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Review Article

Advances in Rotary Endodontics in Pediatric Dentistry

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Abstract

Early loss of infected primary molars leading to space loss is an important concern in pediatric dentistry. Natural tooth is considered as the best space maintainer. Tooth decay continues to be the main causative factor for the high rate of loss. According to the Guidelines of the American Academy of Pediatric Dentistry, pulpectomy is indicated in primary teeth with carious pulp exposures in which, coronal and radicular pulp exhibits clinical signs of hyperaemia, or evidence of pulp necrosis with or without caries involvement. The introduction of nickel titanium (NiTi) rotary instrumentation has made endodontics in permanent teeth easier and faster than manual instrumentation resulting in consistent and predictable root canal shaping. Similar principles of canal debridement and dentin shaping using NiTi instruments can be applied to primary teeth. Successful pulpal therapy in the primary dentition requires a thorough understanding of primary pulp morphology, root formation, and the special features associated with physiologic resorption of primary tooth roots. The most commonly used rotary instrumentation technique, suggested by Barr., *et al*. in 2000 is widely accepted technique. With new versions rapidly becoming available, the clinician may find it difficult to pick the file and technique most suitable for an individual case. Practitioners must always bear in mind that all file systems have benefits and weaknesses. Ultimately, clinical experience, handling properties, usage safety, and case outcomes, rather than marketing or the inventor's name, should decide the fate of a particular design.

Keywords: *Rotary Endodontics; Pediatric Dentistry; Nickel Titanium (NiTi)*

Introduction

Primary teeth are important to preserve until its natural exfoliation time, thus preserving arch integrity. Early loss of infected primary molars leading to space loss is an important concern in pediatric dentistry [1]. Natural tooth is considered as the best space maintainer. Therefore, it is essential to maintain the tooth in the dental arch till natural exfoliation takes place. The premature loss of primary teeth which is commonly caused by inappropriate oral hygiene, dental injuries, and tooth decay may cause changes in the chronology and sequence of eruption of permanent teeth. Maintenance of primary teeth until physiological exfoliation contributes to mastication, phonation and aesthetics and prevents deleterious habits in children. Tooth decay continues to be the main causative factor for the high rate of loss [2-4].

According to the Guidelines of the American Academy of Pediatric Dentistry, pulpectomy is indicated in primary teeth with carious pulp exposures in which, coronal and radicular pulp exhibits clinical signs of hyperaemia, or evidence of pulp necrosis with or without caries involvement [5]. One of the most challenging aspects of pediatric dentistry is managing the behaviour or understanding the

anxious, fearful and uncooperative child. The cooperation of the child during of deciduous teeth is related to several factors, among which the important being the visit duration. A delay during the pulpectomy procedure might be caused in deciduous tooth due to its anatomical and physiological constraints, such as proximity to permanent tooth germ, irregular physiological root resorption, and its tortuous canals. Therefore, in-depth anatomic knowledge of the area and the use of an accurate technique are necessary for a fast and efficient treatment. To overcome some of these issues, nickel-titanium alloy was introduced in endodontics which fulfilled the objectives of simplicity, speed, safety, and stress reduction for both the clinician and the patient [6].

The introduction of nickel titanium (NiTi) rotary instrumentation has made endodontics in permanent teeth easier and faster than manual instrumentation resulting in consistent and predictable root canal shaping. Similar principles of canal debridement and dentin shaping using NiTi instruments can be applied to primary teeth. Rotary instruments were introduced to pediatric endodontics by Barr., *et al*. in 2000 [7]. Manual stainless steel files provide excellent tactile control and sharp, long-lasting cutting surfaces. However, due to the inherent limited flexibility of stainless steel, manual preparation of curved canals is difficult. In the bygone decade, several rotary NiTi endodontic file systems have been launched to improve the shaping procedure. However, all these systems recommended the use of a series of files to accomplish the final shape. Recently, the concept of single-file systems has been introduced and is currently being debated for its applicability in contemporary endodontics.

Morphologic differences

Successful pulpal therapy in the primary dentition requires a thorough understanding of primary pulp morphology, root formation, and the special features associated with physiologic resorption of primary tooth roots. The enamel is thinner (approximately 1 mm) on primary teeth than on permanent teeth, and it has a more consistent depth, giving primary teeth lighter colour compared to permanent teeth. The thickness of the dentin between the pulp chamber and enamel in primary teeth is less than that in permanent teeth. Hence, a carious lesion begins in a primary tooth, it can quickly progress through the thin enamel, the thin dentin, and infect the pulp more quickly than in permanent tooth.

Primary teeth are markedly more constricted at the dentino-enamel junction (DEJ) than permanent teeth. So, probability of pulp exposure is greater due to cervical constriction during proximal cavity preparation if depth of cavity is increased. The contact areas in primary teeth are broader, flatter and situated gingivally, whereas in permanent teeth they are narrower and are situated occlusally. Hence, proximal preparations should be wider at the gingival aspect in primary than in permanent teeth. Also, the roots of primary molars are comparatively more slender and longer than the roots of permanent molars [8]. The pulp chambers in primary teeth are comparatively larger than those in permanent teeth. The pulp horns, especially the mesial horns, are higher in primary molars than in permanent molars. Hence, pulp exposures can occur very easily in primary molars [8,9].

Figure 1: *Cross section of primary and permanent molars. Divergence of the primary molar roots allows space for the developing permanent premolar.*

Before initiating the endodontic therapy, one must have thorough knowledge of pulp anatomy. The pulp cavity must be mentally visualized three dimensionally.

Generations of rotary systems [10,11]

1st Generation files	2nd Generation files	3rd Generation files	4th Generation files	5th Generation Files
Passive cutting radial lands	Active cutting edges	Reduces cyclic fatigue	Single-file technique	Safest, most efficient, and simplest file systems
fixed tapers of 4% and 6%	Mitigate taper lock	Reduced broken files	Due to its compressible open tube design, it exert uniform pressure on the dentinal walls, regardless of the cross-sectional configuration of the canal	Offset design in the file minimize the engagement between the file and dentin, enhances auguring debris out of a canal and improves flexibility along the active portion of a ProTaperNext file
Numerous files to achieve the preparation objectives	fixed tapered design	Heat treatment technology, Twisted File	Have *a* Reciprocating movement that is equal clockwise and counterclockwise rotation and requires more inward pressure to progress	Offset design and produce a mechanical wave of motion that travels along the active length of the file
GT files (DENTSPLY) - fixed taper on a single file of 6%, 8%, 10%, and 12%.	EndoSequence (Brassler USA) and BioRaCe (FKG Dentaire) provide file lines with alternating contact points	Hyflex (Coltene Whaledent) GT, Vortex, Wave One	M4 *(SybronEndo)*, Endo Express *(Essential Dental Systems)*, and Endo-Eze *(Ultradent)*	Revo-S, One Shape, ProTaper Next

Newer file systems in Pediatric endodontics

There are various file systems which are recently developed and are specially designed for pediatric patients.

Kedo file system [12,13]

Kedo files system are the world's first files designed for root canal preparation in primary teeth. Kedo files are available in Hand type (Kedo - SH) and rotary type (Kedo - S, Kedo - SG).

Kedo-S pediatric rotary file system

The Kedo-S file system (Reeganz dental care Pvt. Ltd. India) consists of three Ni-Ti rotary files. The total length of the files is 16 mm. The working length of the files is 12 mm.

The files are named as D1, E1, U1, respectively. All the files have a variable taper corresponding to the use in primary teeth.

D1 file: Has a tip diameter of 0.25 mm with a variable taper. It can be used in primary molars with narrow canals (mesial canals in mandibular molars and disto buccal canal in maxillary molars).

E1 file: Has a tip diameter of 0.30 mm and can be used in wider molar canals (distal canal in mandibular molars and palatal canal in maxillary molars).

U1: Has a tip diameter of 0.40 mm and used in primary incisor teeth.

The taper of the instruments are designed according to the diameter of primary teeth with narrow and wide root canals.

Kedo-S paediatric rotary file system must be used in a low speed constant- torque handpiece.

The ideal rotation speed is 150 - 300 rpm.

The kedo-S paediatric rotary files have a gradual taper aiding in easy coronal enlargement and straight line access. This gradual taper also help in efficient canal preparation and avoids over instrumentation of the inner wall of root surface. It is necessary to use copious amount of irrigating solution to remove any loose pulp tissue and to ensure canal walls are clean before obturation.

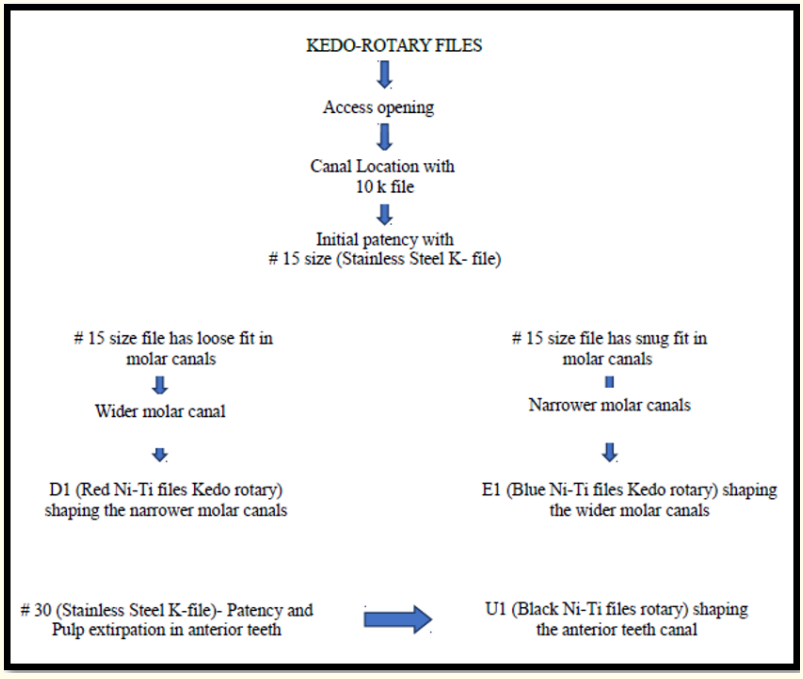

Figure 2: *Method of using Kedo-S rotary file system.*

In 2018, Jeevanandan and Govindaraju conducted a study to compare and evaluate the instrumentation time and quality of obturation between paediatric rotary file (Kedo-S) and manual instrumentation techniques in primary molars in children of age 4 - 7 years with pulp necrosis. Sixty primary mandibular molars were randomly divided into two groups: 30 were instrumented with paediatric rotary files Kedo-S (experimental group) and 30 with hand K-files (control group). They concluded that clinical use of paediatric rotary files Kedo-S was effective during root canal preparation of primary teeth with reduction in instrumentation time and better quality of obturation [12].

Kedo SG Blue (controlled memory files)

Kedo SG Blue file system consists of three Ni-Ti rotary files. The total length of the files is 16 mm. The working length of the files is 12 mm. The files are named as D1, E1, U1, respectively. All the files are heat treated and have controlled memory and have a variably variable taper corresponding to the use in primary teeth. It has super flexibility and 75% greater resistance to cyclic fatigue. The ideal rotational speed is 250 - 300 RPM. The torque required is 2.2 - 2.4 Ncm.

PRO AF baby gold file advanced pediatric rotary endodontic file system [14]

Pro AF Baby Gold file (Dentobizz) consist of 5 files made up of NiTi CM wire- Flexible with Constant taper of 4%, 6%.

Features:

- Specially designed and registered short 17 mm file.
- More safety with comfort to both dentist and patient.
- Unique short orifice enlarger to prevent cervical ledging.

- Advance NiTi M wire with heat treatment for better canal centricity.
- High Flexibility with minimal chances of separation.
- A versatile rotary file system suitable for conservative preparation of all canals.
- Improved shaping of canals with sequential combination of files from orifice enlarger, 4% and 6% taper files.
- Less number of files per canal, most canals required only 2 files for preparation.

Indications:

- Specially for Pediatric rotary endodontic treatment.
- Adult rotary endodontic in conditions of Restricted opening of mouth and Third molar root canals.

Instructions for use:

- The files should be instrumented at 2N 300 rpm.
- The file should be used with 18% EDTA gel in brushing motion.
- Prepare canal manually upto 20/02.
- Place orifice enlarge upto 4 mm in calcified canals or narrow orifice (optional).

Features	Protaper (dentsply)	Hero Shapers (MM)	Pro AF Baby Gold File (Dentobizz)	Kedo- S (Reeganz dental care)
Length	21 mm	21 mm	17 mm	16 mm
Metallurgy	NiTi- rigid files	NiTi- rigid files	NiTi CM wire flexible files	
Taper	F2 (6 - 8%) Sx (3 - 18%)	4%, 6%	Constant taper 4%, 6%	Gradual taper
Files required	2 files	2 files	2 files	1 file
Apical preparation	Aggressive preparation	Conservative preparation	Conservative preparation	Conservative preparation

Table 2: *Comparative assessment of commonly used Rotary files in pediatric endodontics.*

Rotary endodontic instrumentation technique for primary teeth

The most commonly used rotary instrumentation technique, suggested by Barr., *et al.* in 2000 is widely accepted technique. The pulpectomy procedure begins with a standard access and removal of coronal tissue. A NiTi rotary instrument (ProFile; Denstply, Tulsa Dental) is chosen that approximates the canal size. It is inserted into the canal while rotating and is taken to working length as determined on the pretreatment radiograph. The rotating file is withdrawn and cleaned of pulp tissue and dentinal debris. The canal is cleansed and shaped with sequentially larger files until the last file binds. The preparation is now complete.

It is not necessary to use a "crown-down" instrumentation technique in primary teeth since the dentin cuts more easily than in permanent teeth. In primary teeth, care must be taken not to over instrument as perforations can readily occur in the thin dentinal walls. Apical overextension of the NiTi can result in an enlarged apical foramen and lead to overfill of pulpectomy paste. Sterile water, saline or chlorhexidine can be used to keep the canals moist. Instrumenting dry or aggressively can result in broken file tips, especially in the smaller size files. Frequently inspect each file for flute unwinding or distortion and discard immediately. If no flute distortion is detected, discard the files after use in five primary teeth. To keep track of file usage, the file shanks can be notched with a bur at the end of each case. After irrigation, the canals are dried and filled with a stiff paste of USP zinc oxide and eugenol using a hand files to push the paste just short of the apex. A stiff paste is more easily consistently uniform, predictable fills [7].

However, there are few modifications to this:

1. Silva., *et al.* [15] and Madan., *et al.* [16] recommended the use of Profile .04 instruments for deciduous teeth.
2. Kuo., *et al.* [17]

3. Nagratna., *et al.* [18] suggested a technique in which teeth were instrumented with profile 0.04 taper 29 series rotary instruments starting from size 2 to 7. Files were advanced slowly towards the apex, which was withdrawn as soon as working length was reached.
4. Canoglu., *et al.* [19] suggested a crown down technique with nickel titanium rotary Profile .04 ISO (Dentsply/Tulsa Dental, Tulsa, Okla) instruments up to .04 /30 file in deciduous teeth. They activated the files by a Nouvag TCM Endo motor (Goldach, Switzerland) at 250 rpm.
5. Bahrololoomi., *et al.* [20] and Moghaddam., *et al.* [21] used 25-mm long Flexmaster NiTi rotary files in pulpectomy of primary tooth and followed modified crown-down technique with 35/0.06, 35/0.04, 30/0.06 and 40/0.02 tapers. Final shaping was completed with a gentle advance-and-withdraw motion.
6. Kummer., *et al.* [22] used Hero 642 system (Micro-Mega). Preparation was performed with 21-mm nickel titanium instruments with 2% and 4% taper using the crown-down technique and following the manufacturer's instructions. The protocol established for instrumentation comprised a kit with 3 instruments.

   Each Hero instrument was introduced into the canal with a gentle push-pull motion. Instruments were advanced through successive steps not greater than 1 mm.
7. **Azar**., *et al.* [23] performed pulpectomy using 21 mm long Mtwo NiTi rotary files. Four Mtwo instruments (10/0.04, 15/0.05, 20/0.06 and 25/0.06) were used to the full length of the root canal, as for the single-length technique.
8. **Pinheiro.,** *et al.* [24] performed instrumentation with two techniques of rotary instruments Hybrid instrumentation with the ProTaper system and K-files (Dentsply Maillefer).

   While in other technique, root canals were prepared using the rotary system in the following sequence: S1 and S2 followed by F1 and F2.
9. G Jeevanandan and L Govindaraju (2018) used an exclusive pediatric rotary system -Kedo-S file system (Reeganz Dental Care Pvt. Ltd. India). They used D1 rotary files for canal mesiobuccal and mesiolingual canal preparations and E1 rotary files were used for distal canal preparation using a lateral brushing motion. The rotary files were used with an endodontic motor at 300 rpm and 2.2 N cm torque.

   Each file was used for up to five teeth as per the manufacturer's recommendation and to maintain uniformity during canal preparation [12].

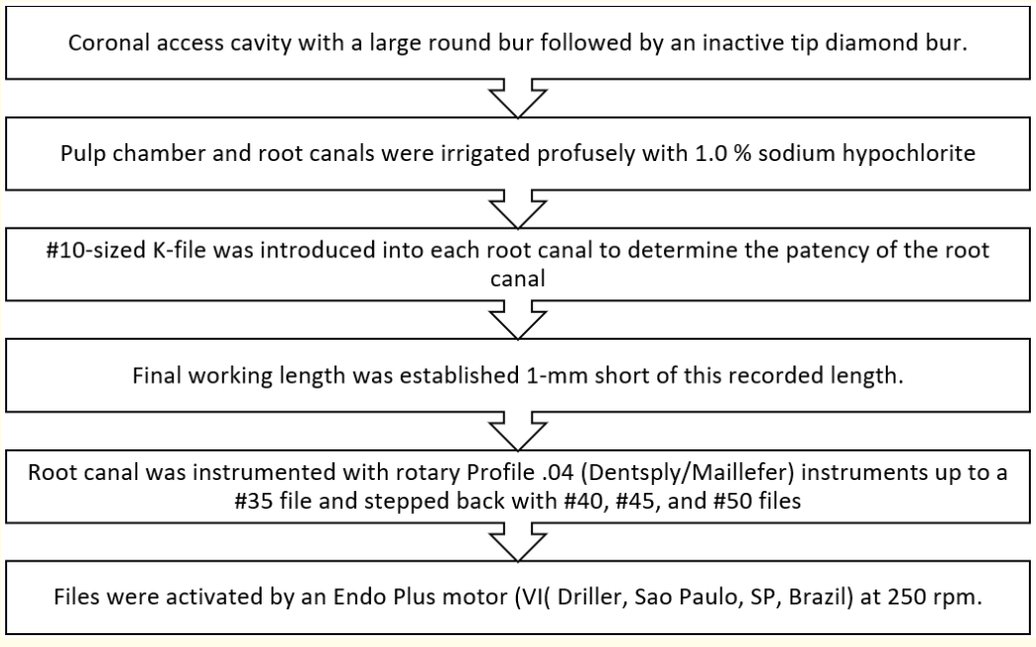

Figure 3

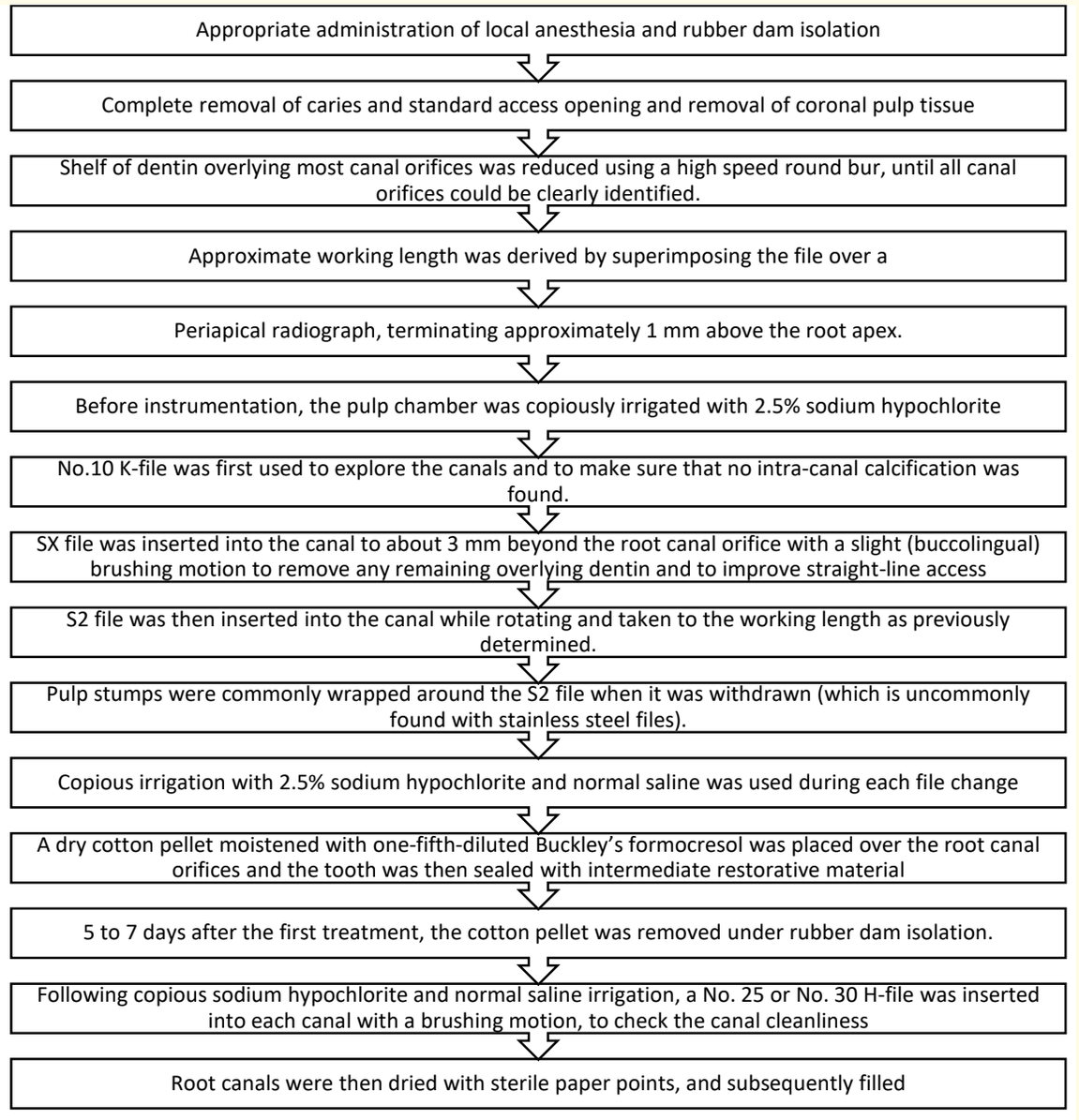

Figure 4

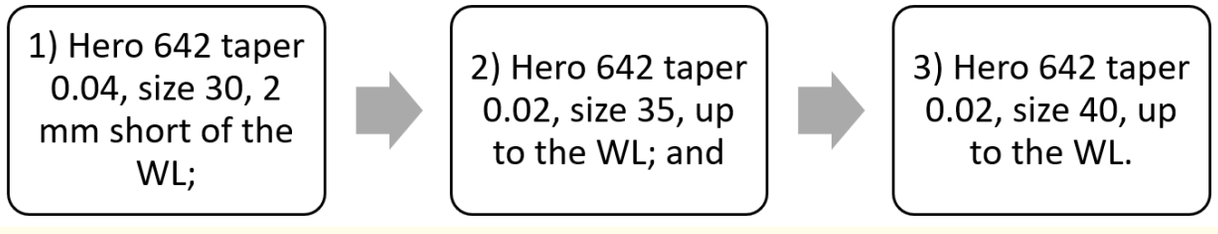

Figure 5

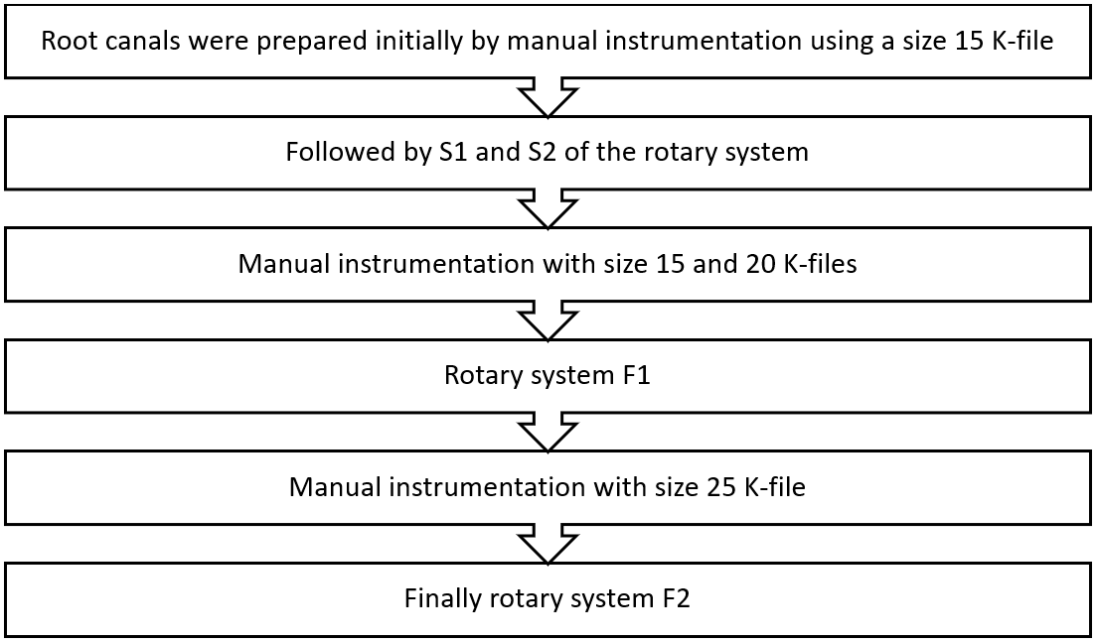

Figure 6

Advantages:

1. Tissue and debris are more easily and quickly removed [7];
2. The nickel-titanium files are flexible, allowing easy access to all canals [7];
3. Nickel titanium files do not need to be precurved [25].
4. Nickel titanium rotary files follow original root canal anatomy [25].
5. Prepared canals are funnel shaped, resulting in a more predictable uniform paste fill;
6. NTs are available in a 21 mm length [7].
7. Shorter instrumentation time than manual techniques, which is a relevant factor in pediatric dentistry because it allows faster procedures while maintaining quality and safety thereby reducing the patient's as well as operator's fatigue [22].

Disadvantages [7,25]:

1. Cost of the endomotor and handpiece;
2. Increased cost of NiTi endodontic files;
3. Cyclic fatigue of endodontic instruments;
4. Endodontic instruments are prone to fracture;
5. Learning the technique.

Cleanin protocol

Cross infection is a major issue in the dental care setting because of concerns about transmission of disease via the oral cavity. Infection control guidelines indicate that cleaning of instruments to remove organic residue is a required step in order to achieve sterility of instruments [26-28]. Endodontic instruments must be cleaned and sterilized before their first use [28].

Technique for cleaning of rotary endodontic instrument [28]:

1. Step I- Chair side manual processes
2. Step II- Chemical processes
3. Step III- Ultrasonication

Chair side manual process

Different types of sponges for chairside wet storage of instruments and initial cleaning are used in chairside cleaning technique. The sponges were saturated in either 0.2 per cent chlorhexidine gluconate aqueous or 1 per cent NaOCl solution The different methods of use of the sponges tested included wiping the files with dry scouring pads, using five or 10 'in-and-out' strokes with the file in a saturated sponge and 'screwing in' the file in the saturated scouring sponges followed by five or 10 strokes [28]. The use of nylon bristle brushes and metal bur brushes to clean endodontic instruments is a common and long-used method. However, Linsuwanont found that brushing was not a very successful procedure. This may be due to the brushing of instruments, while they are in a stand, restricting the access of the bristles to all surfaces of the file blade [28].

Chemical process

Different solutions are used for pre-soaking instruments after the chairside cleaning. These included 1 per cent NaOCl, 4 per cent NaOCl (Endosure, Dentalife); 15 per cent EDTA (EndoPrep); EmPower enzyme solution (Metrex Research Corporation). Enzymatic detergents are currently widely recommended for the cleaning of medical devices because they help to remove proteins, lipids and carbohydrates from the instrument surface. There are many enzymatic detergents available, all of which require a minimum contact time (2 - 10 minutes) and a minimum temperature (35-45ºC) for optimal effect [28].

Ultrasonication

After the pre-soaking stage the files were placed into an ultrasonic bath. These solutions were 1 per cent NaOCl, 15 per cent EDTA, EmPower enzyme solution. Each solution is used for five, 10, 15, 30 or 45 minutes. The different containers used to hold the files during the ultrasonication included a glass beaker, a fine metal mesh basket (Premier Housewares) (Figure), or a plastic file stand. The enzyme solution (EmPower) was as effective as NaOCl but was considered safer than the NaOCl because it lacked the potential for corrosion. EDTA in the ultrasonic bath was ineffective.

Instrument separation and prevention

A major concern with use of nickel-titanium engine-driven rotary instruments is fracture. The clinical concern is that they have been reported to undergo unexpected fracture without warning. Fracture can occur without any visible defects of previous permanent deformation [29].

Fracture of endodontic rotary instruments could occur under two circumstances:

1. Torsional fracture and
2. Flexural fatigue.

Factors predisposing to fracture [30]:

1. Instrument design
2. Manufacturing process
3. Dynamics of instrument use
4. Canal configuration
5. Instrumentation technique
6. Number of uses

7. Cleaning and sterilization procedures
8. Pressure on the instrument
9. Irrigation and lubrication

To minimize the risk of fracture in clinical practice, the following guidelines are recommended [30]:

- Always create a glide path and patency with small (at least #10) hand files.
- Ensure straight line access and good finger rests.
- Use a crown-down shaping technique depending on the instrument system.
- Use stiffer, larger, and stronger files (such as orifice shapers) to create coronal shape before using the narrower, more fragile instruments in the apical regions.
- Use a light touch only, ensuring to never push hard on the instrument.
- Use a touch-retract (i.e. pecking) action, with increments as large as allowed by the particular canal anatomy and instrument design characteristics.
- Do not hurry instrumentation and avoid rapid jerking movements; beware of clicking.
- Replace files sooner after use in very narrow and very curved canals.
- Examine files regularly during use, preferably with magnification.
- Keep the instrument moving in a chamber flooded with sodium hypochlorite.
- Avoid keeping the file in one spot, particularly in curved canals, and with larger and greater taper instruments.
- Practice is essential when learning new techniques and new instruments [30].

Conclusion

The clinician must choose the strategies, instruments, and devices to deal with these challenges and to control the preparation shape, length, and width precisely. The development of new files is a fast and market-driven process. With new versions rapidly becoming available, the clinician may find it difficult to pick the file and technique most suitable for an individual case. Practitioners must always bear in mind that all file systems have benefits and weaknesses. Ultimately, clinical experience, handling properties, usage safety, and case outcomes, rather than marketing or the inventor's name, should decide the fate of a particular design.

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