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Radiographic assessment of endodontic accidents at a Nigerian tertiary health institution: A one-year retrospective study

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Abstract

Introduction: Dental treatment can produce iatrogenic injury to the tooth with endodontic procedural errors occurring during the various stages of endodontic treatment. This study determined the prevalence and pattern of endodontic accidents in clinical practice at a tertiary health center in Nigeria.

Methodology: This was a retrospective study of teeth treated with conventional hand-held file systems. Digital peri-apical working length, pre-obturation and post obturation radiographic images of teeth which received root canal treatment, were assessed for the presence or absence of errors. All errors present were recorded and data analysis was done using IBM SPSS version 22.0.

Results: The prevalence of procedural errors was 31.3% with ledges being the most prevalent error followed by transportation while gouging was the least encountered error. Majority (83.8%) of the errors occurred during root canal instrumentation. A higher proportion of molars had errors compared to the other types of teeth with the prevalence of errors increasing from incisors to premolars and then to molar teeth. The mandibular molars were found to be most frequently involved in procedural errors.

Conclusion: The prevalence of procedural errors seems high. Practitioners should show greater care during the canal preparation stage and to maintain the accuracy of the working length throughout the procedure, as errors which occur during canal preparation accounted for the vast majority of errors seen in this study. Special care should be taken when working on molars, which had a significantly higher error rate when compared to anterior teeth or premolars.

Keywords: Endodontics, procedural errors, iatrogenic accidents

Introduction

Dental treatment can produce iatrogenic injury to the tooth, the soft tissues or both. Any dental procedure can become iatrogenic during any phase of treatment. As with procedures in other complex specialties of dentistry, root canal therapy in endodontics can present unwanted or unforeseen challenges or mishaps[1,2] which may necessitate complex treatments and affect the prognosis of the procedure.[3-5] These mishaps are termed procedural accidents. Endodontic mishaps or procedural accidents are events that could happen during diagnosis, access preparation, cleaning and shaping, obturation and even, post-space preparation with some of these due to inattention to details by the clinician while others are totally unpredictable.[2,6,7] Furthermore, a lack of understanding of the root canal anatomy and the principles of mechanical instrumentation as well as tissue wound healing have been implicated in the etiology of endodontic

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procedural errors.[5]

Endodontic procedural errors can occur during the various stages of endodontic treatment during access cavity preparation (inadequate removal of pulp roof which may lead to missed canals, failure to secure straight line access and perforation of the coronal walls of the pulp chamber), during root canal instrumentation (ledge, root perforation, apical transportation, fractured instrument) and during root canal obturation (inadequate root canal filling length or density, vertical root fracture).[2,8,9]

Being aware of these potential accidents and the possibility of their occurrence leads to useful treatment and a reduction in their incidence.[1] An independent analysis of these errors must be made during the planning of operative procedures.[8] Knowledge of the etiologic factors involved in procedural accidents is essential for their prevention.[6] In addition, the methods for recognizing and treating them as well as the effects of such accidents on the prognosis must be learned. Most problems can be avoided by adhering to basic principles of diagnosis, case selection, treatment planning, access preparation, cleaning and shaping, obturation, and post space preparation. However, errors sometimes do occur in spite of exact and overall consideration of related requirements.[1]

Majority of studies determine endodontic failure on the basis of radiographic findings and clinical signs/or symptoms of the treated teeth. Studies have been reported on endodontic procedural errors in other countries[1,9-13] with only a handful of reports of such studies emanating from developing nations like Nigeria. Hence, this study was designed to determine the prevalence and pattern of endodontic accidents in clinical practice at a tertiary health center in Nigeria.

Methodology: This was a retrospective study of teeth treated with conventional hand-held file systems in the Department of Restorative Dentistry of the University of Benin Teaching Hospital between June 2018 and May 2019. All cases of root canal treated teeth were identified from the clinic records. Inclusion criteria were all permanent maxillary and mandibular teeth, prepared with conventional hand-held files during root canal treatment. Excluded were teeth with calcified canals, external root resorption, lateral root resorption, and periapical pathologies. Digital periapical working length, pre-obturation and post obturation radiographic images of these patients' teeth which received root canal treatment (stored in KODAK imaging software) within the study period, were assessed for the presence or absence of errors. The radiographs were assessed by one of the authors and a senior resident and in case of differences in opinions, the X-ray in contention was shown to a more senior dentist for his opinion.

Errors were classified as follows:[9,14] Ledge: Radiographic image showed deviation of file from main path of canal and the creation of a step in the wall of the root canal. Transportation: Radiographic image showed deviation of file from main path of canal and the creation of an artificial canal in the root. Zipping/apical perforation: Radiographic image showed file beyond the apical foramen and disrupting the apical seal. Furcation perforation: Radiographic image showed association of pulp space with periodontal space in the furcation region of the tooth. Cervical perforation: Radiographic image showed association of pulp space with periodontal space in the cervical region of the tooth. Instrument separation: Radiographic image showed part of file or reamer left in the canal. Gouging: Radiographic image showed over preparation of cavity than required space. Underfilling: Radiographic image showed space between canal obturation and radiographic apex is more than 2mm. Overfilling: Radiograph showed obturation material beyond root apex (Figure 1).

Data analysis was done using IBMSPSS version 22.0. Chi-square test was used to determine association between variables where applicable. Descriptive statistics in form of frequency, percentages and cross tabulations were done. P-value was set at 0.05.

Results were presented as tables and figures.

Results

A total of 346 patients received root canal treatment and a total of 416 root canal treated teeth were assessed, with 50.5% (210) being mandibular teeth and 49.5% (206) being maxillary teeth. The incisors represented 128(30.8%) of the root treated teeth, 3(0.7%) were canines, 107(25.5%) premolars and 178(43.0%) molars (Figure 2).

Out of the total number of 416 root treated teeth

Table 1. Prevalence of types of error

ERRORS	frequency (n)	percentage (%)
Ledge	39	30.0
Gouging	2	1.5
Transportation	21	16.2
Zipping	31	23.8
Cervical perforation	3	2.3
Furcation perforation	6	4.6
Instrument separation	9	6.9
Under filling	11	8.5
Over filling	8	6.2
Total	130	100.0

Table 2 Association between tooth type and presence of errors

Teeth type	error present n (%)	error absent n (%)	total n (%)
Incisor	26(20.3)	102(79.7)	128(100)
Canine	0(0.0)	3(100)	3(100)
Premolar	23(21.5)	84(78.5)	107(100)
Molar	81(45.5)	97(54.5)	178(100)
p=0.0001			
Arch			
Maxillary	67(32.5)	139 (67.5)	206(100)
Mandibular	63(30.0)	147(70.0)	210(100)
Total	130(31.3)	280(68.8)	416(100)
p=0.579			

Table 3: Association between teeth type and class of errors

Teeth	Access cavity Prep n(%)	Root canal Instrumentation n(%)	Root canal Obturation n(%)	Total n(%)
Incisor	1(3.8)	20(76.9)	5(19.2)	26(100)
Premolar	0(0.0)	19(82.6)	4(17.4)	23(100)
Molar	1(1.2)	70(86.4)	10(12.3)	81(100)
Total	2(1.5)	109(83.8)	19(14.6)	130(100)
p=0.68				

Table 4: Association between error type and tooth type

Error	incisor	premolar	molar	total	p-value
	n (%)	n (%)	n (%)	n (%)	
Ledge	8(20.5)	6(15.4)	25(64.1)	39(100)	0.903
Gouge	1(50.0)	0(0.0)	1(50.0)	2(100)	0.516
Cervical pf	0(0.0)	3(100)	0(0.0)	3(100)	0.001
Transport	2(9.5)	3(14.3)	16(6.2)	21(100)	0.315
Zipping	10(32.3)	3(9.7)	18(58.1)	31(100)	0.098
Furcation prf	0(0.0)	0(0.0)	6(100)	6(100)	0.149
Instrument sep	0(0.0)	4(44.4)	5(55.6)	9(100)	0.05
Underfilling	2(18.2)	3(27.5)	6(54.5)	11(100)	0.684
Overfilling	3(37.5)	1(12.5)	4(50.0)	8(100)	0.440

* prf =perforation, sep =separation

Figure 1: Radiographs showing errors

Figure 2: Distribution of endodontically treated teeth

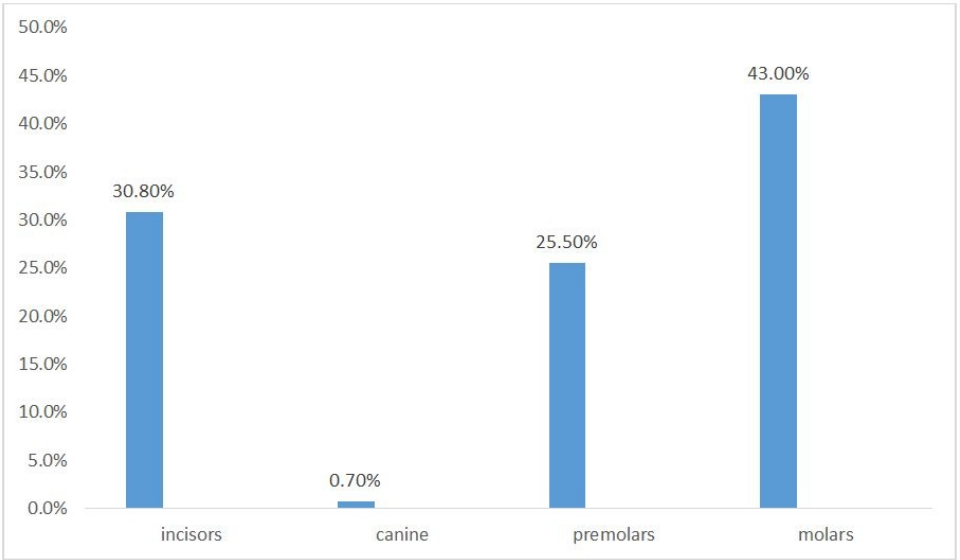
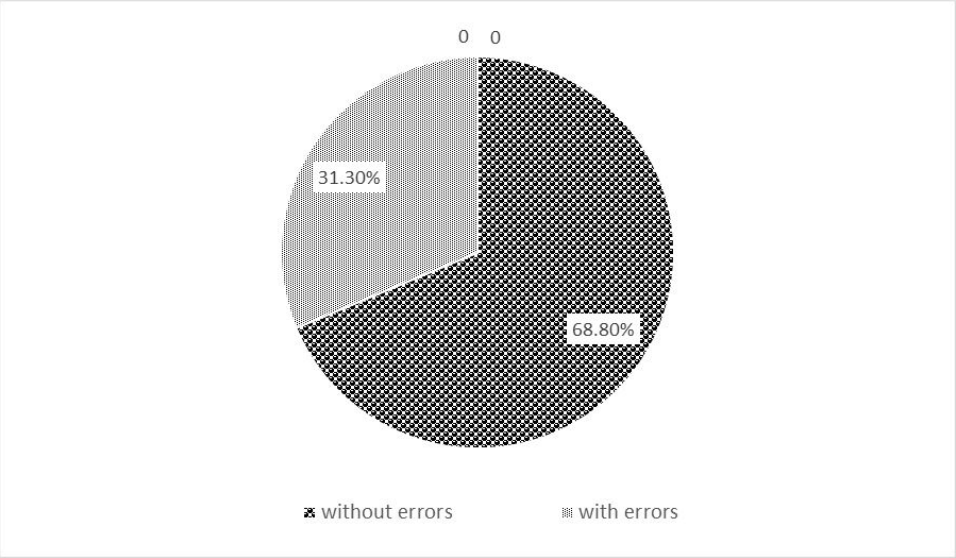


Figure 3: prevalence of errors



assessed radiographically, 130(31.3%) contained procedural errors (Figure 3), out of which 39 (30.0%) were ledges, 2(1.5%) had gouging, 21(16.2%) had transportation, 31(23.8%) had zipping, 3(2.3%) had cervical perforations, 6(4.6%) had furcation perforations, 9(6.9%) had instrument separation, 11(8.5%) were under filled and 8(6.2%) were overfilled (table 1).

Classification of the errors revealed that majority (83.8%) occurred during root canal instrumentation while 19 (14.6%) and 2(1.5%) of the errors occurred during root canal obturation and access cavity preparation respectively.

Table 2 shows the association between the type of tooth, dental arch involved and the presence of errors. There was statistically significant association between the type of tooth and the presence of errors, with a higher proportion of molars having errors compared to other teeth types. Furthermore, the prevalence of errors increased from incisors through premolars and to the molars ($p<0.0001$). However, there was no statistically significant association between the dental arch involved and the presence of errors ($p=0.579$).

The teeth found to possess procedural errors most frequently were mandibular and maxillary molars at 54(41.9%) and 27(20.9%) respectively, followed by maxillary incisors and maxillary premolars at 20(15.5%) and 20(15.5%) respectively. The teeth found to possess procedural errors least frequently were mandibular premolars (1.6%) and mandibular incisors and (4.7%) respectively. In this study, the canines were observed not to encounter any procedural error.

There was no statistically significant association between the type of tooth and class of error observed in all the tooth types that encountered errors during root canal instrumentation ($p =0.68$) as shown in table 3.

Table 4 depicts the association between the error type and tooth type. Only premolars had cervical perforations while only molars had furcation perforations. Instrument separation was observed in premolars and molars only.

Discussion

Endodontic treatment is a common procedure undertaken to treat diseased teeth and to maintain their functionality in the mouth. This study revealed that a higher proportion of endodontically treated teeth were mandibular teeth, a similar finding in previous studies[1,10] but contrary to some other reports.[11,15] The findings of this study corroborate a previous report that the molars are the most frequently root-treated teeth.[15,16] This may be due to their anatomic features such as pits and fissures, which make them more susceptible to plaque accumulation and consequently caries.[10] Predictably, permanent mandibular first molars were the most common teeth to undergo endodontic treatment followed by permanent maxillary first molars. This may be related to their early eruption

and favorable morphology (pits and fissures) for plaque retention.[10] The least common teeth to undergo root canal treatment were third molars, a similar finding in a previous study.[16] This is perhaps due to the fact that third molars show the highest degree of morphological variation. This increases the complexity and expertise required for their successful treatment. In addition, these teeth often have limited value in mastication/occlusion. Therefore, these teeth are preferentially extracted rather than to receive endodontic treatment.[4] Their relatively late eruption in the dental series may also be responsible for their less frequent involvement by caries, especially if caries initiated by impaction is not considered.

The prevalence of procedural errors in this study (31.3%) is comparable to the findings of Waqas Yousuf et al[10] which reported a prevalence of 32.8%, but is far lower than the prevalence values of 66%[9] and 67.3%[1] reported in other studies. The prevalence of errors in this study however, was higher than the 14.33% reported in another study and this difference maybe because nickel-titanium files, with their acknowledged flexibility, were employed.[12] This goes to buttress the need for more meticulous techniques using flexible files during root canal treatment.

The root canal treatment stage with the highest record of errors recorded was during root canal preparation (cleaning and shaping), followed by the obturation stage and then the access cavity preparation stage in descending order, a finding similar to reports of a previous study.[1] This may be because the root canal preparation stage incorporates the sanitization process, which involves the emptying and enlarging, combined with the use of antibacterial strategies and the instrumentation of the root canals.[8]

The most common error observed in this study was ledge formation (30.0%) which was also the most common error reported in some previous studies[14,17] but not in others which reported perforation,[12] voids,[182] and apical transportation[13] as the most common error. Furthermore, Dadresanfar et al[18] and Mozayeni et al reported ledge formation to be the second most prevalent error in their studies. Ledge formation therefore is one of the more prevalent errors encountered in root canal treatment procedure.

Reports from the studies carried out by Dadresanfar et al[18] and Hendi et al[13] support the findings of this study that ledge formation was more prevalent in molar teeth especially in mandibular molars compared to maxillary molars and to other teeth. This may be due to the anatomy of the roots and the root canals of molars making them susceptible to this kind of error. Factors such as the instrumentation technique, flexibility of instruments, root canal curvature, tooth type, and canal location have all been proposed to be associated with ledge formation. Of these, the curvature of the root canal is considered the most significant variable affecting the incidence of ledge formation and the greater the curvature, the higher the chances of ledge formation.[4,8] The least encountered error in this study was gouging which is consistent with some previous reports.[1,17]

Zipping was the second most prevalent error encountered in this study, accounting for 23.8% of the errors. This may be because all the teeth evaluated were instrumented using stainless steel files with cutting tips. The use of these files has been shown to be associated with zipping compared with the use of nickel-titanium rotary instrument.[19] The prevalence of zipping was higher in the molars than in the anterior teeth. This can be due to the complex anatomy of the molars and the presence of multiple root canals compared to the anterior teeth which have single canals.[18] A previous study[14] reported zipping only in premolar teeth which is not consistent with the findings of this study.

The high prevalence of apical transportation seen in molar teeth compared to anterior and premolar teeth is comparable to a previous study[13] and may be due to the complicated anatomy of these teeth, their higher numbers of canals and the curvature of canals in these teeth.[8] Lack of attention to canal curvature, not pre-curving files during preparation of curved canals and lack of removal of interferences around root canal orifices have been adduced as possible reasons for high prevalence of transportation in molar teeth.[18]

In general, it can be stated that the greater the degree of curvature and the smaller the radius of curvature, the greater the risk of canal transportation. There is evidence that root canals with a large angle and a small radius of curvature can hardly be enlarged without any transportation, independent of whether

rotary nickel–titanium or stainless-steel hand instruments are used.[20]

Instrument separation was found in 6.9% of the cases in this study. This was much lower than the 72.58% (during the exploration of root canals) and 55.47% (during the shaping of root canals) reported by Avoaka-Boni et al.[21]

The most prevalent error during root filling was underfilling (8.5%), a finding similar to a previous report1 and contrary to other reports that observed higher prevalence of overfilling[9,10,21] in as high as 55.47% of root treated teeth. The underfilling observed more in molars in this study is consistent with previous reports[10] and may be because of lack of adequate access to these teeth and inadequate canal flaring which prevents suitable penetration of spreader, especially stainless spreaders, which tend to cause poor filling density.[18]

Analysis of procedural errors when related to individual teeth revealed the following results. Anterior teeth were shown to be significantly less prone to errors than their posterior counterparts a finding corroborating previous reports.[1,9,13] In particular, canines were found to have the least or no error. In posterior teeth premolars were found to have fewer errors compared to molars. This can be attributed to their location in the mouth which provides poorer accessibility and visibility as well as the presence of multiple root canals and root curvature in molar teeth.[10]

Mandibular molars were the teeth with the most encountered errors followed by maxillary molars then maxillary incisors and maxillary premolars. There was no significant difference in occurrence of errors by arch, a finding contrary to previous reports which showed that more errors occurred in mandibular teeth than in maxillary teeth.[1,10]

Conclusion

The prevalence of procedural errors seems high especially when using hand-held files for instrumentation. Practitioners should show greater care to maintain the accuracy of the working length throughout the procedure especially during the canal preparation stage, as errors which occur during canal preparation accounted for the vast majority of errors seen in this study. Special care should be taken when working on molars, which had a significantly higher error rate when compared to anterior teeth or premolars. Emphasis must be placed on preventive measures through community awareness programs to reduce the incidence of caries as well as awareness to seek early intervention for carious lesions through simple restorations rather than waiting for such lesions to progress to the point of requiring endodontic treatment. High risk patients should be provided with prophylactic treatment (such as fissure sealants and fluoride therapy) and regular routine checkups.

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