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Original Article

Technical and biological causes of periapical surgery: Retrospective analysis of 301 apical surgical cases

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Abstract

Aim: Endodontic surgery is a treatment for persistent peri-radicular pathological conditions that do not improve after endodontic treatment. The aim of this study was to evaluate the quality of endodontic treatment, technical error types seen in root canals, and the periapical condition of the teeth in patients undergoing periapical surgery, and thus to analyze the reasoning behind the decision to perform periapical surgery.

Methodology: Clinical and radiographic data of 301 periapical surgery cases were retrospectively evaluated in this study. The reasons for performing periapical surgery were classified as either technical or biological.

Results: In this study, 51.8% of periapical surgery cases were related to biological factors, and 48.2% were related to technical factors. Maxillary anterior teeth were the most common teeth to undergo apical surgery, with a rate of 66.8%. The most common technical reasons for surgery were non-homogeneous filling (15.6%), underfilling (12%), and overfilling (9.6%). The most common biological reasons were cysts (30.2%), traumas (16.6%), and apical abscesses (5%). In 37.5% of cases, the diameter of the cystic lesion was 10 mm or larger.

Conclusion: The number of cases of apical periodontitis is increasing in the Turkish community due to insufficiently filled root canals. Increasing the quality of the root canal treatments applied by dentists will reduce the need for periapical surgery by reducing the incidence of apical periodontitis.

Keywords: Endodontic technical error, periapical lesion, periapical surgery, root canal treatment

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Introduction

The principal objective of root canal therapy is to supply an ideal biological atmosphere to prevent the formation of apical periodontitis (AP) or to permit the healing of an established periapical lesion (1). Conventional root canal treatment, with success rates ranging from 48% to 98%, is considered the best method of managing periapical disease (2).

Endodontic treatment is considered successful in cases of completely closed root canals, hermetic sealing, absence of pain, and regression of AP. Achievement in endodontics is directly linked to factors such as effective instrumentation, microorganism neutralization, and suitable obturation of the root canals, all of which entail professional expertise and technical skills (3,4). The complex anatomy of root canal systems, however, is an important cause of treatment failure (5,6), and in fact, most failed cases

are linked to inadequate root canal treatment (7). Surgical endodontic treatment is frequently recommended in cases of recurrent periapical disease or persisting periapical lesions that are unresponsive to root canal treatment (8).

Based on the protocol proposed by the Spanish Oral Surgery Association, the indications for periapical surgery include: 1) periapical illness that affects a permanent tooth exposed to endodontic treatment with inflammation and pain; 2) periapical pathology with prosthesis or conservative restoration, which has proved hard to eliminate; 3) a radiotransparent lesion that is 8 to 10 mm in diameter; 4) symptomatic gutta-percha overfilling, or presence of a foreign body inappropriate to orthograde removal (e.g., broken file); 5) other indications (patient demanding endodontic treatment and periapical surgery in one session, apical third fracture, etc.) (9,10). Periapical surgery should be performed on a tooth with no signs of fracture and with a sufficient periodontal condition (less than 25% of vertical bone loss and periodontal pockets less than 5 mm) (11). In addition, the tooth must maintain adequate coronal structure for prosthesis, and the patient should be able to tolerate the surgery.

El-Swiah and Walker (12) suggest that the indications for periapical surgery are related to biological and technical factors. In the literature, endodontic technical errors are assessed using the following criteria: an obturation length that is 0–2 mm in the coronal of root apex; a homogenous view of the root canal filling; the presence of coronal restoration; and lack of complications or other technical mistakes (13). The obturation is considered to be underfilled when the apical limit is more than 2 mm coronal to the root apex and overfilled when the material is emitted outside the root apex (14).

In an epidemiologic study by De Moor et al. (15), 40.7% of root canal treatments were observed to be sufficient, and apical lesions were not seen in most teeth with root canal fillings 2 mm short of the radiographic apex. When there are pores or voids in the root canal filling, the filling is considered to be incomplete or inhomogeneous (13). The presence of an unfilled canal in endodontically treated teeth, a broken file within the root canal, and deviation from the root channel path are other technical errors. Biological causes of periapical surgery include infections, apical lesions, and cysts. The aim of this study was to analyze periapical surgery cases and to investigate the reasons that led to apical surgery in these cases.

Materials and Methods

This retrospective study was approved by the local ethics committee of the Faculty of Medicine, Afyonkarahisar Health Sciences University (2019/12-401). The sample consisted of periapical surgery cases that were performed between January 2013 and December 2018 at the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Afyonkarahisar Health Sciences University in Afyonkarahisar, Turkey.

The criteria for inclusion in the study were quality radiographs and good diagnostic data (age, gender, clinical symptoms, etc.). Patient records and radiographs were assessed by an oral and maxillofacial surgeon. The medical status of patients was classified according to the American Society of Anesthesiology (16). Periapical surgery cases were divided into six different dental groups: anterior teeth, premolars, and molars (all maxillary teeth), and anterior teeth, premolars, and molars (all mandibular teeth).

Following the literature, the technical quality of endodontically treated teeth was evaluated by means of periapical images and was classified as follows: 1) overfilling, 2) underfilling, 3) non-homogeneous filling, 4) empty root canal, 5) fractured instrument, 6) perforation and deviation, 7) multiple errors, and 8) recurrence after apical surgery. Regarding coronal restoration, the teeth were divided into two groups: sufficient and insufficient.

Biological causes of periapical surgery were classified as traumas, apical abscesses, and cysts. A periapical lesion described any radiolucent image larger than 1 mm (17). In this study, both the smallest and largest diameters of each lesion were measured, and mean diameters were calculated. Panoramic images of the patients were examined, and the diameter of the periapical cysts was calculated. Cystic lesions were divided into five groups according to their mean diameter: 1) smaller than 5 mm, 2) 5–9 mm, 3) 10–14 mm, 4) 15–19 mm, and 5) 20 mm and larger. All measurements and evaluations were performed by a single investigator. In addition, patients were divided into four groups based on the number of teeth that underwent apical surgery: one tooth, two teeth, three teeth, and more than three teeth.

Statistical analysis

Statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS) software (version 22.0, IBM Corp., New York, NY, USA). Data were expressed as frequencies and percentages. Pearson's chi-square test was used to analyze the causes of endodontic surgery and the relationship between periapical surgery site and periapical cyst size. A p-value <0.05 was considered statistically significant.

Results

A total of 306 cases of periapical surgery were initially included in this study. Five patients (nine teeth) were excluded from the study because there were no radiographs or treatment records available. Thus, a total of 485 teeth obtained from 301 patients (171 females and 130 males), aged 13 to 81 years, were assessed. Table 1 shows the demographic

characteristics of patients. 56.8% of the cases were female, and 43.2% were male. Approximately half of the patients were 20–40 years old; 10% of patients were under 20; and approximately 40% of patients were older than 40. Patients' medical histories were reviewed, and all patients were classified as Class I or Class II according to the American Society of Anesthesiology (ASA) criteria.

Table 2 provides information on the periapical surgical site, the size of the cystic lesion, and the teeth undergoing apical resection. Apical resection was performed mostly in maxillary anterior teeth (66.8% of cases). This was followed by mandible anterior teeth and maxillary premolar teeth (15.9% and 11.3%, respectively). Apical resection was performed on the maxillary molar teeth in only 0.7% of cases. When the periapical condition was examined, the average cyst diameter was smaller than 5 mm in 30.9% of cases, 5-9 mm in 31.6%, 10-14 mm in 17.9%, 15-19 mm in 8.6%, and 20 mm or larger in 11%. These cysts were identified histopathologically as radicular cysts. When the number of resected teeth was examined in each case, 60.1% of the cases involved one tooth, 25.9% involved two teeth, 10.6% involved three teeth, and 3.3% involved more than three teeth.

Table 1. Demographic characteristics of cases

Demographic findings	Number (n)	Percentage (%)
Gender		
Male	130	43,2
Female	171	56,8
Age		
<20 years	30	10
20-29 years	79	26,2
30-39 years	74	24,6
40-49 years	54	17,9
50-59 years	50	16,6
60 years <	14	4,7
Total	301	100

Table 2. Clinical characteristics of periapical surgery cases

		Number (n)	Percentage (%)
Periapical surgical site	Maxilla incisor-kanin	201	66,8
	Maxilla premolar	34	11,3
	Maxilla molar	2	0,7
	Maxilla total	236	78.4
	Mandible incisor- canine	48	15,9
	Mandible premolar	12	4,0
	Mandible molar	4	1,3
	Mandible total	65	21.6
Diameter of cystic lesion	<5mm	93	30,9
	5-9 mm	95	31,6
	10-14 mm	54	17,9
	15-19 mm	26	8,6
	20 mm <	33	11
Number of teeth resected	1 tooth	181	60,1
	2 teeth	78	25,9
	3 teeth	32	10,6
	3 teeth <	10	3.3
	Total	**301**	**100**

Table 3 summarizes the reasons for periapical surgery. It was revealed that periapical surgery was performed for technical reasons in 48.2% of cases and for biological reasons in 51.8%. The most common technical reasons for periapical surgery were non-homogeneous filling (15.6%), underfilling (12%), and overfilling (9.6%). The least common technical reasons were perforation or deviation (1%), empty root canal (2%), and fractured instrument (2%). 1.3% of cases had a recurrence after apical surgery. Coronal restorations were evaluated as being sufficient in 72.76% of cases and insufficient in 27.24%. The most common biological reasons for periapical surgery were cysts (30.2%), traumas (16.6%), and apical abscesses (5%).

Table 4 shows the distribution of errors causing periapical surgery by region. It can be seen that the

errors causing periapical surgery occurred mostly in the maxillary incisor region (66.8%), followed by the mandibular incisor-canine region (15.6%) and the maxilla premolar region (11.3%). 72.4% of overfilling cases, 78.7% of non-homogeneous filling cases, and half of underfilling cases occurred in the maxillary incisor-canine region. Similarly, 66.7% of perforations and fractured instruments and 78.6% of multiple errors also occurred in this region. All relapses after periapical surgery occurred in this region. Pearson's chi-square test was conducted to investigate any significant differences between the types of errors causing periapical surgery and the jaw regions, but no significant difference was observed (p= 0.48).

Table 5 shows the relationship between the causes of periapical surgery and cyst size. Pearson's chi-square test was used to investigate whether there was a significant difference between the types of errors causing cyst and periapical surgery; a significant difference was observed (p = 0.036). Overfilling and underfilling were most common in cysts smaller than 10 mm. Half of the empty canals and relapses after periapical surgery were seen in 10-15 mm cysts, while half of the instrument fractures occurred in cysts smaller than 5 mm.

Table 3. Technical and biological reasons of periapical surgery.

		Number (n)	Percentage (%)
Technical reasons	Overfilling	29	9,6
	Underfilling	36	12,0
	Non-homogeneous filling	47	15,6
	Empty root canal	6	2,0
	Fractured instrument	6	2,0
	Perforation or deviation	3	1,0
	Multiple errors	14	4,7
	Recurrence after apical surgery	4	1,3
	Coronal restoration (sufficient)	219	72.76
	Coronal restoration (insufficient)	82	27.24
Biological reasons	Trauma	50	16,6
	Cyst	91	30,2
	Apical abscess / infection	15	5,0

Table 4. Distribution of periapical surgery reasons by the regions of the jaws

	Periapical surgical region						
	Maxilla incisor-canine	Maxilla premolar	Maxilla Molar	Mandible incisor-canine	Mandible Premolar	Mandible Molar	Total
Overfilling	21	4	0	1	2	1	29
	72,4%	13,8%	0,0%	3,4%	6,9%	3,4%	100,0%
Underfilling	18	10	1	4	2	1	36
	50,0%	27,8%	2,8%	11,1%	5,6%	2,8%	100,0%
Non-homogeneous filling	37	1	1	6	2	0	47
	78,7%	2,1%	2,1%	12,8%	4,3%	0,0%	100,0%
Empty root canal	5	0	0	1	0	0	6
	83,3%	0,0%	0,0%	16,7%	0,0%	0,0%	100,0%
Fractured instrument	4	2	0	0	0	0	6
	66,7%	33,3%	0,0%	0,0%	0,0%	0,0%	100,0%
Perforation/ deviation	2	0	0	1	0	0	3
	66,7%	0,0%	0,0%	33,3%	0,0%	0,0%	100,0%

Multiple errors	11	2	0	1	0	0	14
	78,6%	14,3%	0,0%	7,1%	0,0%	0,0%	100,0%
Trauma	35	2	0	12	1	0	50
	70,0%	4,0%	0,0%	24,0%	2,0%	0,0%	100,0%
Cyst	55	11	0	20	3	2	91
	60,4%	12,1%	0,0%	22,0%	3,3%	2,2%	100,0%
Apical abscess/ infection	9	2	0	2	2	0	15
	60,0%	13,3%	0,0%	13,3%	13,3%	0,0%	100,0%
Recurrence after apical surgery	4	0	0	0	0	0	4
	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%
Total	201	34	2	48	12	4	301
	66,8%	11,3%	0,7%	15,9%	4,0%	1,3%	100,0%

Table 5. Relationships between periapical surgery reasons and cyst size

	Cyst size					
	<5mm	5-9 mm	10-14 mm	15-19 mm	20 mm <	Total
Overfilling	13	11	3	1	1	29
	44,8%	37,9%	10,3%	3,4%	3,4%	100,0%
Underfilling	20	10	2	1	3	36
	55,6%	27,8%	5,6%	2,8%	8,3%	100,0%
Non-homogeneous filling	14	14	11	4	4	47
	29,8%	29,8%	23,4%	8,5%	8,5%	100,0%
Empty root canal	1	1	3	1	0	6
	16,7%	16,7%	50,0%	16,7%	0,0%	100,0%
Fractured instrument	3	2	1	0	0	6
	50,0%	33,3%	16,7%	0,0%	0,0%	100,0%
Perforation/ deviation	1	1	1	0	0	3
	33,3%	33,3%	33,3%	0,0%	0,0%	100,0%
Multiple errors	5	3	1	3	2	14
	35,7%	21,4%	7,1%	21,4%	14,3%	100,0%
Trauma	8	14	11	6	11	50
	16,0%	28,0%	22,0%	12,0%	22,0%	100,0%
Cyst	26	35	14	8	8	91
	28,6%	38,5%	15,4%	8,8%	8,8%	100,0%
Apical abscess/ infection	1	4	5	1	4	15
	6,7%	26,7%	33,3%	6,7%	26,7%	100,0%
Recurrence after apical surgery	1	0	2	1	0	4
	25,0%	0,0%	50,0%	25,0%	0,0%	100,0%
Total	**93**	**95**	**54**	**26**	**33**	**301**
	30,9%	**31,6%**	**17,9%**	**8,6%**	**11,0%**	**100,0%**

Discussion

Recent endodontic surgery studies have primarily addressed the treatment outcomes of modern microsurgical techniques and prognostic factors (18-21). Initial treatment steps, however, involve the selection of case and treatment decisions. Few previous studies have evaluated the relative importance of the different factors involved in the decision to perform periapical surgery (12). This study investigated the technical and biological reasons for choosing to perform periapical surgery. For this purpose, the endodontic quality of treatment, the types of technical mistakes observed in root canals, and the periapical state of the teeth were evaluated in periapical surgery cases. The relationship between technical errors and periapical status and the periapical site was also investigated.

The decision to perform apical surgery should be founded on an extensive examination of the related tooth, but the decision-making process should also consider the patient's oral, dental, and medical situations. In deciding whether to perform endodontic surgery, clinicians need to weigh a number of factors, including whether a patient's symptoms include discomfort; whether a patient has a medical history that might influence treatment; whether the goal of treatment is an aesthetic or functional improvement; whether surgery has been performed previously and, if so, what the outcome was; clinical and radiological findings; the economic status of the patient; and the experience of the clinician (22). Treatment decisions, however, are always based on the clinician's expectations and experiences (23). In addition, patients still appear to prefer dental extraction, ignoring the functional, esthetic, and psychological results of tooth loss (24).

According to El-Swiah and Walker (12), the decision to perform apical surgery cases is based on 60% biological factors and 40% technical factors. Kaya et al. (25) found that biological reasons for periapical surgery were given for 35% of patients, while technical reasons were given for 17.9%. In comparison, Abramovitz et al. (26) found that technical factors were cited as the person for periapical surgery in 70% of teeth. In a study by Kojima et al. (27), the incidence of endodontic technical errors in root canals was found to be 44.5%; in comparison, Gomes et al. (28) found the incidence to be 63.73%. In the latter study, 51.8% of periapical surgery cases were related to biological factors, and 48.2% were related to technical factors. Kojima et al. (27) demonstrated that the success rates for nonvital pulp obturation were similar to those of vital ones. Therefore, pulp status before endodontic treatment does not appear to affect the association between endodontic technical errors and apical lesions.

In this study, maxillary anterior teeth were the most common teeth to undergo apical surgery. Maxillary teeth generally undergo traditional root canal treatment more often than mandibular teeth. Mandibular anterior teeth are the second most common teeth to undergo periapical surgery. According to Abramovitz et al. (26), this may be due to the fact that mandibular incisors have a second uncleaned canal that may be responsible for the failure of conventional root canal treatment. In this study, it was observed that the errors leading to periapical surgery occurred mostly in the maxillary incisor region (66.8%), followed by the mandibular incisor-canine region (15.6%) and the maxilla premolar region (11.3%). Gomes et al. (28) found a remarkably higher degree of apical radiolucencies in the maxillary molars, while Liang et al.(14) did not find any difference between the tooth groups. However, these authors did not study the correlation between apical radiolucency and endodontic technical errors.

If the average diameter of the periapical lesion exceeds 5 mm, it is considered a large lesion (29). In comparison to teeth with lesions smaller than 5 mm, many studies have shown a decreased success rate in teeth with larger lesions (30). In this study, lesions smaller than 5 mm comprised 30.9% of the teeth treated with periapical surgery. In 37.5% of cases undergoing periapical surgery, the diameter of the cystic lesion was 10 mm or larger. Arx et al. (20) recommended that for lesions greater than 10 mm, the extraction decision should consider periodontal conditions, such as increased tooth mobility, pain, and other clinical symptoms. Therefore, the authors chose to extract 51.8% of teeth with lesions exceeding 10 mm in their study (24). Clinical symptoms, such as pain and increased mobility, in combination with large lesions, may convince the clinician to make a tooth extraction decision. However, a huge periapical lesion is not a contraindication for periapical surgery. The option of allowing teeth to remain in the mouth should be considered so long as extraction is not required for periodontal reasons.

Periapical condition is one of the markers of achievement in endodontics, and its assessment is significant for monitoring treatment outcomes. In this study, significant differences were observed between types of endodontic errors and apical lesion size. Overfilling and underfilling were most common in cysts smaller than 10 mm. Also, half of the empty canals and relapses after periapical surgery were seen in 10–15 mm cysts, while half of the instrument fractures occurred in cysts smaller than 5 mm in this study. Helena et al. (31) found that apical radiolucency appeared most frequently in maxillary anterior and maxillary molars. They also reported that various types of endodontic technical mistakes were severely related to apical lesions. However, due to the more complex anatomy of the posterior teeth, apical radioactivity and endodontic technical error rates could be higher (32,33).

Underfilling is one of the most common technical errors in all root canals. In this study, underfilling was found to occur in 12% of root canals that involved apical surgery, non-homogeneous filling in 15.6%, and overfilling in 9.6%. Helena et al. (31) found that the most common technical mistake involving maxillary molars was a lack of filling of the mesiobuccal second canal (MB2), occurring in 78.4% of cases. Ozbaş et al.

(34) found that 69.11% of root canals had inadequate endodontic fillings, and six of these (8.84%) were overfilled. Boucher et al. (35) identified an important relationship between the level of obturation of root canal therapy and periapical pathology. Bergström et al. (36) stated that the level of obturation rather than the homogeneity of the canal filling is linked to periapical lesions. Petersson et al. (37) found periapical lesions to be more common in teeth with unfilled roots compared to complete obturation. These results show that there is an important correlation between the level of obturation and periapical pathology. However, the risk of apical pathology in teeth with poor obturation density is higher (14). This condition could increase the proliferation of bacteria. Prevention of coronal leakage is a significant factor influencing the long-term success of endodontic treatment. The success of treatment in endodontically treated teeth depends on the quality of the coronal restoration as well as the quality of the endodontic treatment (38,39). In the present study, coronal restorations were evaluated as sufficient in 72.76% of cases and as insufficient in 27.24%. Ray and Trope (40) found fewer periapical lesions in teeth with good coronary restoration.

In this study, endodontic technical errors were evaluated using periapical radiographs, and periapical lesions were evaluated using panoramic radiographs. Periapical radiographs are the most common imaging method used to determine the existence of endodontic technical errors and periapical lesions. The absence of cone beam computerized tomography can be considered the biggest limitation of the present study. However, using cone-beam computerized tomography for every case is not very practical in endodontic clinical studies due to the unnecessary cost and unnecessary exposure of patients to radiation.

Conclusions

The high prevalence of endodontic-induced AP is an important public health problem in many countries, resulting in medical, economic, and ethical consequences. This is mainly due to the poor quality of endodontic treatments available in dental clinics. The results of this study show that remarkable effort should be spent by dentists in Turkey to improve the technical quality of root canal fillings. Increasing the quality of root canal treatments performed by dentists will reduce the need for periapical surgery.

Ethical Approval: Ethics committee approval was received for this study from Afyonkarahisar Health Sciences University, Ethics Committee in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2019/12-401.

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