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ORIGINAL RESEARCH

Complications During Root Canal Shaping: A Survey Among Dentists in Morocco

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ABSTRACT

Introduction: Endodontic therapy is a complex procedure that requires a high level of precision due to the intricacies of the root canal system. Despite advancements in endodontic tools and techniques, incidents such as instrument fractures, dentinal plugs, false routes, and root perforations can occur when best practice recommendations are not adhered to. These complications pose a significant public health concern as they can lead to potentially severe infectious complications and ultimately result in endodontic treatment failure. The aim of this study is to elucidate the causes of endodontic complications, particularly during the root canal shaping stage, and to identify strategies for their prevention.

Materials and Methods: A cross-sectional, analytical, descriptive, and unidirectional study was conducted on a randomly selected sample of 300 private dentists in Casablanca. The questionnaires were completed anonymously, and statistical analyses were performed using SPSS software. The discussion will be enriched through a comprehensive literature search of major databases, complemented by a series of clinical cases illustrating these complications and the means by which they can be mitigated.

Results: The study reveals that 91% of dentists encountered complications during endodontic therapy, with 284 dentists (94.98%) experiencing complications during root canal shaping. The most prevalent complication was instrument fracture, reported by 235 dentists (82.75%). Key contributing factors to these complications included forced file passage, non-adherence to the instrumental sequence, and absence or inadequacy of irrigation. However, these incidents can be averted by adhering to a meticulous treatment protocol and respecting the various steps critical to the success of root canal shaping.

Conclusion: In conclusion, there exists a disparity between recommended best practices and the current practices in the field of endodontics, which can lead to multiple complications and subsequent endodontic treatment failures.

KEYWORDS: Endodontic complications, canal blockage perforation, ledge formation, instrument separation, untreated canal, endodontic treatment, prevention.

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INTRODUCTION

Endodontic treatment is a complex procedure whose goal is to mechanically and chemically eliminate necrotic tissue, microorganisms, and infected dentin to prevent or cure apical periodontitis. The complex morphology of the root canal system makes this objective difficult to achieve. Therefore, a clear understanding of the variation in root canal anatomy is an important prerequisite for successful root canal treatment, as well as proper root canal cleaning and shaping. In recent decades, many improvements have facilitated endodontic therapy in terms of instrumentation, technique, and procedure [1].

However, regardless of the technology or technique used, procedural errors like apical canal transportation, uncentered preparations, and ledge formation will always occur if the recommendations of good practice are not followed [2]. These complications can have various and complex etiologies, which essentially depend on each stage of endodontic therapy. They are often the result of errors in diagnosis, complex endodontic anatomy, non-compliance with asepsis and antisepsis rules, shaping, and other patient and practitioner factors.

Professionals must be aware that at each phase of the RCT, an operating error can have harmful consequences on the prognosis and be the cause of endodontic treatment failure. Knowledge of possible errors, particularly during root canal shaping and their consequences, is essential to prevent them and avoid failures. It is also important to adhere to the biological and mechanical objectives for shaping canals and cleaning root canal systems to minimize needless complications.

Several studies have identified many procedural errors as common during endodontic procedures, such as apical transportation, ledge formation, strip perforation, apical perforation, and instrument separation [3-5]. This motivation prompted us to conduct this study, which focused on the main complications that may arise during endodontic treatments performed by dentists in Casablanca, aiming to highlight their possible causes and provide recommendations for their prevention.

MATERIAL AND METHODS

This is a cross-sectional descriptive study conducted by random survey in Casablanca between January and April 2021, involving 300 dentists who completed individual and anonymous questionnaires. The objective of this study is to evaluate the various complications that may arise during endodontic preparation.

Study Design

Survey Environment: The survey was conducted through direct contact with all practitioners to clarify the task and solicit their cooperation.

Target Population: Our survey targeted all dentists selected from the total number of dentists practicing privately in Casablanca.

Inclusion Criteria: Our study included all dentists who perform endodontic treatments.

Exclusion Criteria: Our study excluded all dentists who do not practice endodontics.

Sampling: Systematic sampling was employed. From a total of 1547 dentists, a sample of 300 dentists from the private sector was selected.

Study Tool: A structured questionnaire was developed after reviewing related studies conducted in Morocco and elsewhere. The survey includes two sections: The first section gathers demographic details of the dentists, including gender, age, origin of the diploma, number of years of practice, and continuing education in endodontics. The second section focuses on complications occurring during root canal shaping, as well as their possible causes identified by the participants.

Statistical Analysis: Data gathered through the questionnaire were analyzed using SPSS version 20.0. The association between different variables was established using the chi-square test.

RESULTS

Among the 300 dentists surveyed, 58% were women, and 68% were between the ages of 23 and 35. The majority of the dentists surveyed (78%) had graduated in Morocco, 85.5% had been practicing for less than 15 years, and 59.3% had received continuing training in endodontics (Table 1).

Of the 300 dentists surveyed, 91% reported encountering complications during their endodontic practice, and 94.98% had experienced iatrogenic errors while shaping the root canal, while only 15 dentists (5.02%) had never done so (Table 2).

Table 1: Representative table of the studied variables.

		N	%
Gender	Female	173	58
	Male	127	42
	Total	300	100
Age	[23-35]	204	68
	[36-45]	57	19
	> 45	39	13
	Total	300	100
Exercise period	< 15 years	254	85,5
	> 15 years	46	14,5
	Total	300	100
Endodontic training	Yes	178	59,3
	No	120	40,3
	Total	300	100

Table 2: Distribution according to the occurrence of complications during endodontic treatment and canal shaping.

		N	%
Complications during endodontic treatment	Yes	273	91
	No	27	9
	Total	300	100
Complications during canal shaping	Yes	284	94,98
	No	15	5,02
	Total	299	100

Regarding the distribution of types of complications encountered during root canal shaping, 82.75% of the dentists had experienced instrument separation accidents, 60.56% had encountered dentinal plugs, 42.96% had created false pathways, 41.90% had both encountered ledges and forgotten to prepare a canal, and 26.76% had created root perforations (Table 3).

Table 3: Distribution according to the types of complications found during root canal shaping.

	N	%
Instrument separation	235	82,75
Canal blockage	172	60.56
False path	122	42.96
Ledges	119	41.90
Canal missing	119	41.90
Root perforation	76	26.76

The principal causes of canal shaping complications encountered by privately practicing dentists in Casablanca are summarized in the following table (Table 4).

The association between the studied variables and complications occurring during endodontic treatment revealed the following results:

AGE:

87.75% of dentists aged between 23 and 35 reported experiencing difficulties when performing root canal treatment, compared to 98.25% of dentists aged between 36 and 45, and 97.44% of dentists aged over 45. In fact, the frequency of complications during endodontic treatment was associated with age, showing a statistically significant difference (p=0.016).

GENDER:

91.33% of female dentists experienced complications during endodontic treatment, as did 90.55% of male dentists. The frequency of complications during endodontic treatment was not associated with the gender of the practitioner, showing a non-significant difference (p=0.81).

Table 4: Principal causes of canal shaping complications.

			N	%
Causes of canal blockage	**Forced use of instruments**	Yes	94	55,29
		No	76	44,71
		Total	170	100
	Lack or insufficient irrigation	Yes	88	51,76
		No	82	48,24
		Total	170	100
Causes of ledges	**Lack of pre-curvature of steel files**	Yes	75	59,52
		No	51	40,48
		Total	126	100
	Not following the instrumental sequence	Yes	58	46,03
		No	68	53,97
		Total	126	100
Causes of creating a false path	**Forced passage of files after creating a plug**	Yes	86	61,42
		No	54	38,58
		Total	140	100
	Lack of pre-curvature of steel files	Yes	61	43,57
		No	79	56,43
		Total	140	100
Causes of root perforations	**Complex root anatomy**	Yes	51	49,03
		No	53	50,97
		Total	104	100
	Forced passage of files over a ledge	Yes	46	44,23
		No	58	55,77
		Total	104	100
Causes of missing canal	**Root canal calcifications**	Yes	89	72,36
		No	34	27,64
		Total	123	100
	Incomplete access cavity	Yes	51	41,46
		No	72	58,54
		Total	123	100
	Not using angulated radiographic incidences	Yes	50	40,65
		No	73	59,35
		Total	123	100
Causes of instrument separation	**Alloy fatigue**	Yes	197	83,47
		No	39	16,53
		Total	236	100
	Overused Instrument	Yes	154	65,25
		No	82	34,75
		Total	236	100

Endodontic Training:

93.26% of dentists who had undergone endodontic training found it difficult to perform root canal treatment, which is very similar to the percentage of dentists who had not completed endodontic training (87.50%). In fact, the frequency of complications during endodontic treatment is not associated with endodontic training, with an insignificant difference (p=0.089).

Practice Period:

100% of practitioners with more than 15 years of experience experienced difficulties during root canal treatment, compared to 89.37% of practitioners with less than 15 years of experience. The frequency of complications during endodontic treatment was associated with the period of practice, showing a statistically significant difference (p=0.025).

DISCUSSION

In order to judge the study's value, it is essential to highlight certain points that will help assess the quality of our study's results and prevent any potential confusion for readers: The obtained results are specific to the studied sample; The reliability of the collected information depends on the sincerity of the dentist in representing reality and the accuracy of the summary scales.

Root canal shaping is the initial step that determines the disinfection and obturation of the root canal. When combined with ample irrigation, it remains crucial for achieving the biological and mechanical objectives of root canal preparation [6].

However, the introduction of any instrument into a canal brings forth a multitude of challenges, orchestrated by two primary parameters: instrument locking and the tip effect. Instrument locking typically occurs in the coronary 2/3 region when there is parietal interference, while the tip effect expresses the projection of the instrument tip into an arbitrary trajectory that deviates from the canal's path. These two parameters are the starting points for all root canal shaping complications [7, 8].

APICAL BLOCKAGE

Apical blockage occurs when K-files are used with forward-backward movements below the working limit. This large-amplitude movement leads to cutting and compaction of dentin chips in the apical direction. It also occurs during the forced use of instruments and when canal irrigation is insufficient. To prevent this incident, it is recommended to maintain and check apical patency throughout the root canal preparation by consistently recapitulating with a small-diameter steel file, typically K08 or K10, between successive passes of preparation instruments, along with abundant irrigation [9].

Indeed, irrigation plays a dual role in endodontics: it has an effective antibacterial chemical action and a physical action that eliminates organic and mineral debris as well as microorganisms.

Additionally, the use of modern rotary instruments with a specialized design can help remove debris and prevent apical blockage [10] (Fig. 1).

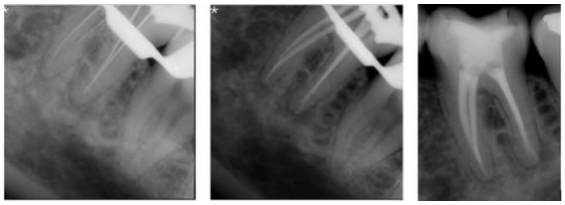

Fig. 1: Clinical case management of several dentinal plugs in a left mandibular first molar.

LEDGE FORMATION

A ledge is an iatrogenically created irregularity or platform on the outer side of the canal curvature. Ledge formation typically occurs when rigid files with sharp, inflexible cutting tips are used in a rotational motion within a curved root canal. It can also result from the repeated application of pressure with the same file at a certain level, especially before the beginning of an apical curve, the use of non-precurved stainless steel files, insufficient pre-flaring, or the absence of a glide path [11] (Fig. 2).

To prevent this complication, preparation using the "crown-down" technique and manual shaping with pre-curved files over the last 3 to 4 millimeters in a smooth and regular manner allows the file to follow the root canal path effectively [12].

Kapalas et al. (2000) cited the accentuated root canal curvature as the most significant factor affecting ledge formation due to the abutment of the instrument against the wall opposite the curvature [13].

According to Lambrianidis (2009), the most frequent causes of ledge formation are: Inadequate access cavity preparation; Incorrect determination of root canal length; Use of non-pre-bent stainless steel instruments in a curved root canal; Use of too curved rigid instruments [14].

The only chance to address this error is to introduce into the canal a fine K-file (08 to 010), very strongly pre-curved, with 1-2 mm apical slight movements and a 30° watch-winding rotation, which will inevitably deviate from the false trajectory [11, 13].

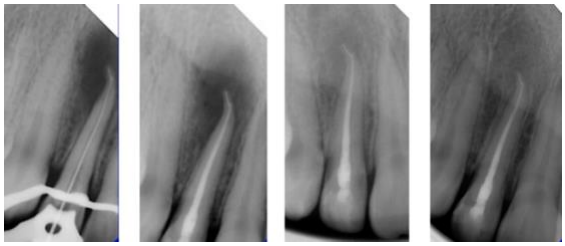

Fig. 2: Clinical case illustrating an instrumental fracture with a perforation and then a hermetic root canal filling allowing a good healing of the chronic apical periodontitis after one year.

PERFORATION

This refers to a deviation of the canal path during shaping characterized by the creation of an iatrogenic canal or communication between the root canal space and surrounding cementum. The causes are similar to those for the creation of a ledge, as it can also result from stiff instruments with sharp cutting tips used in a rotational motion in curved canals. Additionally, this iatrogenic error can occur due to a lack of analysis of the preoperative X-ray, which may not show an accentuated apical curvature and anticipate difficulty in root canal preparation [11].

It is necessary to act in the same way as for the prevention of the ledge: Do not force with the instruments; Respect the initial canal trajectory; Eliminate dentinal interferences through effective preflaring, allowing instrumentation without constraints. Often, accidents in root canal shaping accumulate and will lead initially to the dentinal plug, followed by the ledge and the creation of a false canal path. If the practitioner continues the preparation with force, this will undeniably lead to root perforation.

The anatomical complexity of the root canal system can make the different steps more complicated. For example, curved and spindly roots represent a major risk of deviation from the initial trajectory, which can only be addressed by systematically pre-curving the instruments [15].

UNTREATED CANAL

Some canals are difficult to locate and prepare, while others are simply forgotten due to a lack of knowledge of canal anatomy. This type of complication can be avoided through adequate and reasoned access cavity preparation. In addition to this, knowledge of the fundamentals of endodontic anatomy and a reasoned analysis of the radiographic images to identify a non-centered file in the canal are necessary.

In a published article by Bhavin Bhuva (2020), canals missed during endodontic treatment are an important cause of treatment failure. The limitations of two-dimensional radiography, lack of magnification facilities, anatomical variations, calcifications, and operator skill can all contribute to missed canals. These canals include the MB2 of maxillary molars, the middle mesial of mandibular molars, the lingual canal of mandibular incisors, and the second or third canal of premolars [15].

INSTRUMENT SEPARATION

Several factors may be involved in instrument separation, including instrument wear, alloy fatigue, abusive or forced use of the instrument, and a lack of knowledge of endodontic anatomy.

It is advisable to perform a preoperative analysis of the root canal anatomy to anticipate the level of difficulty, respect the crown-down technique, create a correct access cavity, always check the instrument before using it, and limit the frequency of use.

The main causes of steel file fracture are repeated use, especially with small-diameter files, and blocking of the tip in the canal followed by anti-clockwise rotation. Fracture of rotary instruments can occur due to torsional overload or fatigue through flexure. Torsional fracture happens when the elastic limit of the metal is exceeded, and the tip of the instrument binds to the canal walls. Meanwhile, fracture resulting from flexural fatigue occurs when an instrument that has already been weakened by metal fatigue is placed under stress. Various factors have been associated with the fracture of rotary instruments, including rotational speed, canal curvature, instrument design, and operator experience [11] (Fig. 3).

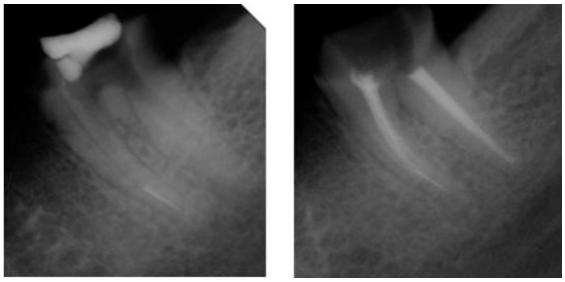

Fig. 3: Impossiblity to bypass/remove the fractured instrument tip and hermetically sealing of the root canal system to the fracture line.

Removing fractured instruments remains a complicated and expensive process. That is why this procedural error should be avoided as much as possible.

To prevent instrumental separation, Laurichesse suggested five basic steps:

Examine the instrument thoroughly before, during, and after use, and eliminate any instrument showing signs of deformation such as despiralization and elongation.

Respect the rules of instrument handling; do not force or screw.

Use instruments in sequence; never skip a number.

Stop working in case of fatigue or non-cooperation.

If an accident occurs, be prepared to deal with it immediately [12] (Fig. 2).

CANAL TRANSPORTATION

Canal transportation is a persistent deviation from the original canal axis during root canal instrumentation. It occurs due to the elimination of canal wall structure on the outer curve in the apical half of the canal, caused by the tendency of the files to return to their original linear shape during canal preparation.

Rigid endodontic instruments, especially large stainless steel files, tend to exert high lateral forces in curved canals and can lead to straightening, particularly in the medial and apical thirds [11].

Widening the apical part with large, rigid files destroys the initial apical constriction and creates an enlarged, irregularly shaped apical third [16].

RECOMMENDATIONS

Procedural errors during endodontic treatment are associated with inferior outcomes and possible non-resolution of apical periodontitis. This study reveals that

procedural errors depend on various factors, including: The shape of the access cavity; The alloy from which the files are made; The design of the tip of the file; The preparation technique; The irrigation in the root canal; The degree of curvature; The operator's experience.

As a result, several recommendations can be issued to prevent these complications: Knowledge of the anatomy and possible variations; Analysis of the preoperative X-ray; Isolation of the tooth with a rubber dam and pre-endodontic reconstruction; Creating a correct access cavity; Determining the correct working length; Using flexible instruments made of high-quality alloys or pre-curved instruments; Avoiding overuse and excessive force.

Instrumentation of a curved canal should be done using flexible instruments, avoiding rigid ones, and the preparation should be minimally invasive. Adhere to sequential instrumentation, switching to a larger file only after the smaller one moves freely in the canal. Recapitulation should be performed to maintain the patency of the root canal. Finally, review the file before and after use.

CONCLUSION

This study among private practitioners in Casablanca revealed a significant number of dentists experiencing difficulties in performing endodontic treatment. We also noted that the difficulties encountered are those linked to: Instrumental separation incidents (82.75%); Canal blockage (60.56%); False paths (42.96%); Ledges (41.90%); Root perforations (26.76%).

However, such complications can be avoided by adhering closely to treatment protocols and through experience gained over the years of practice. Dentists must keep in mind that in every phase of root canal treatment, an operative error may occur. The success of the RCT is not influenced by isolated factors but by the combination of a rigorous operative sequence throughout the root canal shaping.

Knowledge of probable operative procedural errors and their possible causes allows the practitioner to prevent them at each stage of the preparation and achieve optimal endodontic practice. Our survey was undoubtedly a means of self-assessment for these dentists, making them aware that some of their routine techniques need to be improved to meet current endodontic standards.

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None.

COMPETING INTERESTS

The authors declare no competing interests with this study.

AUTHORS' CONTRIBUTIONS

The participation of each author corresponds to the criteria of authorship and contributorship emphasized in the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly work in Medical Journals of the International Committee of Medical Journal Editors. Indeed, all the authors have actively participated in the redaction, the revision of the manuscript, and provided approval for this final revised version.

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