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Original Research Article | **Endodontics**

An Apprise on Root Canal Preparation Procedures and How to Evade Procedures Errors in Endodontics A New Assessment

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Abstract

Background: Effective root canal treatment involves cleaning and shaping root canals using a range of instrumentation procedures and techniques. The aim of this review was to provide an update on root canal hand instrumentation techniques and how to overcome iatrogenic errors. ***Purpose***: Purpose of this review was to provide an update on root canal hand instrumentation techniques commonly used in endodontics, including how to overcome iatrogenic errors and optimize the quality of endodontic treatment outcomes. ***Methods***: A comprehensive search was carried out using multiple databases, PubMed, Medline, Google scholar, and Scopus, to identify relevant studies addressing the objective of this study and to summarize the current evidence to readers. ***Results***: The hybrid technique is a commonly used approach that combines the benefits of both the crown-down and step-back techniques and was reported to be one of the best techniques to produce an optimal root canal preparation outcome. Hand-instrument manipulation using the balanced forced technique is also favored as it rapidly and safely permits removal of canal contents allowing irritants and medications to reach deep inside canal spaces. ***Conclusion***: The use of hand files is still recommended for initial canal negotiation and preparation and is essential for the correction of procedural errors. This study provided an update on several hand instrumentation techniques commonly used in endodontics. The correct and safe application of these techniques can prevent iatrogenic procedural errors from occurring which optimizes the quality oftreatment outcome.

Keywords: Endodontics, Root canal preparation, Hand instrumentation, Techniques, Procedural errors, Treatment.

INTRODUCTION

For many years, Root Canal Treatments (RCT) used traditional protocols imposing the careful cleaning of the canals, the removal of the smear layer, and the sealing of the filling materials inside the pulp chamber.

These procedures were combined with the manual, instrumental or chemical shaping of the root lumen. The preparation of the canal(s) includes chemical mechanical enlargements. We also took into account the coordination of the successive steps, leading ultimately to the preparation of the root canal before filling the empty space. After disinfection, pulp remnants were removed. A clean root canal was obtained after root widening [1, 13].

Endodontic cements filled the pulp chamber, namely when a zinc oxide eugenol mixture was used. Employing a central master cone, and a series of small accessory cones, after axial and lateral condensation the root chamber was gradually filled. These steps include the sealing of lateral, secondary and accessory canals. In addition to conventional protocols, more recently attempts were made to regenerate the dental pulp. A few pulp cells proliferate and renewed the pulp tissue. We envision the formation of a dental pulp and furthermore its mineralization occluding the root lumen. Part of the endodontic cavity was still alive, or proliferation of pulp cells was requested to restore the biology of the dental pulp [5].

Extracellular matrix molecules and/or other growth or transcription factors contributed to regenerate the pulp. In contrast with mechanical methods, biological options were considerate. The innovative approaches proposed were envisaging the implication of structural cells and signaling factors. In this context, we used stem cells, bioengineered scaffolds, growth factors, transcription factors, and cytokines. Altogether, the molecules were implicated in the different procedures that pave the way as biological substitutes for root canal treatments. In the first part of this review, we summarize the basic concepts and related methods devoted to the traditional Root Canal Treatment (RCT). In the second part, we focus on recent concepts aiming to regenerate the dental pulp, leading to pulp renewal that further underwent mineralization. Along these lines of evidence, biological concepts provide the basis of innovating pulp therapies [8].

Dental students learn the required skills as depicted in their BDS program in two stages, namely, pre- clinical simulated clinical activities followed later by the clinical activities carried out on patients. Due to the high cost and demand on the resources to run these simulated activities, it is important to optimise the methods of learning and make sure that these methods have been evidenced. The objective of root canal treatment is to thoroughly clean, disinfect, and seal the root canal system. To accomplish this goal, a biomechanical debridement of the root canal system is essential.

This process involves a combination of mechanical instrumentation with chemical disinfection to eliminate most of the infective microorganisms in the root canal system, as well as the inorganic contaminant debris and dentin. Cleaning and shaping the root canal system is a complex procedure that involves the manipulation of endodontic hand instruments in a variable, curved multiple canal system. For completing the instrumentation procedure, there is a range of hand instrument preparation and manipulation techniques to mechanically remove canal contents and infected dentine, e.g., crown-down, step-back, and hybrid techniques, using reaming, filing, watch-winding, circumferential filing, and the balanced force manipulations [1, 11].

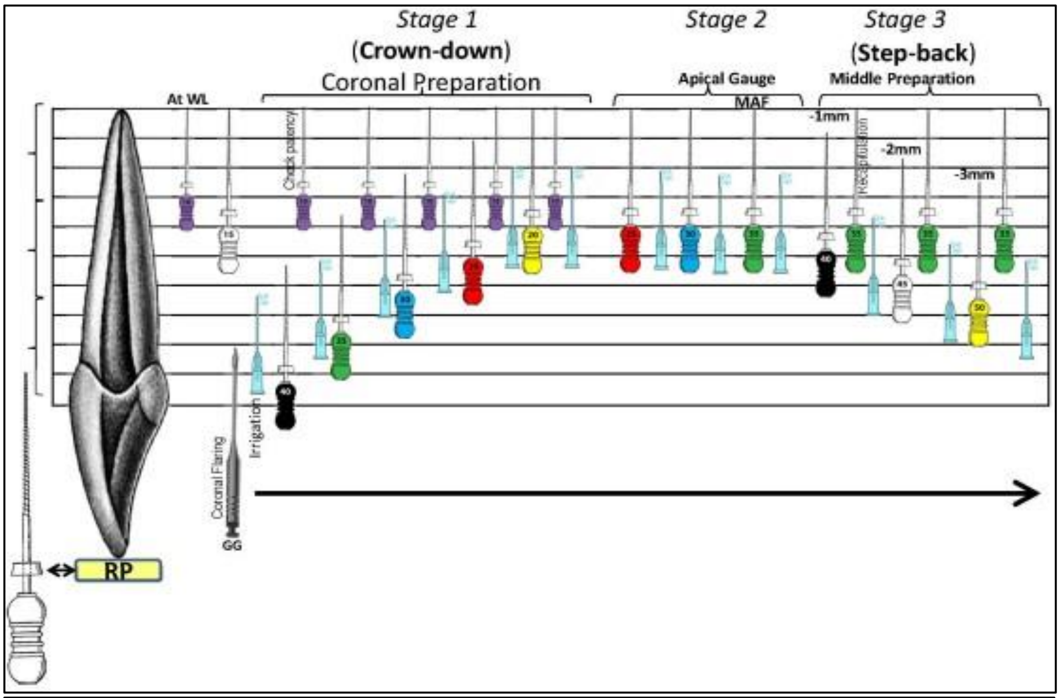
The inaccurate or incorrect manipulation of endodontic hand instruments during canal instrumentation can result in a number of iatrogenic procedural errors. These may include straightening of the root canal, the development of ledges, apical zipping, canal transportation, perforations, and instrument separation [8]. The purpose of this review was to provide an update on root canal hand instrumentation techniques commonly used in endodontics, including how to overcome iatrogenic errors and optimize the quality of endodontic treatment outcomes [6, 9].

METHODS

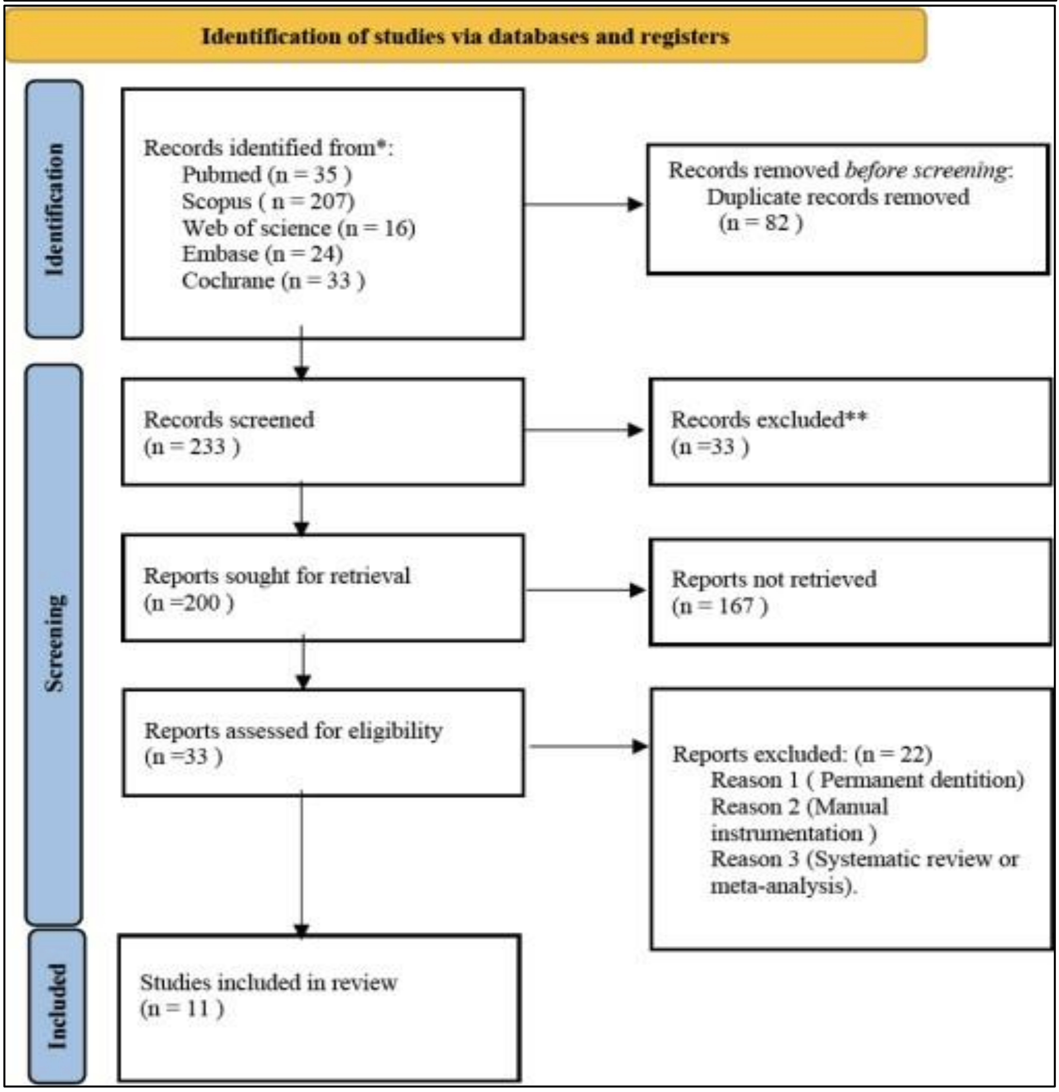
The following electronic databases were searched to identify relevant articles according to our topic: PubMed, Medline, Google scholar, and Scopus until November 2020. The task of searching the above databases was carried out by two investigators to eliminate any potential bias in selecting the relevant articles. The following keywords were used to conduct a comprehensive search so that no key studies were missed during the search: hand files, root canal preparation, techniques, hand instrumentation, procedural errors, performance, and endodontics, as well as, MeSH terms, i.e. “endodontics,” “instrumentation,” and root canal preparation”. Inclusion criteria included all types of studies investigating root canal hand instrumentation techniques and discussing the prevention of resulting procedural errors in endodontics.

RESULTS

Learning Endodontic Skills It is well established that learning endodontic theory and techniques can be challenging for undergraduate dental students [9-12]. Students are required to gain essential knowledge and develop related practical skills in a relatively short period of time. Specifically, they need to integrate their theoretical knowledge and fine motor skills and show continuous improvement in performance to achieve the competencies required to provide patient care. Learning endodontic skills often begins with the simulated practice of the different stages of root canal treatment on extracted human teeth. Biomechanical cleaning and shaping of the root canal space is an essential step [6, 13, 14], aimed at eliminating or minimizing the number of microorganisms causing infection in the root canal system. This includes removing debris and microorganisms from the root canal system and shaping root canal spaces to facilitate cleaning and subsequent filling of the canal space. When using extracted human teeth, variable external and internal anatomy, as well as the condition of the root, make the biomechanical preparation of root canal systems a challenging and sometimes discouraging task. Therefore, a recent recommendation for the simulation stage of learning endodontic procedures is to use simulated plastic models of canals and teeth prior to the use of extracted human teeth.



Stage 1
(Crown-down)
Coronal Preparation
Stage 2
Apical Gauge
MAF
Stage 3
(Step-back)
Middle Preparation
At WL
Check patency
-1mm
Recapitulation
-2mm
-3mm
Irrigation
Coronal Flaring
GG
RP



Identification of studies via databases and registers
Identification
Records identified from*:
Pubmed (n = 35)
Scopus (n = 207)
Web of science (n = 16)
Embase (n = 24)
Cochrane (n = 33)
Records removed *before screening*:
Duplicate records removed
(n = 82)
Screening
Records screened
(n = 233)
Records excluded**
(n =33)
Reports sought for retrieval
(n =200)
Reports not retrieved
(n = 167)
Reports assessed for eligibility
(n =33)
Reports excluded: (n = 22)
Reason 1 (Permanent dentition)
Reason 2 (Manual instrumentation)
Reason 3 (Systematic review or meta-analysis).
Included
Studies included in review
(n = 11)

The simulated root canals permit the standardization of the root canal hardness, length, width (diameter), location and degree of canal curvature. This standardization allows the reproducibility of the outcomes [16]. Consistent with the recommendations of learning using simulated root canals, simulated plastic blocks and teeth have been found to be a valuable adjunct for learning how to determine root canal working lengths and how to carry out preparation techniques. Studies have used simulated root canals (e.g., resin blocks, plastic teeth, and artificial dentine) to investigate and compare the shaping ability of instruments, to compare different root canal instrumentation techniques, and to identify possible procedural errors during root canal preparation.

However, how realistically simulated canals in resin teeth or blocks mimic canals in natural teeth is unclear. For example, differences in properties between resin and dentine may be an issue. Micro hardness of root canal dentine has been reported to be 35-40 kg/mm2 compared to 20-22 kg/ mm2 for clear resin endodontic blocks, and 25-26 kg/ mm2 for artificial resin teeth. Moreover, it has been reported that the size of shavings resulting from resin and dentine is different, leading to more canal blockages in resin-simulated root canals. Despite these concerns, simulated root canal models have been reported to be a suitable alternative for natural teeth in learning root canal preparation procedures.

The blinded nature of endodontic procedures adds further complications for novice students. They do not have visual cues to support their linking and transferring their theoretical knowledge of root canal morphology and root canal preparation techniques to produce appropriately shaped and cleaned root canal spaces that are ready to be filled. In response, recommendations from the Australian Society of Endodontology and guidelines from the European Society of Endodontology support the use of visual demonstrations (observation) of simulated root canal procedures and techniques during learning. The success of root canal treatment relies mainly on effective cleaning and shaping of the root canal. This involves using a range of instrumentation procedures. The correct and safe application of these procedures and techniques can also prevent iatrogenic procedural errors from occurring

Root Canal Preparation Instruments

Root canal preparation includes mechanical (i.e., debridement and shaping of root canal space) and chemical procedures (i.e., cleaning root canals using irritants and medications to minimize bacterial presence). Learning to mechanically prepare root canals requires the use of instruments, such as hand files and engine-driven rotary files. While nickel-titanium (NiTi) rotary files may be considered the gold standard for root canal preparation, the use of traditional hand files remains of critical importance.

Hand files are recommended for initial canal negotiation and preparation prior to the use of rotary files to further enlarge the canal. If rotary instrumentation techniques are used, it is also recommended that hand files should be used in between rotary file applications to help prevent any blockage of the canal system with debris created by a rotary file system. In addition, hand files are essential for the correction of procedural errors (e.g., by-passing ledges or blockages), preparation of large canals (e.g., maxillary central incisors, canines), and in cases where the use of rotary files may be limited (e.g., in cases of apical resistance and anatomical variations in the canal system). Therefore, learning the fundamental skills of hand file manipulation is a crucial step prior to learning the use of other advanced armamentariums (i.e., rotary files) for root canal instrumentation procedures.

Root Canal Instrumentation Techniques

Mechanical root canal preparation using hand instruments involves the adaptation of relevant techniques to enable the instrument to properly clean and shape the root canal system to the full length of the canal. The objective of mechanical preparation is to remove infected soft and hard tissues, to facilitate the delivery of root canal irrigants and medicaments to the apical area of the root canal system, and to preserve the integrity of the root canal structure (i.e., prevent weakening of the root structure by removing too much dentine). This objective can be achieved by cleaning and shaping the root canal from a reference point (i.e., a point on the sound tooth structure) to a slightly short area (0.5-1 mm) of the canal terminus, i.e., the foramen.

This length is referred to as the working length of the root canal. The working length is estimated using a pre-operative radiograph of the tooth, often established with the use of an electronic apex locator and confirmed radiographically after inserting a small file in the root canal to the predicted working length. The maintenance of working length can be achieved by using copious amounts of irrigation and frequent insertions of a small file to the full working length to clear and loosen accumulated debris and dentine shavings from the apical portion of the canal. Many different instrumentation techniques (e.g., standardized, circumferential filing and step-down) have been discussed in the literature. The choice of root canal preparation technique is dictated somewhat by the design and shape of the instrument. K-type hand instruments are most commonly used during root canal preparation procedures. This is mainly due to their safety during the cleaning and shaping of root canals.

Crown-Down

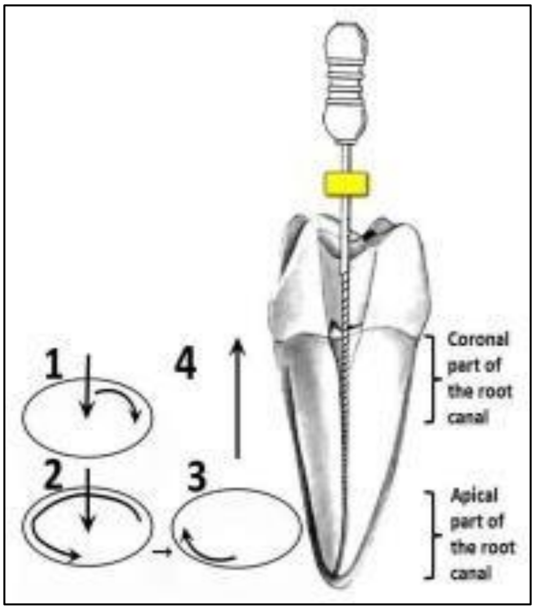
The crown-down technique prepares the root canal by starting from the coronal part of the root canal system and then progressing to the apical region. This technique relies on flaring the coronal part of the root canal (i.e., progressing from large to small hand instruments), which enables the removal of infected soft tissue, reduces the risk of blockage of the apical portion of the root canal, and minimizes extrusion of canal contents beyond the apical area. By commencing with the coronal section of the root canal, this technique improves access to the full length of the canal, enhances tactile sensation to the apical portion of the canal, and reduces the risk of fractures. The crown-down technique has been reported to be superior to the step-back technique in the preparation of curved root canals ranging from 10 to 35 degrees of curvature.

Step-Back

The step-back technique relies on preparing the root canal, starting from the apical part and progressing to the coronal part [35]. It incorporates a stepwise reduction in the working length (i.e., 1 mm steps), but with progressively larger instruments, it produces a flared and tapered root canal. This technique is one of the traditional root canal preparation techniques and is believed to be effective in minimizing procedural errors.

Hybrid (Modified Double-Flared)

The double-flared technique was first introduced by Fava. This technique was then improved and referred to as the 'modified double-flared' technique or 'hybrid' technique. It negotiates by reaching the end of the root canal with a hand instrument. This is followed by preparation of the coronal part of the canal using the crown-down technique, then enlarging the apical part of the root canal. Finally, the middle part of the root is prepared using a step-back technique. This technique combines the benefits of both the crowndown and step-back techniques.



Frequency, distribution, and comparison of types of mishaps

Author, Year	n *	Limes	Length	Diameter	Taper	Rotation speed	Irrigant	Sealing material	Tracking time	Results
Yüksel B, 2022 [10]	30	One Shape system XP- endo® Shaper WaveOne Gold system	17 mm 21 mm 21 mm	#25 #30 #25	0.06 0.04 0.07	400 rpm 800 rpm 800 rpm	2.5% sodium hypochlorite	N.A	6 months	One Shape lower danger value. >Microcracks in the middle of the root.
Vaishali D, 2021 [11]	30	Kedo SG Blue rotary files Pro AF Baby gold rotary files Pedo Flex rotary files	16 mm 17 mm 16 mm	#25, 30, 40 #20–40 #20–30	D1, E1, U1 0.06 0.04	300 rpm 300 rpm 350 rpm	10 mL of 1% sodium hypochlorite + saline + EDTA	zinc oxide eugenol (ZOE)	1 week	Kedo SG Blue > Optimal fillings and filled canals. <Gaps.
Mohammadi, D, 2021 [12]	80	Reciproc Protaper universal Hyflex CM Neolix	25 mm 21 mm 21 mm 15–21 mm	#25 #20–25 #25 #25	0.06 0.07/0.08 0.06/0.08 0.06/0.12	300 rpm 500 rpm	Sodium hypochlorite and distilled water	N.A	2 days	Reciproc: ++Extrussion.
Moraes RDR, 2021 [13]	20	WaveOne® GOLD XP-Endo® Shaper XP-Endo® Finisher XP Clean (XPC) System	21 mm 21 mm 21 mm 21 mm	#45 #30 #25 #25	0.05 0.04 - 0.02	Slowly 1000 rpm 1000 rpm 1000 rpm	0.9% saline solution	N.A	N.A	Acumulated debris, WOG y XPS +++. HF, remove + debris. XPC homogeneous. HF and XPC better instrumentation.
Gekelman D, 2009. [14]	20	GT rotary files ProTaper rotary files	25 mm 21 mm	S1,S2,F1	0.07/0.08	300 rpm	Tap water	N.A	N.A	No significative differences.
Boonchoo, K. 2020 [15]	37	WaveOne GoldTM	21 mm	#20	0.07	800 rpm	1% sodium hypochlorite	VitapexTM	1 y	Better filling of canals M.
Juliet, S. 2020 [16]	45	ProTaper Kedo-S RaCe	21 mm 16 mm	S1,S2,F1 #25–30 #25	0.07/0.08 D1, E1, U1 0.04	330 rpm 300 rpm	1 mL of 3% sodium hypochlorite + saline	Metapex	N.A	Kedo-S longer instrumentation time.
Moraes, R D R. 2019 [17]	1	Reciproc system	25 mm	#25 #40 #50	08 06 05	300 rpm	Saline	N.A	N.A	R50 bigger risk of perforation. R40 Most valid option
Govindaraju L, 2018 [19]	30	ProTaper rotary file F1 Kedo-s rotary file	21 mm 16 mm	#20 #25–30	0.20/0.7 D1, E1, U1	330 rpm 300 rpm	Saline	Metapex	N.A	Kedo-S less postoperative pain. PT = KS preparation of the canal.
Marques da Silva, B. 2018 [20]	48	ProTaper rotary system f4 WaveOne Large	21 mm 25 mm	#40 #40	0.06 0.08	330 rpm	2.5% sodium hypochlorite 17%EDTA	N.A		No differences found between them.
Tabbara, A. 2019 [21]	20	XP-endo Shaper	21 mm	#30	0.04	800 rpm	Dakin's solution 37 °C	Gutta-percha cone	N.A	The number of passes depends on the radicular anatomy. XP-endo Shaper obtains 30/0.04

Items	Yüksel B, 2022 [10]	Vaishali D, 2021 [11]	Mohammadi, D, 2021 [12]	Moraes RDR, 2021 [13]	Gekelman D, 2009 [14]	Boonchoo, K. 2020 [15]	Juliet, S. 2020 [16]	Moraes, RDR. 2019 [17]	Govindaraju L, 2018 [19]	Marques da Silva, B. 2018 [20]	Tabbara, A. 2019 [21]
The selected criterio were specified	🟢 pg.3	🟢 pg.2	🟢 pg.2	🟢 pg.2	🟢v pg. 2	🟢 pg.2	🟢 pg.2	🟢v pg.2	🟢v pg.2	🟢v pg.2	🟢v pg.2
Sibjects were randomly assigned to group	🟢 pg.3	🟢 pg.2	🟢v pg.2	🟢v pg.5	🔴v pg.2	🟢 pg.2	🟢 pg.2	🔴v pg.2	🟢v pg.2	🔴v pg.2	🔴v pg.3
Concealed allocation of pacients	🔴 pg.3	🔴 pg.2	🔴 pg.2	🔴 pg.3	🔴v pg.2	🟢 pg.3	🟢 pg.2	🔴v pg.2	🟢v pg.2	🔴v pg.2	🔴v pg.2
Groups at baseline were similar in relation to the most important prognosis indicators	🟢 pg.3	🟢 pg.2	🟢 pg.4	🟢 pg.6	🟢 pg.3	🟢 pg.3	🟢 pg.3	🟢 pg.4	🟢 pg.3	🟢 pg.3	🟢 pg.3
All subjects were blinded	🔴 pg.3	🔴 pg.2	🔴 pg.2	🔴 pg.3	🔴v pg.2	🔴pg pg.3	🔴 pg.3	🔴v pg.2	🔴v pg.2	🔴v pg.2	🔴v pg.2
All clinicians were blinded	🔴 pg.3	🔴 pg.2	🔴 pg.2	🔴 pg.3	🔴v pg.2	🔴 pg.2	🔴 pg.3	🔴v pg.2	🔴v pg.2	🔴v pg.2	🔴v pg.2
All assessors were blinded	🔴 pg.3	🔴 pg.2	🔴 pg.2	🔴 pg.3	🔴v pg.2	pg🔴 pg.2	🔴 pg.3	🔴v pg.2	🔴v pg.2	🔴v pg.2	🔴v pg.2
Means were obtained from more tan 85% of subjects	🟢 pg.4	🟢 pg.2	🟢 pg.4	🟢 pg.6	🟢 3pg.3	🟢 pg.3	🟢 pg.3	🟢 pg.4	🟢 3pg.3	🟢 3pg.3	🟢 pg.3
Results for all subjects were presented	🟢 pg.4	🟢 pg.2	🟢 pg.4	🟢 pg.6	🟢 pg.3	🟢 pg.3	🟢 pg.3	🟢 pg.4	🟢 pg.3	🟢 pg.3	🟢 pg.3
Statistical comparison results between groups were reported for at least one key outcome	🟢 pg.4	🔴 pg.2		🟢 pg.5	🔴 pg.5	🟢 pg.2	🟢 pg.3-4	🟢 pg.3	🟢 pg.3	🟢 pg.3	🟢 pg.3
The study provides one-off and variability measures for at least one key aoutcome	🟢 pg.5	🔴 pg.5		🟢 pg.7-8	🟢 pg.5	🟢 pg.3	🟢 pg.4	🟢 pg.4	🟢 pg.4	🟢 pg.3	🟢 pg.3
Total:	7/11	5/11		7/11	6/11	8/11	8/11	6/11	6/11	4/11	6/11

Inclusion and exclusion criteria

Regarding the sample included in the studies obtained, most of them analyzed an average of 30 teeth. Highlighting Mohammadi, D with a maximum of 80, and Moraes with a minimum of 1. Regarding the variables analyzed, and considering the length of the files, the longest were those used by Gekelman, with a length 25 mm, and the shortest, 15 mm, used by Mohammadi. It should be noted that the mean length used in most studies was 21 mm [15]. When assessing the diameter used, the mean was 25, varying between a maximum of 50 and a minimum of 20. Finally, when referring to file conicities, the most used are those of 0.06–0.07, but others of 0.04 can be used, and even up to 0.20. Regarding the speed of the files, 300 rpm is usually recommended for performing pulpectomies. However, authors such as Mohammadi, D have used higher speeds such as 1200 rpm. Lastly, regarding the irrigant used, sodium hypochlorite is the most used at different concentrations: 2.5%, 5.25% or 1%, although other authors also use saline solution to eliminate bacteria.

Hand Instrument Manipulation:

Balanced Force Technique for completing the instrumentation procedure, a range of hand instrument manipulation strategies to mechanically remove canal contents and infected dentine, e.g., reaming, filing, watch-winding, circumferential root canal filing, and the balanced force technique, are performed. The balanced force technique (BFT) involves a series of rotational movements that enable hand instruments to advance in the root canal. BFT has been shown to be a favorable hand instrument manipulation technique compared with other instrumentation techniques due to its superior maintenance of canal curvature and prevention of iatrogenic procedural errors. It provides adequate apical control of the tip of the hand instrument and good centering of the instrument in the root canal. The balanced force technique involves introducing the instrument into the root canal with a quarter-clockwise motion with light pressure to engage the hand instrument with the canal walls.

This is followed by maintaining the pressure while completing a three-quarter counter-clockwise turn, thereby cutting the dentine of the canal, resulting in enlargement of the canal. The final step involves a quarter clockwise motion, without pressure, to collect the shavings from the canal walls and removal of the hand instrument from the root canal. The incorrect use of any of the previously mentioned techniques or failure to maintain working length could lead to procedural errors, such as the blockage and ledge formation in the root canal.

Endodontic Measures of Success

The success of root canal treatment depends on accessing the apical part of the root canal during root canal preparation and maintaining this access during chemo-mechanical preparation. The clinical outcome measures for root canal preparation procedures involve assessing the quality of canal instrumentation, including accuracy of the preparation and the presence or absence of procedural errors during the shaping of the root canals.

Quality of Root Canal Preparation

As mentioned earlier, the success of root canal preparation relies mainly on effective cleaning and shaping of the root canal system. This can be achieved through chemo-mechanical preparation of the canal from a coronal reference point (i.e., a point on the incisal or occlusal surface of the tooth) to the apical end of the root canal. The assessment of the quality of the root canal preparation can be achieved clinically and radiographically. Clinically, the accuracy of canal preparation can be determined via tactile digital sense by inserting the hand instrument in the root canal, ensuring that the instrument can smoothly reach the full working length of the canal. This then can be confirmed radiographically by measuring the distance from the tip of the instrument to 0.5 to 1 mm short of the radiographic end of the root canal. Instrumentation to a shorter length can result in the accumulation of debris, leading to procedural errors. These errors include canal blockage, ledge formation, canal transportation, and fracture of the hand instrument.

Root Canal Preparation Errors

As mentioned previously, procedural errors can occur during root canal instrumentation using hand instruments.

Blockage of the Root Canal

This involves an obstruction in a previously patent canal, resulting from the accumulation and retention of dentine chips or residual tissues at the apical part of the canal. Canal blockage can be identified by an inability to advance an instrument to the full working length of the canal. A blockage can be associated with the instrumentation technique used. In a study that compared eight preparation techniques, it was found that canal blockage occurred least when the balanced force technique was used.

Ledge Formation

This has been shown to be associated with the degree of canal curvature and the design of the selected hand instrument. For example, ledging of a root canal can result from preparing the canal using inflexible instruments (e.g., large files that have reduced flexibility). A ledge usually occurs on the outer side of the canal curvature as a step (platform) that can then be challenging to bypass and can ultimately lead to an inability to negotiate past the root canal ledge. Ledges can be differentiated from canal blockage by the characteristics of tactile sensation and radiographically. Specifically, advancing an instrument in the canal will feel like the file is hitting a solid wall, while radiographically, the image would show the tip of the instrument directed away from the true canal path.

Canal Transportation

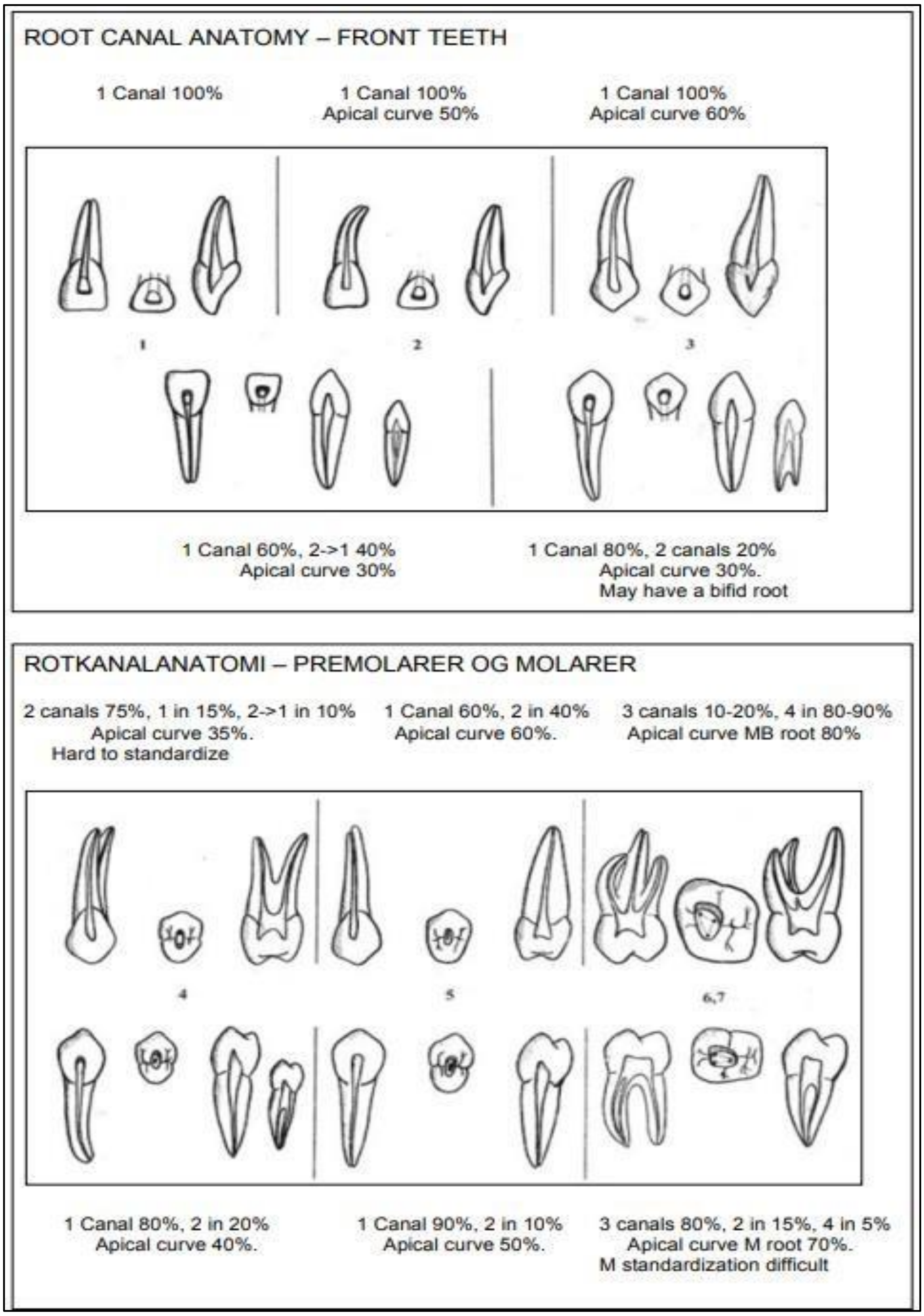
This results from a tendency of the instrument to straighten a curved canal; as a result, the main path of the canal is deviated from its original canal pathway. Canal transportation can be detected radiographically due to the straightening of a curved canal as compared with the original path of the root canal. It has been reported that using NiTi files results in less canal transportation compared with stainless steel files.

Fracture of Hand Instruments

Fracture of hand instruments can result from torsion stress (i.e., an overload of force during twisting) or fatigue through flexure and repeated use of the instrument. Hand instrument fracture can be associated with the radius and angle of the canal curvature, instrumentation technique, rotational forces applied on the instrument, and experience of the operator. Fracture of hand instruments can also be related to the type of hand instrument used. For example, H-type hand instruments are more likely to fracture compared with K-type instruments due to the manufacturing process and reduced cross-sectional area. The use of NiTi instruments during root canal preparation can result in reduced procedural errors compared with stainless-steel hand instruments. This can be explained by the flexible nature of NiTi files and their ability to conform within curved root canals, therefore being less susceptible to the fracture.

Fracture of a Tooth

This usually occurs in the crown and/or root. Cracked or fractured root canals are frequently difficult to diagnose and treat. In relation to root canal preparation, root canal fracture can occur when the forces used during canal preparation are beyond the elastic limit of the root canal wall. However, there is limited evidence that root fractures are associated with forces generated during root canal preparation procedures.



ENDODONTIC FAILURES

In some cases, RCT leads to a failure after endodontic treatments. It results from the microorganism colonies persisting in the apical portion. A whole list of traumatic failures is available. In addition to intraluminal endodontic infection, broken instruments, perforations, overfilling or under filling, are the main reasons of endodontic failures, even in apparently well-treated teeth. Bacteria located in areas such as isthmuses, ramifications, deltas, irregularities, niches and dentinal tubules seem to be not affected by endodontic disinfection procedures. Treatments of teeth affected by deep caries preserve in the apical part of the root remnants that are still alive after indirect capping. Direct pulp capping with Calcium Hydroxide (CH), and/or Mineral Trioxide Aggregates (MTA) constitutes actual therapies. They contribute to the formation of dentinal bridges containing tunnel defects, fissures, and bone-like osteocyte lacunae.

Among the different options for the available therapies, pulpotomy (partial ablation of the pulp in the coronal pulp chamber) constitute a valid option. However, we give privilege to a solution removing totally the dental pulp. Chemo-mechanical and careful cleaning of the cavity (also named pulpectomy) constitutes a useful method. This end-point is very close to noninfectious conditions, as mentioned below. The risk factors associated with endodontic failures increase the chance of success of a RCT (Root Canal Treatment). It is based on the accuracy of the initial diagnosis, the excellence of disinfection, the value of the instrumentation and filling procedures, leading finally to rehabilitation management. The treatment requires inactivation of microorganisms. It is mandatory to disrupt the bacterial biofilm.

Antimicrobial strategies, root canal shaping, and coronal and apical seal appears to be key-factors for a successful treatment. Finally the rehabilitation management appears to be essential for the success of endodontic therapy. Absence of pain, regression of the bone lesion, tight seal of the canal and coronal spaces, recoveries of the tooth function are parameters that should be re-evaluated over time. The basic aims of endodontic therapy are in distinguishable in adults and children. Removal of the infection, and reduction of chronic inflammation are identical and follows the same lines of evidence. Three techniques have been proposed and they are requiring specific therapies:

- Vital formocresol pulpotomy: The pulp tissue of deciduous teeth is dipped in a 1 :5 dilution of Buckley's formocresol (tricresol 35%, formaldehyde 19%, glycerol 16%, water 31%).
- Devitalization pulpotomy: The paste includes paraformaldehyde 1.00g, carbowax 1500: 1.30g, lignocaine 0.06g, propylene glycol 0.5ml, and carmine 10mg.
- Non-vital pulpotomy: Beechwood creosote solution is sealed into the cavity with a zinc oxide-eugenol dressing (0-Methoxy phenol (guaicol) 47%, P-methoxy phenol 26%, 2-methoxy, 4 methyl phenol (Cresol) 13%, M-methoxy phenol 7%, other 7%). These three distinct options open gates for conventional endodontic therapies. Pulp regeneration and mineralization allows new therapeutic approaches.

CONCLUSION

The hybrid technique is a commonly-used approach that combines the benefits of both the crown-down and step-back techniques and was reported to be one of the best techniques to produce an optimal root canal preparation outcome. Hand instrument manipulation using the balanced forced technique is also favored as it rapidly and safely permits removal of canal contents allowing irrigants and medications to reach deep inside canal spaces. The correct and safe application of these techniques can prevent iatrogenic procedural errors from occurring. This study provided an update on several techniques commonly used in endodontics, including how to overcome iatrogenic errors and optimize the quality of endodontic treatment outcomes.

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