

IMPACT OF THE QUALITY OF ROOT CANAL FILLING ON THE PERIAPICAL STATUS

Lidija Popovska

Faculty of Dental Medicine, University of “Ss. Cyril and Methodius” Skopje, North Macedonia,
lpopovska@stomfak.edu.mk

Abstract: The relationship between the quality of endodontic treatment and the prevalence of apical periodontitis has been demonstrated in a number of epidemiological studies. In addition to providing insight into the oral health status of the population, epidemiological studies are a relevant source of data for health care policy and further planning directions. The aim of the study was to obtain detailed data on the quality of root canal treatments performed through radiological examination, the frequency of periapical changes in treated teeth and their relationship with the quality of endodontic treatments. Methods: The material required for the realization of the set goal was 1300 orthopantomographic images taken over a period of two years in 1300 patients at the University Dental Clinical Center "St. Panteleimon" in Skopje. The subjects were divided into six groups according to age. To be included in the study, patients had to be older than 18 years; have at least 10 remaining teeth and at least one tooth where endodontic therapy was performed. The following were monitored: 1. the quality of the performed endodontic therapy monitored through the condition of the canal filling and 2. the condition of the apical periodontium, classified according to the modification of the periapical index (PAI). Results: This paper is a cross-sectional/translational study, based on retrospective follow-up of radiographic data, a study in which we included 1300 subjects after exclusion selection, in which 3273 endodontically treated teeth and over 5000 roots were evaluated. The quality of the performed endodontic therapies was mostly unsatisfactory. The most common finding was too short or inhomogeneous fillings, confirmed in 37.36% of cases, clinically acceptable fillings were determined in 31.92% of teeth, and excellent endodontics in 24.11% of cases. Overfilled canals and canals with a visible fragment of a fractured instrument were rarely observed. According to the results of the periapical index, the majority of this group of analyzed roots had normal periapical structures– 3122(60.83%). Small changes in bone structure were found in 1551 (30.22%) roots, changes in bone structure with some mineral loss in 339 (6.61%), periodontitis with a well-defined radiolucent area. was shown in a small part of the treated roots – 70 (1.36%) and 50 (0.97%), respectively. The most common finding of normal periodontium and was statistically confirmed as significant, ($p < 0.0001$) The quality of filling the root canals and the value of the periapical index significantly correlate with each other ($p < 0.0001$). The correlation is of a negative, indirect type ($R = -0.376$), and shows that with an increase in the value of the periapical index, the quality of filling the root canals decreases. **Conclusion:** Endodontic therapy is generally unsuccessful in the studied material. Inadequate therapy is correlated with the presence of apical periodontitis. Efforts are needed to improve the quality of endodontic therapy in order to reduce the incidence and prevalence of apical periodontitis.

Keywords: endodontics, endodontic outcome, periapical lesions, periapical radiography root canal treatment quality.

1. INTRODUCTION

Modern dentistry strives to ensure the preservation of the vitality of the pulp tissue. If the carious tissue is not removed and the tooth is not restored, the carious process progresses, the microorganisms found in the carious lesion damage the dental pulp, which subsequently leads to its necrosis, infection and the spread of the infection to the periapical tissue (Ricucci et al. 2014). If the pulp tissue is already infected, the only solution is to perform endodontic therapy. It is known that the prognosis for the success of endodontic therapy depends equally on all stages of endodontic treatment, and failure in any of them will lead to failure of the therapy itself and subsequent loss of the tooth (Daocar and Kalekar 2013).

There are several criteria by which the success of endodontic therapy can be assessed. The assessment of the outcome can be clinical, radiographic and histological. The restoration of the morphological appearance and functionality of the tooth, without pain, discomfort or occasional deterioration, are signs of clinical cure (Almufleh 2025).

The outcome of endodontic therapy is usually examining by radiographs. Periapical radiographs are necessary at all stages of endodontics - for diagnosis, during therapy, and later for assessment of the outcome and success of therapy. One of the most important factors for the success of endodontic therapy is the quality of the procedures performed. and is assessed through the appearance of the definitive canal filling. The criteria are based on the recommendations of the European Society of Endodontists (Duncan et al. 2023).

What is the estimated success of endodontic therapy depends on the type of examinations and applied methodologies. While in controlled prospective studies the percentage of success is always very high, up to 90% (Bhatt et al (2025), Olivieri et al (2023)), it is interesting to note that almost all epidemiological studies have shown disappointing results for the quality of the therapy performed. The percentage of successful homogeneous root canal fillings ranges from only 23% (Jersa and Kundzina 2013) to a maximum of 59.3% (De Moor et al. 2000). Most studies show that only half of the performed endodontics are technically satisfactory (Ilić et al. 2014, Sunay et al.2007). Unsuccessful fillings are most often classified as unfilled root canals, although according to Cakici et al. (2016) a much bigger problem is the inhomogeneity of the filling. Matijević et al. (2011) found in their study that only in 34.2% of endodontically treated cases the working length was correctly determined, while only 36.2% of the root canal fillings had a homogeneous filling.

More often, the parameter for the success of an endodontic therapy is the condition of the apical periodontium after the treatment is completed. After adequately performed endodontic treatment, the apical periodontium is expected to remain healthy, and if there were previously pathological changes, to heal, which is monitored by clinical or radiological examination. Through radiographic images taken at certain intervals after the completion of the therapy, it is possible to monitor whether there is healing, deterioration of the condition or stagnation (Baseri et al.2023). Many authors use both clinical and radiological criteria when assessing the quality of endodontic therapy and its correlation with apical lesions (Sălceanu et al.2024).

Epidemiological studies confirm that the prevalence of apical periodontitis is higher in endodontically treated teeth. According to the study by Tibúrcio-Machado et al. 2021, the prevalence of AP was 52% at the individual level and 5% at the tooth level. The frequency of AP in root-filled teeth and untreated teeth was 39% and 3% respectively. The prevalence of AP was greater in samples from dental care services than in those from the general population. This relationship is also confirmed in the work of Gencoglu et al. (2010). Only 1.63% of the population had pathological apical changes, but they were found in 37.99% of endodontically treated teeth.

The prevalence of apical periodontitis is increased if the endodontic therapy performed was inadequate. The frequency of apical periodontitis was significantly higher (Ilić et al. 2014) in teeth with inadequate fillings (72.2%) than in those with adequate root canal obturation (25.9%). In Georgopoulou et al. (2008) this ratio is less pronounced (the prevalence of apical periodontitis was 51.7% in cases with good endodontics, compared to 63.4% with poorly performed endodontic therapy).

This did not lead to the goal of this study, which we conducted with the intention of obtaining detailed data on the quality of root canal treatments performed through radiological examination, the frequency of periapical changes in treated teeth and their relationship with the quality of endodontic treatments.

2. MATERIAL AND METHODS

The material required for the realization of the set goal was 1300 orthopantomographic images taken over a period of two years (2016-2017) in 1300 patients at the University Dental Clinical Center "St. Panteleimon" in Skopje. To be included in the study, patients had to be older than 18 years; have at least 10 remaining teeth and at least one tooth where endodontic therapy was performed.

The following were evaluated:

1. the quality of the performed endodontic therapy was analyzed through the condition of the canal filling. Seven groups were formed according to the quality. As a gold standard for the technical quality of the root fillings, the (ESE) quality guideline for endodontic treatment was adopted [6] Fillings that were homogeneous and ended 0.5-1.5mm lower than the radiographic apex without lateral or apical voids was considered adequate . If they ended lower than 1.5-2mm they were considered clinically acceptable. Underfilled (had fillings terminated shorter than 2 mm from the radiographic apex), Inadequate density fillings (non-homogeneous root canal filling included non-uniform density of root filling with clear space visible) and overfilled canals (those that had extruded filling beyond the radiographic apex) were considered unsuccessful

2. the condition of the apical periodontium, classified according to the modification of the periapical index (PAI). The modification is necessary for this study, because grade 5 of this index describes a state of formed periapical lesion in the exacerbation phase. Since in this study only radiographs were analyzed, and there was no direct contact with the patients, data on exacerbations could not be obtained; The lesions in this study were divided into 5 groups: roots with normal periapical structures, small changes in bone structure, changes in bone structure with some mineral loss, clearly visible periapical lesion, lesion or cyst with dimensions greater than 4 mm.

3. RESULTS

The study included 1300 respondents, patients of the University Dental Clinical Center "St. Panteleimon" in Skopje. The patients were selected according to their panoramic radiographs belonging to the central database of the

University Dental Clinical Center "St. Panteleimon" in Skopje. Among the respondents, 3273 endodontically treated teeth and 5132 roots were analyzed. The results presented in this study refer to the treated root canals of the teeth. If the tooth had multiple roots, the data refer to each root separately.

When assessing the quality of obturation in the root canals, the findings were not satisfactory. The most common finding was inadequate filling, namely short, short and inhomogeneous, and filling with inadequate density, detected in 35.38 root canals, or 14.07%, 6.31%, and 15.0% respectively. In 31.92% of root canals the filling quality was clinically acceptable. Only in 24.1% of cases there was a therapy that could be described as excellent endodontics. In 6.2% a pulpotomy was performed, in 1.46% there were completely undetected and untreated canals, 0.31% of root canals were overfilled, and 0.62% of root canals contained a fractured instrument. (table 1). A statistically significant difference in the distribution of root canals in relation to the quality of filling was confirmed at $p < 0.0001$, as a result of a significantly more frequent finding of short and fillings with Inadequate density.

Table 1. Quality of endodontic therapy in root canals

Quality of obturation	n	%
missed and untreated canals	75	1.46
pulpotomy	318	6.2
short fillings	722	14.07
Inadequate density	324	6.31
Short and inadequate density	770	15.0
Clinically adequate (1,5-2,5 mm from radiographic apex)	1638	31.92
Excellent obturation (< 1,5mm from radiographic apex)	1237	24.1
overfilling	16	0.31
fractured instrument	32	0.62
total	5132	100
Chi-square =5260 $p < 0.0001$		

Source: author's own research

According to the results of the periapical index, the majority of this group of analyzed roots had normal periapical structures– 3122 (60.83%). small changes in bone structure were found in 1551 (30.22%) roots, apical periodontitis with minor bone loss in 339 (6.61%), clearly visible large lesion and granuloma or cyst larger than 4 mm had a small part of the treated roots – 70 (1.36%) and 50 (0.97%), respectively. The most common finding was normal periodontium and was statistically confirmed as significant ($p < 0.0001$) (table 2)

Table 2. Distribution of the periapical index according to treated roots

PAI	n	%
normal periapical structures	3122	60.83
small changes in bone structure	1551	30.22
apical periodontitis with minor bone loss	339	6.61
clearly visible large lesion	70	1.36
granuloma or cyst larger than 4 mm	50	0.97
total	5132	100
Chi-square=68217.1 $p < 0.0001$ sig		

Source: author's own research

Table 3 shows the distribution of the PAI index in relation to the quality of root canal obturation. Normal apical periodontium was most often found in root canals with excellent filling quality – 90.35%, small changes in bone structure were most often found root canals with pulpotomy–50.53%, apical periodontitis with minor bone loss was most often detected in root canals with a fractured instrument –30.43%. Clearly visible large lesions were most often found in missed canals and overfilled canals –15.29% and 15%, respectively. Granuloma or cyst larger than 4 mm were around 2 undetected root canals, 3 teeth with pulpotomy, 4 of 917 short fillings, 8/906 short and inhomogeneous canals, 9/1166 canals with clinically acceptable endodontics, 6/1036 canals with excellent endodontics, and 1/23 with a fractured instrument. (Table 3)

Table 3. Relationship between Quality of obturation and periapical status

Quality of obturation	Periapical status					total
	Normal apical periodontium	small changes in bone structure	Small periapical lesion with minor bone loss	clearly defined periapical lesion	granuloma or cyst larger than 4mm	
missed and untreated canals	50 29.41	50 29.41	42 24.71	26 15.29	2 1.18	170
pulpotomy	197 34.68	287 50.53	66 11.62	15 2.64	3 0.53	568
short fillings, filling with inadequate density	1033 48.15	844 39.34	233 10.86	33 1.53	12 0.56	2145
Clinically adequate obturation	843 72.29	281 24.1	25 2.14	8 0.69	9 0.77	1166
Excellent obturation	936 90.35	71 6.85	19 1.83	4 0.39	6 0.58	1036
Overfilled canal	8 40.0	8 40.0	1 5.0	3 15.0	0	20
fractured instrument	3 13.04	11 47.83	7 30.43	1 4.35	1 4.35	23
total	3070	1552	383	90	33	5128

Chi-square=1147.9 p=0.0000 sig

Source: author's own research

The quality of root canal filling and the value of the periapical index are significantly correlated with each other ($p < 0.0001$). The correlation is of a negative, indirect type ($R = -0.376$), and shows that with an increase in the value of the periapical index, the quality of root canal filling decreases, and vice versa. (Table 4)

Table 4 Correlation between filling quality and periapical index

Correlation	Spearman R	t(N-2)	p-value
filling quality & PAI	-0.376	-29.092	***0.000000

*** $p < 0.0001$

Source: author's own research

4. DISCUSSION

Our study is a cross-sectional/transversal study, based on retrospective follow-up of radiographic data. The main disadvantage of such studies is that the radiographic images provide limited data on the actual condition of the patients. For example, we did not have information about the period when the endodontic treatment was performed, as well as the clinical picture and symptoms before and after the treatment. Regarding the apical periodontitis, we did not know whether it was a persistent lesion, a lesion in the healing phase or a newly created lesion after the completion of the treatment. However, the main advantage of transversal studies is that they can cover a large number of patients, selected at random. So our study was a fairly extensive study with which we covered 1300 respondents.

One of our main objectives of this study was to determine the quality of endodontic treatments performed in our study population. Due to the study design, we had no knowledge of where and when the treatment was performed. The aim was to determine the quality of the filling determined on the radiograph, by evaluating the technical characteristics of the endodontic procedures, which are an indicator of the success of the therapy.

However, the quality of the endodontic filling is not a reliable indicator that the cleaning and shaping of the canal was also carried out correctly. This data is also confirmed by the following works. Pecora et al.(2015) conducted a histological study of 100 samples obtained by resection of the root tips, in order to analyze the possible reasons for the failure of endodontic therapy. The most common finding was the presence of bacteria and debris in underfilled canals in 51% of cases, followed by the presence of accessory canals and isthmuses in 11%, overfilled canals in 4%, apex transposition in 3%, and bacterial colonization of the root surface in 2%. They conclude that the most common

cause of endodontic treatment failure is insufficient instrumentation, which may or may not result in adequate obturation, which we can analyze exclusively radiographically.

Despite the progress of endodontic therapy instrumentation and techniques, most epidemiological studies have shown unsatisfactory quality of endodontic therapies. According to the results of Alkis and Kustarci (2019) the number of adequate RCT was 32.9%, The percentage of successfully obturated homogeneous root canal fillings ranges from only 19% (Tavares et al. 2009) to a maximum of 67.4% (Laukkanen et al. 2021).

Our study also showed unsatisfactory results. The most common finding was underfill or inhomogeneous fillings, confirmed in 35.38% of cases. Quite the opposite, only 0.37% of canals were overfilled, which may mean that the apex locator is not used often enough during therapy, so for fear of excessive instrumentation through the apex, the instrumentation and obturation are short. Another possible error is that if recapitulation is not done, debris accumulates in the apical part.

Fractured instruments were detected in only 0.79% of treated teeth. It is likely that the number of fractured instruments is much higher, but the reason that the thinnest instruments break most often is that they may not be visible on radiographs, or are most likely embedded in the filling itself.

Apical periodontitis often presents as chronic asymptomatic lesions. Their presence is therefore most often diagnosed by radiological examination. Various imaging techniques, including periapical radiographs, panoramic radiographs, and cone beam computed tomography (CBCT), are employed to evaluate periapical lesions. The question is whether panoramic radiographs are sensitive enough to detect apical lesions, especially in anterior teeth, but also molars in the upper jaw. This means that the prevalence of periapical changes may be higher than shown. Cone beam computed tomography (CBCT) has become the gold standard for evaluating periapical lesions, offering superior sensitivity and three-dimensional imaging capabilities compared to conventional radiography. Numerous studies confirm that the health of the apical periodontium is directly related to the quality of endodontic therapy, although of course it is not the only factor. Jersa and Kundzina (2013) proves that there was a statistically significant relationship between quality of root canal fillings and apical periodontitis ($p < 0.0001$). In teeth with complete fillings only 15% were with apical periodontitis, but apical periodontitis were detected in 35% with incomplete root fillings. This was also proven in our study. Healthy apical periodontium was most often present in root canals with excellent filling quality, and clearly visible large lesions were most often present in completely missed canals and unsuccessfully filled canals.

Fadhil et al. (2024) showed significantly higher apical periodontitis prevalence was present in unfilled canal, perforations, non-homogenous and underfilled RCF ($p < 0.05$). This compromised seal may facilitate bacterial colonization and impede periapical tissue repair.

Şahin and Gündüz (2026) concluded that the occurrence of apical periodontitis is much more common in both underfilled and overfilled canals. However, their results diverge from those reported by Zagar et al. (2024), and Meirinhos et al. (2020) who found no significant association between short or overextended root canal fillings and AR size. consider that overfilled canals do not have a negative effect on the outcome. In our material, overfilled canals were few in number, so we could not draw a relevant conclusion. Other authors, quite the opposite, such as Aminoshariae and Kulild. (2020) and de Sousa Gomide et al. (2019) who consider that overfilled canals have a worse prognosis than underfilled ones. This discrepancy may be attributable to methodological variations.

This study highlights the crucial role of endodontic treatment, and the results emphasize the major impact of inadequate endodontic therapy on the occurrence and persistence of periapical lesions.

5. CONCLUSIONS

According to the data obtained from our study, it can be concluded that:

- The quality of the performed endodontic therapies is unsatisfactory. The most common finding was too short or inhomogeneous fillings, confirmed in 37.36% of the cases, clinically acceptable filling was observed in 31.92% of the teeth, and excellent endodontics in 24.11%. Overfilled canals and canals with a visible fragment of a fractured instrument were rarely observed.

- The examination of the periapical index showed that in 9.5% there was the presence of periapical changes of varying sizes. 89.5% of the cases had either completely healthy periapical tissue in 60.83%, or small changes in bone structure in 30.22% of the roots. The most common finding of healthy periodontium and statistically confirmed as significant ($p < 0.0001$)

- The quality of root canal filling and the value of the periapical index significantly correlate with each other ($p < 0.0001$). The correlation is of a negative, indirect type ($R = -0.376$), i.e. with an increase in the value of the periapical index, the quality of root canal filling decreases

REFERENCES

- Alkis, H.T., & Kustarci, A. (2019). Radiographic assessment of the relationship between root canal treatment quality, coronal restoration quality, and periapical status. *Niger J Clin Pract.* 22(8),1126-1131
- Almufleh, L.S. (2025). The outcomes of nonsurgical root canal treatment and retreatment assessed by CBCT: a systematic review and meta-analysis. *Saudi Dent J.* 4,37(4-6),14
- Aminoshariae, A., & Kulild, J.C. (2020). The impact of sealer extrusion on endodontic outcome: a systematic review with meta-analysis. *Aust Endod J.* 46, 123–129
- Baseri, M., Radmand, F., Milani, A.S., Gavvani, L.F., Salehnia, F., & Dianat, O. (2023). The effect of periapical lesion size on the success rate of different endodontic treatments: a systematic review and meta-analysis. *Evid Based Dent.* 24(1), 43
- Bhatt, M., Seth, T., Chaudhary, S., Rajguru, K., Khalane, C.S., Chib, A.S., & Gupta, S. (2025). Nonsurgical Retreatment of Endodontically Treated Teeth: A Prospective Cohort Study on Success Rates and Quality of Life. *Cureus.* 28,17(7), e88886
- Cakici, E.B., Yildirim, E., Cakici, F., & Erdogan, A.S. (2016). Assessment of periapical health, quality of root canal filling, and coronal restoration by using cone-beam computed tomography. *Niger J Clin Pract.* Sep-Oct,19(5),673-7
- Daokar, S., & Kalekar, A. (2013). Endodontic failures- a review *IOSR Journal of Dental and Medical Sciences*, 4, 5-10
- De Moor, R.J.G., Hommez, G.M.G., De Boever, J.G., Delme, K.I.M., & Martens, G.E.I. (2000). Periapical health related to the quality of root canal treatment in a Belgian population. *Int Endod J.*, 33,113-20
- de Sousa Gomide Guimarães, M.R.F., Samuel, R.O., Guimarães, G., Nalin, E.K.P., Bernardo, R.T., Dezan-Júnior, E., & Cintra, L.T.A. (2019). Evaluation of the relationship between obturation length and presence of apical periodontitis by CBCT: an observational cross-sectional study. *Clin Oral Investig.* May,23(5), 2055-2060
- Duncan, H.F., Kirkevang, L.L., Peters, O.A., El-Karim, I., Krastl, G., Del Fabbro, M., Chong, B.S., Galler, K.M., Segura-Egea, J.J., & Kebschull, M; ESE (2023). Workshop Participants and Methodological Consultant. Treatment of pulpal and apical disease: The European Society of Endodontology (ESE) S3-level clinical practice guideline. *Int Endod J.* Oct;56 Suppl 3:238-295
- Fadhil, N.H., Ali, A.H., Al Hashimi, R.A., Sabri Al-Qathi, O., & Foschi, F. (2024). Assessment of Treatment Quality Risk Factors Influencing the Radiographic Detection of Apical Periodontitis in Root-Filled Teeth: A Retrospective CBCT Analysis. *Eur Endod J.* Aug 22, 9(3),252-259.
- Gencoglu N, Pekiner FN, Gumru B, Helvacioğlu D. (2010) Periapical status and quality of root fillings and coronal restorations in an adult Turkish subpopulation. *Eur J Dent.* Jan, 4(1), 17-22
- Georgopoulou MK, Spanaki-Voreadi AP, Pantazis N, Kontakiotis EG, Morfis AS. (2008) Periapical status and quality of root canal fillings and coronal restorations in a Greek population. *Quintessence Int*, 39, 85-92.
- Ilić J, Vujašković M, Tihaček-Šojić L, Milić-Lemić A. (2014) Frequency and quality of root canal fillings in an adult Serbian population. *Srp Arh Celok Lek.* Nov-Dec,142 (11-12),663-8
- Jersa I, Kundzina R. (2013). Periapical status and quality of root fillings in a selected adult Riga population. *Stomatologija*,15(3),73-7.
- Laukkanen E, Vehkalahti MM, Kotiranta AK (2021). Radiographic outcome of root canal treatment in general dental practice: tooth type and quality of root filling as prognostic factors. *Acta Odontol Scand.* Jan;79(1),37-42.
- Matijević J, Cizmeković Dadić T, Prpic Mehicic G, Ani I, Slaj M, Jukić Krmek S. (2011) Prevalence of apical periodontitis and quality of root canal fillings in population of Zagreb, Croatia: a cross-sectional study. *Croat Med J.* Dec 15.52(6).679-87.
- Meirinhos J, Martins JNR, Pereira B, et al. (2020) Prevalence of apical periodontitis and its association with previous root canal treatment, root canal filling length and type of coronal restoration – across-sectional study. *Int Endod J.* 53, 573–84
- Olivieri JG, Feijoo Pato N, Labraca P, Tomàs J, Miró Q, Duran-Sindreu F. (2023) Outcome of Nonsurgical Root Canal Retreatment Procedures Obturated with Warm Gutta-percha Techniques: A Longitudinal Clinical Study. *J Endod.* Aug,49(8),963-971
- Pecora CN, Baskaradoss JK, Al-Sharif A, Al-Rejaie M, Mokhlis H, Al-Fouzan K, Pecora GE. (2015) Histological evaluation of the root apices of failed endodontic cases. *Saudi Endod J.* 5, 120-4
- Ricucci D., Loghin S., Siqueira J.F., Jr. (2014) Correlation between clinical and histologic pulp diagnoses. *J. Endod.*, 40,1932–1939
- Şahin P, Gündüz H. (2026) Impact of endodontic treatment quality on the severity of apical periodontitis in molars teeth: a retrospective CBCT study. *Oral Radiol.* Jan,42(1),101-115.

- Sălceanu M, Dascălu C, Melian A, Giuroiu C, Antohi C, Concita C, Hamburda T, Topoliceanu C, Mârțu MA. (2024). Assessment of Periodontitis Risk Factors in Endodontically Treated Teeth: A Cross-Sectional Study. *Diagnostics (Basel)*. 6,14(17),1972.
- Sunay H, Tanalp J, Dikbas I, Bayirli G. (2007) Cross-sectional evaluation of the periapical status and quality of root canal treatment in a selected population of urban Turkish adults. *Int Endod J*. 40,139-45
- Tavares PB, Bonte E, Boukpepsi T, Siqueira JF Jr, Lasfargues JJ. (2009) Prevalence of apical periodontitis in root canal-treated teeth from an urban French population: influence of the quality of root canal fillings and coronal restorations. *J Endod*. Jun, 35(6), 810-3.
- Tibúrcio-Machado CS, Michelon C, Zanatta FB, Gomes MS, Marin JA, Bier CA. (2021) The global prevalence of apical periodontitis: a systematic review and meta-analysis. *Int Endod J*. May,54(5), 712-735
- Zargar N, Khosravi K, Zadsirjan S, Safi Y, Vatankhah M, Akbarzadeh Baghban A, Aghajani Varzaneh F. (2024) The association of endodontic prognostic factors with the presence of periapical lesion, its volume, and bone characteristics in endodontically treated molars: a cross-sectional study. *BMC Oral Health*. Jan 5,24(1),28