195661.
- Jose J, Subbaiyan H. Different treatment modalities followed by dental practitioners for Ellis class 2 fracture—A questionnaire-based survey. *Open Dent J.* 2020 Feb 18;14(1):59-65.
- Manohar MP, Sharma S. A survey of the knowledge, attitude, and awareness about the principal choice of intracanal medicaments among the general dental practitioners and nonendodontic specialists. *Indian J Dent Res.* 2018 Nov-Dec;29(6):716-720. Pubmed PMID: 30588997.
- Nandakumar M, Nasim I. Comparative evaluation of grape seed and cranberry extracts in preventing enamel erosion: An optical emission spectrometric analysis. *J Conserv Dent.* 2018 Sep-Oct;21(5):516-520. Pubmed PMID: 30294113.
- Tawil PZ, Saraiya VM, Galicia JC, Duggan DJ. Periapical microsurgery: the effect of root dental defects on short- and long-term outcome. *J Endod.* 2015 Jan;41(1):22-7. Pubmed PMID: 25282374.
- Rajendran R, Kunjusankaran RN, Sandhya R, Anilkumar A, Santhosh R, Patil SR. Comparative evaluation of remineralizing potential of a paste containing bioactive glass and a topical cream containing casein phosphopeptide-amorphous calcium phosphate: An in vitro study. *Pesqui Bras Odontopediatria Clin Integr.* 2019 Oct 10;19:1-10.
- Kumar D, Antony S. Calcified canal and negotiation—A review. *Res J Pharm Technol.* 2018;11(8):3727-30.
- Hiebert BM, Abramovitch K, Rice D, Torabinejad M. Prevalence of Second Mesiobuccal Canals in Maxillary First Molars Detected Using Cone-beam Computed Tomography, Direct Occlusal Access, and Coronal Plane Grinding. *J Endod.* 2017 Oct;43(10):1711-1715. Pubmed PMID: 28735796.
- Baratto Filho F, Zaitter S, Haragushiku GA, de Campos EA, Abuabara A, Correr GM. Analysis of the internal anatomy of maxillary first molars by using different methods. *J Endod.* 2009 Mar 1;35(3):337-42.
- Teja KV, Ramesh S. Shape optimal and clean more. *Saudi Endod. J.* 2019 Sep 1;9(3):235.
- Noor SS. Chlorhexidine: Its properties and effects. *Res J Pharm Technol.* 2016;9(10):1755-60.
- Betancourt P, Navarro P, Muñoz G, Fuentes R. Prevalence and location of the secondary mesiobuccal canal in 1,100 maxillary molars using cone beam computed tomography. *BMC Med Imaging.* 2016 Dec 1;16(1):66. Pubmed PMID: 27908285.
- Witherspoon DE, Small JC, Regan JD. Missed canal systems are the most likely basis for endodontic retreatment of molars. *Tex Dent J.* 2013 Feb;130(2):127-39. Pubmed PMID: 23930451.
- Kim Y, Lee SJ, Woo J. 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. *J Endod.* 2012 Aug;38(8):1063-8. Pubmed PMID: 22794206.
- Patel S, Brown J, Pimentel T, Kelly RD, Abella E, Durack C. Cone beam computed tomography in endodontics—a review of the literature. *Int. Endod. J.* 2019 Aug;52(8):493.
- Cleghorn BM, Christie WH, Dong CC. Root and root canal morphology of the human permanent maxillary first molar: a literature review. *J Endod.* 2006 Sep 1;32(9):813-21.
- Stropko JJ. Canal morphology of maxillary molars: clinical observations of canal configurations. *J Endod.* 1999 Jun 1;25(6):446-50.
- Görduysus MO, Görduysus M, Friedman S. Operating microscope improves negotiation of second mesiobuccal canals in maxillary molars. *J Endod.* 2001 Nov;27(11):683-6. Pubmed PMID: 11716081.
- Siddique R, Sureshbabu NM, Somasundaram J, Jacob B, Selvam D. Qualitative and quantitative analysis of precipitate formation following interaction of chlorhexidine with sodium hypochlorite, neem, and tulsi. *J Conserv Dent.* 2019 Jan-Feb;22(1):40-47. Pubmed PMID: 30820081.
- Henry BM. The fourth canal: its incidence in maxillary first molars. *J Can Dent Assoc.* 1993 Dec 1;59(12):995-6.
- Ramanathan S, Solete P. Cone-beam Computed Tomography Evaluation of Root Canal Preparation using Various Rotary Instruments: An in vitro Study. *J Contemp Dent Pract.* 2015 Nov 1;16(11):869-72.
- Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S, Meyers J. A 5 yr clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. *J Endod.* 2005 Apr;31(4):262-4. Pubmed PMID: 15793380.

- [27]. Rajakeerthi R, Nivedhitha MS. Natural Product as the Storage medium for an avulsed tooth-A Systematic Review. *Cumhuriyet Dent J*. 2019 Jun 11;22(2):249-56.
- [28]. Janani K, Palanivelu A, Sandhya R. Diagnostic accuracy of dental pulse oximeter with customized sensor holder, thermal test and electric pulp test for the evaluation of pulp vitality: an in vivo study. *Braz. Dent. Sci.* 2020 Jan 31;23(1):8.
- [29]. Coelho MS, Lacerda MFLS, Silva MHC, Rios MA. Locating the second mesiobuccal canal in maxillary molars: challenges and solutions. *Clin Cosmet Investig Dent*. 2018 Sep 20;10:195-202. Pubmed PMID: 30288125.
- [30]. Hussainy SN, Nasim I, Thomas T, Ranjan M. Clinical performance of resin-modified glass ionomer cement, flowable composite, and polyacid-modified resin composite in noncarious cervical lesions: One-year follow-up. *J Conserv Dent*. 2018 Sep-Oct;21(5):510-515. Pubmed PMID: 30294112.
- [31]. Hafeez N. Accessory foramen in the middle cranial fossa. *Res J Pharm Technol*. 2016;9(11):1880-2.
- [32]. Krishnan RP, Ramani P, Sherlin HJ, Sukumaran G, Ramasubramanian A, Jayaraj G, et al. Surgical Specimen Handover from Operation Theater to Laboratory: A Survey. *Ann Maxillofac Surg*. 2018 Jul-Dec;8(2):234-238. Pubmed PMID: 30693238.
- [33]. Somasundaram S, Ravi K, Rajapandian K, Gurunathan D. Fluoride Content of Bottled Drinking Water in Chennai, Tamilnadu. *J Clin Diagn Res*. 2015 Oct;9(10):ZC32-4. Pubmed PMID: 26557612.
- [34]. Felicita AS. Orthodontic extrusion of Ellis Class VIII fracture of maxillary lateral incisor - The sling shot method. *Saudi Dent J*. 2018 Jul;30(3):265-269. Pubmed PMID: 29942113.
- [35]. Kumar S, Rahman R. Knowledge, awareness, and practices regarding biomedical waste management among undergraduate dental students. *Asian J Pharm Clin Res*. 2017;10(8):341.
- [36]. Gurunathan D, Shanmugaavel AK. Dental neglect among children in Chennai. *J Indian Soc Pedod Prev Dent*. 2016 Oct 1;34(4):364.
- [37]. Sneha S. Knowledge and awareness regarding antibiotic prophylaxis for infective endocarditis among undergraduate dental students. *Asian J Pharm Clin Res*. 2016 Oct 1:154-9.
- [38]. Dhinesh B, Lalvani JJ, Parthasarathy M, Annamalai K. An assessment on performance, emission and combustion characteristics of single cylinder diesel engine powered by Cymbopogon flexuosus biofuel. *Energy Convers. Manag*. 2016 Jun 1;117:466-74.
- [39]. Choudhari S, Thenmozhi MS. Occurrence and Importance of Posterior Condylar Foramen. *Res J Pharm Technol*. 2016;9(8):11-43.
- [40]. Paramasivam A, Vijayashree Priyadharsini J, Raghunandhakumar S. N6-adenosine methylation (m6A): a promising new molecular target in hypertension and cardiovascular diseases. *Hypertens Res*. 2020 Feb;43(2):153-154. Pubmed PMID: 31578458.
- [41]. Wu F, Zhu J, Li G, Wang J, Veeraraghavan VP, Krishna Mohan S, et al. Biologically synthesized green gold nanoparticles from Siberian ginseng induce growth-inhibitory effect on melanoma cells (B16). *Artif Cells Nanomed Biotechnol*. 2019 Dec;47(1):3297-3305. Pubmed PMID: 31379212.
- [42]. Palati S, Ramani P, Shrelin HJ, Sukumaran G, Ramasubramanian A, Don KR, et al. Knowledge, Attitude and practice survey on the perspective of oral lesions and dental health in geriatric patients residing in old age homes. *Indian J Dent Res*. 2020 Jan-Feb;31(1):22-25. Pubmed PMID: 32246676.
- [43]. Saravanan M, Arokiyaraj S, Lakshmi T, Pugazhendhi A. Synthesis of silver nanoparticles from Phenerochaete chrysosporium (MTCC-787) and their antibacterial activity against human pathogenic bacteria. *Microb Pathog*. 2018 Apr;117:68-72. Pubmed PMID: 29427709.
- [44]. Govindaraju L, Gurunathan D. Effectiveness of Chewable Tooth Brush in Children-A Prospective Clinical Study. *J Clin Diagn Res*. 2017 Mar;11(3):ZC31-ZC34. Pubmed PMID: 28511505.
- [45]. Vijayakumar Jain S, Muthusekhar MR, Baig MF, Senthilnathan P, Loganathan S, Abdul Wahab PU, et al. Evaluation of Three-Dimensional Changes in Pharyngeal Airway Following Isolated Lefort One Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study. *J Maxillofac Oral Surg*. 2019 Mar;18(1):139-146. Pubmed PMID: 30728705.
- [46]. Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S. Clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. *J Endod*. 2002 Jun 1;28(6):477-9.
- [47]. Sempira HN, Hartwell GR. Frequency of second mesiobuccal canals in maxillary molars as determined by use of an operating microscope: a clinical study. *J Endod*. 2000 Nov;26(11):673-4. Pubmed PMID: 11469299.
- [48]. Baruwa AO, Martins JNR, Meirinhos J, Pereira B, Gouveia J, Quaresma SA, et al. The Influence of Missed Canals on the Prevalence of Periapical Lesions in Endodontically Treated Teeth: A Cross-sectional Study. *J Endod*. 2020 Jan;46(1):34-39.e1. Pubmed PMID: 31733814.
- [49]. Costa FF, Pacheco-Yanes J, Siqueira Jr JF, Oliveira AC, Gazzaneo I, Amorim CA, et al. Association between missed canals and apical periodontitis. *Int Endod J*. 2019 Apr;52(4):400-6.
- [50]. Nascimento EHL, Gaêta-Araujo H, Andrade MFS, Freitas DQ. Prevalence of technical errors and periapical lesions in a sample of endodontically treated teeth: a CBCT analysis. *Clin Oral Investig*. 2018 Sep;22(7):2495-2503. Pubmed PMID: 29354883.
- [51]. Martins JNR, Marques D, Silva EJNL, Caramês J, Mata A, Versiani MA. Second mesiobuccal root canal in maxillary molars-A systematic review and meta-analysis of prevalence studies using cone beam computed tomography. *Arch Oral Biol*. 2020 May;113:104589. Pubmed PMID: 31735252.
- [52]. Hasan M, Raza Khan F. Determination of frequency of the second mesiobuccal canal in the permanent maxillary first molar teeth with magnification loupes (× 3.5). *Int J Biomed Sci*. 2014 Sep;10(3):201-7. Pubmed PMID: 25324702.
- [53]. Abd Rahman N, Halim M, Khamis M, Abd Ghani H. Analysis of root and canal morphology of maxillary first and second molars among Malay ethnic in the Malaysian population with the aid of cone-beam computed tomography: A retrospective study. *European J Gen Dent*. 2020 May 1;9(2):84.
- [54]. Alrahabi M, Younes HB. A cross-sectional study of the quality of root canal treatment in Al-Madinah Al-Munawwarah. *Saudi Endodontic Journal*. 2016 Jan 1;6(1):31. Alrahabi MK, Younes HB. A cross-sectional study of the quality of root canal treatment in Al-Madinah Al-Munawwarah. *Saudi Endod. J*.
- [55]. Weller RN, Hartwell GR. The impact of improved access and searching techniques on detection of the mesiolingual canal in maxillary molars. *J Endod*. 1989 Feb;15(2):82-3.
- [56]. Teja KV, Ramesh S, Priya V. Regulation of matrix metalloproteinase-3 gene expression in inflammation: A molecular study. *J. Conserv. Dent*. 2018 Nov;21(6):592.
- [57]. Hartwell G, Bellizzi R. Clinical investigation of in vivo endodontically treated mandibular and maxillary molars. *J Endod*. 1982 Dec;8(12):555-7. Pubmed PMID: 6962275.
- [58]. Vertucci FJ. Root canal anatomy of the human permanent teeth. *Oral Surg Oral Med Oral Pathol*. 1984 Nov 1;58(5):589-99.
- [59]. Ravinthar K. Recent advancements in laminates and veneers in dentistry. *Res J Pharm Technol*. 2018;11(2):785-7.
- [60]. Vijayashree Priyadharsini J. In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. *J Periodontol*. 2019 Dec;90(12):1441-1448. Pubmed PMID: 31257588.
- [61]. Pc J, Marimuthu T, Devadoss P, Kumar SM. Prevalence and measurement of anterior loop of the mandibular canal using CBCT: A cross sectional study. *Clin Implant Dent Relat Res*. 2018 Apr 6;20(4):531-4.
- [62]. Ramesh A, Varghese S, Jayakumar ND, Malaiappan S. Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study. *J Periodontol*. 2018 Oct;89(10):1241-1248. Pubmed PMID: 30044495.
- [63]. Ramadurai N, Gurunathan D, Samuel AV, Subramanian E, Rodrigues SJ. Effectiveness of 2% Articaine as an anesthetic agent in children: randomized controlled trial. *Clin Oral Investig*. 2019 Sep;23(9):3543-50.
- [64]. Sridharan G, Ramani P, Patankar S, Vijayaraghavan R. Evaluation of salivary metabolomics in oral leukoplakia and oral squamous cell carcinoma. *J Oral Pathol Med*. 2019 Apr;48(4):299-306.
- [65]. Ezhilarasan D, Apoorva VS, Ashok Vardhan N. Syzygium cumini extract induced reactive oxygen species-mediated apoptosis in human oral squamous carcinoma cells. *J Oral Pathol Med*. 2019 Feb;48(2):115-121. Pubmed PMID: 30451321.
- [66]. Mathew MG, Samuel SR, Soni AJ, Roopa KB. Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: randomized controlled trial. *Clin Oral Investig*. 2020 Sep;24(9):1-6. Pubmed PMID: 31955271.
- [67]. Samuel SR. Can 5-year-olds sensibly self-report the impact of developmental enamel defects on their quality of life? *Int J Paediatr Dent*. 2021 Mar;31(2):285-286. Pubmed PMID: 32416620.
- [68]. R H, Ramani P, Ramanathan A, R JM, S G, Ramasubramanian A, et al. CYP2 C9 polymorphism among patients with oral squamous cell carcinoma and its role in altering the metabolism of benzo[a]pyrene. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2020 Sep;130(3):306-312. Pubmed PMID: 32773350.
- [69]. Chandrasekar R, Chandrasekar S, Sundari KKS, Ravi P. Development and validation of a formula for objective assessment of cervical vertebral bone age. *Prog Orthod*. 2020 Oct 12;21(1):38. Pubmed PMID: 33043408.
- [70]. Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. In silico analysis of virulence genes in an emerging dental pathogen *A. baumannii* and related species. *Arch Oral Biol*. 2018 Oct;94:93-98. Pubmed PMID: 30015217.