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RESEARCH ARTICLE

PREVALENCE OF IATROGENIC PERFORATIONS ACCORDING TO THEIR LOCATION AND AFFECTED ROOT SURFACES

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Abstract

Background: The location of the endodontic perforation has shown a strong correlation with the healing process and successful outcome. The **aim** of this study was to determine the prevalence of iatrogenic perforations according to their location and affected root surfaces.
Materials and methods: Over a period of 7 years, 100 cases of iatrogenic root perforations were recorded from the digital radiographs of each case. The perforations were classified according to the following criteria: (1) perforation location – cervical, furcation, stripping, lateral, and apical; (2) affected root surface. The prevalence of different types of perforation was calculated and subjected to statistical analysis.
Results: Among all types of perforations, the most common are those located in the furcation area of the molars (46%), followed by lateral root perforation (35.8%). The mesial root surfaces are most often affected by iatrogenic perforations (71.9%), followed by the distal ones (21%).
Conclusion: Prior to root canal treatment, it is essential to assess the morphologic conditions in the key areas prone to iatrogenic perforations.

Introduction:-

Iatrogenic perforations are among the most common procedural errors that may occur accidentally at any stage of endodontic treatment (Alamoudi et al., 2019; Estrela et al., 2018; Kouzmanova, 2019).

They cause the procedure to become more complicated, resulting in a poor prognosis finally (Alrahabi et al., 2019; Haji-Hassani et al., 2015). According to Yamaguchi et al. (2018), the main causes of treatment failure in patients who required tooth extraction after or without endodontic treatment were perforation in 44.4%, root fracture in 38.9%, and open apices in 22.2%.

Many factors influence the prognosis and healing outcome of root perforations, including their location and size, the presence of bacterial contamination, proximity to the crestal bone and epithelial attachment, time elapsed, clinician skills, and so on. The location of the perforation has shown a strong correlation with the healing process (Baroudi and Samir, 2016; Estrela et al., 2018; Mitthra et al., 2020). Among the different types of perforations, those located at the level of radicular furcation are considered to have the most questionable and even worst prognosis (Ciobanu et

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al., 2016; Nandakumar and Nasim, 2017). Inadequate sealing of this area can result in fluid movements into the perforation defect, favouring an interradicular chronic inflammatory reaction and thus compromising the healing process (Baroudi and Samir, 2016).

According to Lin et al. (2005), endodontic procedural errors are not the direct cause of treatment failure; rather, the presence of pathogens in the incompletely treated or untreated root canal system is the primary cause of periradicular pathosis. According to many other authors, however, iatrogenic root perforations are one of the most common reasons for endodontic failure (Goldberg, 2020; McCabe, 2006; Yamaguchi et al., 2018).

The current literature search showed insufficient knowledge regarding the frequency of iatrogenic perforations according to the affected root area and with respect to the probable risk zones. The **aim** of this study was to determine the distribution of iatrogenic perforations by their location and the affected root surfaces encountered in root canal treatment in a Bulgarian population.

Materials and Methods:-

This retrospective cross-sectional study was conducted at the Faculty of Dental Medicine, Sofia, Bulgaria. Over a period of 7 years, 100 cases of iatrogenic root perforations (one tooth per patient) were recorded at the Department of Conservative Dentistry. Most of the patients were referred to the Department of Conservative Dentistry by general dental practitioners due to endodontic treatment complications. The study was approved by the Ethics Commission for Research at Sofia Medical University (KENIUMUS).

Data were collected from observation, clinical examination, and oral radiographs. Iatrogenic perforations were recorded from the preoperative, interoperative, or immediate postoperative digital radiographs of each case. If needed, additional radiographs taken from different horizontal angulations were used to determine the occurrence of a perforation. Criteria for exclusion from the study were previous endodontic surgical procedures, cases of teeth with immature root development, and cases with unreadable radiographs. In fact, although the number of cases of iatrogenic perforations was 100, the total number of perforations was 106, because in some cases, more than one perforation was registered.

The presence of perforations was detected and proven by an endodontic instrument in the perforation site or when an extrusion of the filling material outside the root confines was detected. Furcation perforation was recorded if any obturating material extruded from the furcation in multi-rooted teeth. Strip perforation was recognized when filling material was seen in the inner wall of curved roots. Lateral root perforation was reported when filling material was extruded from any other lateral area of a root other than the furcational area or the convex wall of curved roots. The absence of an apical stop and free passage through the apical foramen of an endodontic file equal to or larger than #35 was accepted as the criterion for the clinical detection of apical perforation, provided that the initial size of the physiological constriction corresponds to a smaller file.

All radiographs were evaluated by two independent calibrated clinicians at the Department of Conservative Dentistry with more than 10 years of endodontic experience. The method of viewing the radiographs was standardized, and an evaluation form was designed to record the information gathered from the radiographs. All the radiographs were systematically examined in a darkened room using an illuminated viewer box with a magnifying glass. When the two examiners were in disagreement, they discussed the case with a radiologist to solve the problem.The examiners' agreement was measured by the Cohen kappa test using one hundred radiographs for assessment. The Kappa values obtained for the inter-examiner reliability were 0.80, which indicates strong agreement.

The perforations were classified according to the following criteria: (1) perforation location – cervical, furcation, stripping, lateral, and apical; Lateral perforations were divided into three major kinds – in the coronal root third, in the middle third, and in the apical third; (2) affected root surface – medial, distal, buccal or lingual/palatal (except the cases with furcal perforation).

Statistical Analysis

All data were entered and processed with the statistical package IBM SPSS Statistics 25.0 (SPSS, Inc., Chicago, IL). The results were submitted to descriptive and alternative statistical analysis to evaluate the perforation prevalence and ditribution. The significance of the differences between the different types of perforation was examined by using a t-test. α-level was set at 0.05 and a P-value less than 0.05 ($p<0.05$) was considered statistically significant.

Results:-

The prevalence and distribution of the perforations in accordance with their location are presented in Table 1. Of the total of 106 iatrogenic perforations registered, the furcation area of the molars was affected in 46.23%, as in 40.57% the perforations were direct furcal and in 5.6% they were stripping. Lateral perforations were found in 35.84%, as 14.15% were in the coronal root third, 15.09% were in the middle third and, 6.6% in the apical third. Additionally, cervical perforations were registered in 10.38% and apical ones in 7.54%. A statistically significant difference was found between the different types of perforations ($p<0.05$) with the highest prevalence of furcal perforations.

Table 1:- Distribution of the iatrogenic perforations according to their location (affected root ar.

Perforation type	**N**	**%**	**Sp**
Cervical perforation	11	10,38^{d}	2,96
Furcation perforation (direct)	43	**40,57^{a}**	4,77
Furcation perforation (strip)	6	5,66^{f}	2,24
Lateral (in the coronal third of the root)	15	14,15^{c}	3,39
Lateral (in the middle third)	16	15,09^{c}	3,48
Lateral (in the apical third)	7	6,60^{e,f}	2,41
Lateral perforation (total)	(38)	(**35.84^{b}**)	4.52
Apical perforation	8	7,55^{e}	2,57
Total	106	100,00	

* Legend: Sp – Standard error; same letters reveal no significant difference, whereas different letters show statistically significant difference at $p<0.05$

In cases where the root or cervical surfaces were affected (N=57), the perforations on the mesial surfaces were predominant (71.93%), with statistically significant differences between them and other groups ($P<0.05$). The distal surfaces were affected in 21.06%, while the buccal and lingual surfaces were only in 5.26% and 1.75%, respectively. In relation to the molars, perforations were detected mainly on the medial surfaces of the medial roots in lower molars (19.3%), followed by the medial surfaces of the distal roots (14.03%) (Table 2). Table 2 represents the percentual distribution of iatrogenic perforations according to the affected root surfaces.

Table 2:- Distribution of the iatrogenic perforations according to the affected root surfaces (N=57).

Toot group	**B surface**		**L surface**		**M surface**		**D surface**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Upper anteriors	-	-	-	-	5	8,77	-	-
Upper premolars	-	-	-	-	2	3,50	1	1,75
Upper molars								
MB-root	-	-	-	-	1	1,75	-	-
DB-root	-	-	-	-	-	-	1	1,75
P-root	-	-	-	-	1	1,75	-	-
Lower anteriors	1	1,75	1	1,75	3	5,26	1	1,75
Lower premolars	1	1,75	-	-	3	5,26	3	5,26
Lower molars								
M-root	-	-	-	-	11	19,30	2	3,50
D-root	-	-	-	-	8	14,03	1	1,75
Cervical area	1	1,75	-	-	7	12,28	3	5,26
Total (surfaces)	**3**	**5,26^{a}**	**1**	**1,7^{b}**	**41**	**71,93^{c}**	**12**	**21,0^{d}**

* Legend: Sp – Standard error, B – buccal, L – lingual, M – mesial, D – distal ;same letters reveal no significant difference, whereas different letters show statistically significant difference at $p<0.05$

Discussion:-

Factors reported to affect the prognosis of perforation repair include immediacy, location, size, and previous microbial contamination (Estrela et al., 2018). The location of the perforation is probably the most critical prognostic factor. Perforations in the apical or middle third of the root have a better prognosis than those in the cervical third or in the furcation area. Unless a fresh furcal perforation is repaired immediately under aseptic conditions, the prognosis of the treatment is good. Root perforations at the alveolar crest exhibit the poorest prognosis because of potentiamicrobial contamination from the gingival sulcus and apical migration of epithelium into the perforation, leading to periodontal breakdown (Baroudi and Samir, 2016; Goldberg, 2020; Mitthra et al., 2020).

Strippings are problems that are frequent on thin and concave roots. Treatment and prognosis differ from that of a lateral root perforation because of the danger of developing rapid and intense destruction of periodontal tissues in the furcation with loss of interradicular bone. Its occurrence may drastically affect the outcome of the treatment, transforming a common, otherwise efficient endodontic procedure into a complication such as tooth extraction (Ciobanu et al., 2016). The prognosis of vestibular root perforations is considered more favorable than that of lingual ones due to easier surgical access (Nandakumar and Nasim, 2017).

Only a small number of authors have studied the frequency of perforation types relative to their total number. Most of them have indicated their rate in relation to the total number of endodontic treatments. For this reason, it was difficult to compare our results with those reported by other researchers. Among 21 cases of perforations repaired by MTA, Mente et al. (2010) reported that 19% were furcal and 81% were lateral (33% crestal, 24% mid-root, and 24% in the apical third of the root). In a case series of 16 perforations, followed-up by Main et al. (2004), lateral and strip perforations were predominant.

Investigating the procedural errors encountered in root canal treatment, Jamani and Fayyad (2005) found that 1.10% of the evaluated teeth have perforations of the root walls or the floor of the pulp chamber. Moreover, 1.35% of teeth had preparations that deviated from the line of the root canal and 6.25% were overfilled. These findings may be related to probable apical perforations and a high risk of lateral perforations. Akbar (2015) registered strip perforations in 3% of 100 cases of endodontic treatment, while the presence of furcal perforation was observed in 1%.

Exploring endodontic mishaps committed by undergraduate dental students in Saudi Arabia, Abdulrab et al. (2018) found furcation perforation in 32.1% and apical perforation in 31.6% for the whole sample of errors. In the same country and in the same conditions, Alghamdi et al. (2021) found 1% apical perforations, 0.7% mid root perforations and 0.5% coronal perforations, calculated in relation to the whole sample of endodontic treatments.

In the present study, the predominant types of perforations found by us were furcal (46.23%), followed by lateral perforations (35.84%). These results were close to those established by Main et al. (2004) but were inconsistent with the findings of Jamani et al. (2005), Mente et al. (2010), and Akbar (2015). In contrast to our results, some authors found a high rate of apical perforations. Khabbaz et al. (2010) reported foramen perforation (apical) in 32.6% and root perforation in 11.8%. Haji-Hassani et al. (2015) reported 21% apical perforations in the mandible, 17.8% in the maxilla, and low frequency of strip perforations in both jaws (0.9%).

AlRahabi (2017) reported only apical perforations of 2.3%. In a study by Alamoudi et al. (2019), apical perforation was detected in 1.2%, lateral root perforation was found in 0.7%, strip perforation was seen in 0.3%, furcation perforation was found in 0.2%, and corono-cervical perforation was detected in 0.1% of the total number of cases. Alghamdi et al. (2021) registered apical perforation in 1.0%, furcal and mid-root perforation in 0.7%, respectively, and coronal perforations in 0.5%. The frequency of apical perforations we found is probably lower than the real one because this type of perforation is not always detectable radiographically.

McCabe (2006) stated that the potential for iatrogenic errors in endodontics may be reduced by focusing on “key areas” during the endodontic process. Some authors warn about the so-called ”danger zones” where the smallest dentine thickness of the root walls was measured (De-Deus et al., 2019; Kuttler et al., 2004; Tabrizizadeh et al., 2010). There is a lack of investigations regarding the frequency of iatrogenic perforations with respect to the probable risk zones.

In mandibular molars, the concavity observed in the furcation area reduces dentin thickness, making this region more susceptible to perforation. According to Kvinnsland et al. (1989), the most common areas of perforation were the mesial and vestibular surfaces of the roots and the furcation area. Many authors investigated the effects of rotary burs such as Gates-Glidden, Largo, LA-Axxess, etc. on coronal pre-enlargement in this group of teeth, but only in a few studies the effect of deep enlargement using these instruments was evaluated.

Tabrizizadeh et al. (2010) found that the mean thickness of the distal wall of the mesial root (1.2 mm) was smaller in comparison to all other portions of the roots. Wu et al. (2005) also reported that flaring with Gates-Glidden drills in curved mesial root canals in mandibular molars may result in perforations of the distal wall of the mesial root, and the application of anticurvature pressure did not reduce the risk. According to Yoldas et al. (2004), the use of Masserann Kit drills in a severely and moderately curved mesial root of mandibular molars, increased the risk of creating thin or perforated walls, as after 7.5 mm depth of drilling, the percentage of perforations increased significantly.

Another danger zone in lower molars is the medial wall of their distal roots. Kuttler et al. (2004) examined the impact of post space preparation with Gates-Glidden drills on residual dentin thickness in the distal roots of these molars and reported that a no. 4 drill caused strip perforations in 7.3% of the canals studied.

Contrary to most of the aforementioned reports, the results found in the present study do not confirm the distal surface of the medial roots of lower molars as a risk area. According to the results found by us, such a zone was the mesial surface of these roots (19.3%). Moreover, our results confirmed that mesial wall of the distal roots was also frequently affected (14.03%). We have found a definite predominance of perforations on the mesial surfaces, regardless of tooth type, their thickness, and localization, and this fact was in agreement with the results of Kvinnsland et al. (1989). This is probably due to the slight axial inclination of the teeth in the disto-apical direction, which clinicians fail to consider during endodontic treatment.

Recently, De-Deus et al. (2019) confirmed by means of micro-CT technology and digital image analysis that the mesial wall of the mesial roots of mandibular molars is a danger zone. They found that the smallest dentine thickness was on the mesial plane of the roots in about 40% of the canals. The vertical location of the danger zone in relation to the furcation area was in the middle third of the root.

In the upper molars, the furcation area and distal surface of the mesiobuccal root are also considered danger zones. Azimi et al. (2020) indicate that highly tapered instruments and other aggressive instruments, such as Gates-Glidden drills, should be used with caution in the mesiobuccal root canals.

In general, it could be summarized that the medial and distal root walls are more at risk compared to the vestibular and lingual ones (De-Deus et al., 2019; Kuttler et al., 2004; Kvinnsland et al., 1989), and therefore the authors recommend that Gates-Glidden drills larger than a no. 3 not be used in these roots (Kuttler et al., 2004; Wu et al., 2005).

Having knowledge about the most common locations of perforations and affected root surfaces is essential to achieve successful root canal treatment and provides information for avoiding, detecting, and treating such defects. Additionally, it is important to assess the relative root inclination, curvature, and axis and supplementary radiographs to rule out the above-mentioned conditions can be indicated if needed.

Conclusion:-

Based on the results of this study and within its limitations, it can be concluded that among all the types of iatrogenic perforations, the most common are those located in the furcation area of the molars, and the mesial root surfaces are most often affected. Prior to root canal treatment, the morphologic conditions in key areas prone to iatrogenic perforations, such as root inclination and curvature, root walls, and pulpal floor thickness, must be assessed.

References:-

1. Abdulrab, S., Alaajam, W., Al-Sabri, F., Doumani, M., Maleh, K., Alshehri, F., Alamer, H. and Halboub, E. (2018): Endodontic procedural errors by students in two saudi dental schools. Eur. Endod. J., 3(3): 186-191.
2. Akbar, I. (2015): Radiographic study of the problems and failures of endodontic treatment. Int. J. Health Sci. (Qassim), 9(2): 111–118.

3. Alamoudi, R.A., Alharbi, A.H., Farie, G.A. and Fahim, O. (2020): The value of assessing case difficulty and its effect on endodontic iatrogenic errors: a retrospective cross-sectional study. Libyan J. Med., 15(1): 1688916.
4. Alghamdi, N.S., Algarni, Y.A., Ain, T.S., Alfaifi, H.M., AlQarni, A.A., Mashyakhi, J.Q., Alasmari, S.E. and Alshahrani, M.M. (2021): Endodontic mishaps during root canal treatment performed by undergraduate dental students: An observational study. Medicine (Baltimore), 100(47): e27757.
5. AlRahabi, M.K. (2017): Evaluation of complications of root canal treatment performed by undergraduate dental students. Libyan J. Med., 12(1): 1345582.
6. Alrahabi, M., Zafar, M.S. and Adanir, N. (2019): Aspects of clinical malpractice in endodontics. Eur. J. Dent., 13(3): 450-458.
7. Azimi, V.F., Samadi, I., Saffarzadeh, A., Motaghi, R., Hatami, N. and Shahravan, A. (2020): Comparison of dentinal wall thickness in the furcation area (Danger zone) in the first and second mesiobuccal canals in the maxillary first and second molars using cone-beam computed tomography. Eur. Endod. J., 5(2): 81-85.
8. Baroudi, K. and Samir, S. (2016): Sealing ability of MTA used in perforation repair of permanent teeth; Literature review. Open Dent. J., 10: 278-286.
9. Ciobanu, I. E., Rusu, D., Stratul, S.I., Didilescu, A.C. and Cristache, C.M. (2016): Root canal stripping: malpractice or common procedural accident-An ethical dilemma in endodontics. Case Rep. Dent., 2016: 4841090.
10. De-Deus, G., Rodrigues, E.A., Belladonna, F.G., Simões-Carvalho, M., Cavalcante, D.M., Oliveira, D.S., Souza, E.M., Giorgi, K.A., Versiani, M.A., Lopes, R.T., Silva, E.J.N.L. and Paciornik, S. (2019): Anatomical danger zone reconsidered: a micro-CT study on dentine thickness in mandibular molars. Int. Endod. J., 52(10): 1501-1507.
11. Estrela, C., de Almeida Decurcio, D., Rossi-Fedele, G., Silva, J.A., Guedes, O.A. and Borged, Á.H. (2018): Root perforations: a review of diagnosis, prognosis and materials. Braz. Oral. Res., 32(Suppl 1): e73.
12. Goldberg, M. (2020): Failures of endodontic treatment: Pulp floor and root perforations. Acta Scientific Microbiology, 3(2): 58-64.
13. Haji-Hassani, N., Bakhshi, M. and Shahabi, S. (2015): Frequency of iatrogenic errors through root canal treatment procedure in 1335 chart of dental patients. Journal of International Oral Health, 7(Suppl 1): 14-17.
14. Jamani, K.D. and Fayyad, M.A. (2005): A radiographic study of the prevalence of endodontically treated teeth and procedural errors of root canal filling. Odontostomatol. Trop., 28(111): 29-33.
15. Khabbaz, M.G., Protogerou, E. and Douka, E. (2010): Radiographic quality of root fillings performed by undergraduate students. Int. Endod. J., 43(6): 499-508.
16. Kouzmanova, Y. (2019): Endodontic perforations – hermeticity of sealing with calcium silicate cements and prevention. Thesis, Sofia Medical University.
17. Kuttler, S., McLean, A., Dorn, S. and Fischzang, A. (2004): The impact of post space preparation with Gates-Glidden drills on residual dentin thickness in distal roots of mandibular molars. J. Am. Dent. Assoc., 135(7): 903-909.
18. Kvinnsland, I., Oswald, R.J., Halse, A. and Grønningsaeter, A.G. (1989): A clinical and roentgenological study of 55 cases of root perforation. Int. Endod. J., 22(2): 75-84.
19. Lin, L.M., Rosenberg, P.A. and Lin, J. (2005): Do procedural errors cause endodontic treatment failure? J. Am. Dent. Assoc., 136(2): 187-193, quiz 231.
20. Mente, J., Hage, N., Pfefferle, T., Koch, M.J., Geletneky, B., Dreyhaupt, J., Martin, N. and Staehle, H.J. (2010): Treatment outcome of mineral trioxide aggregate: repair of root perforations. J. Endod., 36(2): 208-213.
21. Main, C., Mirzayan, N., Shabahang, Sh. and Torabinejad, M. (2004): Repair of root perforations using mineral trioxide aggregate: A long-term study. J. Endod., 30(2): 80-83.
22. McCabe, P.S. (2006): Avoiding perforations in endodontics. J. Ir. Dent. Assoc., 52(3): 139-148.
23. Mitthra, S., Shobhana, R., Venkatachalam, P. and Vivekanandhan, P. (2020): An overview on root perforations: Diagnosis, prognosis and management. European Journal of Molecular & Clinical Medicine, 7(5): 1240-1244.
24. Nandakumar, M. and Nasim, I. (2017): Management of perforation - A review. J. Adv. Pharm. Edu. Res., 7(3): 208-211.
25. Tabrizizadeh, M., Reuben, J., Khalesi, M., Mousavinasab, M. and Ezabadi, M.G. (2010): Evaluation of radicular dentin thickness of danger zone in mandibular first molars. J. Dent. (Tehran), 7(4): 196-199.
26. Wu, M.K., van der Sluis, L.W. and Wesselink, P.R. (2005): The risk of furcal perforation in mandibular molars using Gates-Glidden drills with anticurvature pressure. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., 99(3): 378-382.

27. Yamaguchi, M., Noiri, Y., Itoh, Y., Komichi, S., Yagi, K., Uemura, R., Naruse, H., Matsui, S., Kuriki, N., Hayashi, M. and Ebisu, S. (2018): Factors that cause endodontic failures in general practices in Japan. BMC Oral Health, 18(1): 70.
28. Yoldas, O., Oztunc, H., Tinaz, C. and Alparslan, N. (2004): Perforation risks associated with the use of Masserann endodontic kit drills in mandibular molars. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., 97(4): 513-517.