Evaluation of Root Canal Cleaning Efficacy of third, fourth and fifth generation Protaper Rotary in Primary Teeth - An In vitro Comparative Study

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Abstract

Background: The success of pulpectomy depends on complete eradication of microbial load by cleaning and shaping the primary root canals that is difficult to achieve because of anatomical intricacy of primary pulp dentin complex. Numerous instruments were tried, however, they removal with maximal cleansing of root canals.

Aim: To evaluate and compare the in vitro root canal cleaning efficacy with SAF, Protaper Universal, and Hand K-files in primary teeth.

Materials and Methods: Sixty extracted primary anterior teeth were randomly divided into three groups by lottery method. Access cavity was prepared, the canals were enlarged up to 20 K file, n = 20) was treated with SAF, Group II (n = 20) with Rotary Protaper Universal and Group III (n = 20) with Hand K-files and the walls under stereomicroscopy. Data were analyzed using Kruskal–Wallis one way ANOVA test and post hoc Tuckey test for intragroup and intergroup comparison, respectively.

Results: A statistically highly significant difference was observed with SAF (mean = 1.5), Protaper (mean = 2.5), and Hand K-files (mean = 2.9). However, there was no significant difference in root canal cleaning efficacy with Protaper Universal and Hand K-files.

Conclusion: The SAFs had shown superior cleaning efficacy compared with rotary Protaper Universal and manual K files

Keywords:- Protaper rotary file, third generation, fourth generation, fifth generation, stereomicroscope

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Introduction

Biomechanical preparation helps clear out pulp tissue and necrotic residue, with consequent cleaning, shaping, and increased root canal dentin permeability in turn defining the success of endodontic treatment.[1,2] Moreover biomechanical preparation also relies upon the use of proper root canal instrumentation. Clinicians encounter numerous challenges in cleaning and shaping of primary teeth root canals as they have complex morphology, which is characterized by ribbon shape narrow, tortuous, and connected with multiple accessory canals. Traditional hand files and

nickel–titanium (Ni–Ti) files used for cleaning and shaping are proven to be inadequate as the former increases instrumentation time and operator fatigue, whereas the rotary Ni-Ti files are centered within the canal, thus, compromising the unique anatomy of primary root canals.[3] Recently, a novel self-adjusting file (SAF) system is marketed that is a single, hollow file system designed as a compressible, thin walled, asymmetrical-tapered tip, composed of thin Ni–Ti lattice, with freely rotating hub. It is connected to an irrigation pump, which allows the flow of the irrigants throughout the procedure.[4,5] The SAF adapts closely to the cross section of the canal by virtue of its flexible design. It consists of lightly abrasive lattice threads that allow a uniform as well as minimal removal of dentine all around the given root canal thus producing a clean canal while maintaining the original root canal morphology. The unique advantages of SAF system facilitates the practice of minimal intervention concept in root canal treatment, perhaps these advantages are clinically valid when treating complex root canal system of primary teeth. However, literature search about its usage in primary teeth root canal treatment is extremely limited. Hence, an in vitro study was designed to evaluate the root canal cleaning efficacy in primary teeth with SAF in comparison with rotary and Hand files.

Materials and Methodology

The present in vitro study was conducted after obtaining ethical approval from institutional ethical review board (IEC/IRB NO: VDC/IEC/2020-22). Sixty primary anterior teeth with intact 2/3 root length without external or internal resorption and canal calcification were included in the study and stored in 0.1% thymol until further usage. The samples were then divided into three equal groups of 20 teeth using simple random sampling procedure (lottery method). Endodontic coronal access was achieved using a large round diamond bur (BR-46; Mani Inc., Japan) and the canals were located using DG16 instrument. Following irrigation of the pulp chamber with 1% NaOCl (Prime Dental Products, Mumbai, India), working length and patency of the root canals were determined digitally by introducing #10k-file (Dentsply-Maillefer, Ballaigues, Switzerland) into the root canal 1 mm short of the apex or the root level. Teeth were then prepared till #20k-file with recapitulation (Dentsply-Maillefer, Ballaigues, Switzerland), and Indian ink was injected with a 30-gauge insulin syringe. A K-file size #10 was inserted into the canal to assure penetration of the dye through the canal. Each time after drying, the ink is reapplied and is carried for three to four times.

Preparation of canals

A single operator who was experienced in both manual and rotary instrumentation prepared the root canals. Group I (SAF): Thirty teeth were prepared with SAF system. A prior glide path established accommodated the 1.5 mm SAF. The SAF file was operated by using in-and-out pecking motion for 4 min in the canal (0.4-mm amplitude and 5,000 vibrations per minute), with continuous irrigation by using 1% sodium hypochlorite, using VATEA peristaltic pump (ReDent-Nova) at a rate of 4 mL/min. Group II (Rotary Protaper Universal files): The root canals were instrumented with rotary Protaper Universal files (Dentsply/Maillefer, Ballaigues, Switzerland) using modified protocol given by Kuo et al. [6] The orifices were enlarged with # SX file (21 mm, 19% taper) then shaped with # S2 files (21 mm, 20% taper) using lateral brushing motion. Group III (K-files): The root canals were manually prepared with 21 mm K-files (Dentsply/Maillefer, Ballaigues, Switzerland) in a step-back manner through ISO size # 35 by watch winding motion. During instrumentation of teeth in group II and III, canals were irrigated with 10 ml of 1% sodium hypochlorite solution. After drying canal with sterile paper points, the pulp chamber was sealed with temporary cement (Coltosol, Coltene Whaledent, Switzerland) and the apical end with sticky wax. The instrumentation time in each canal was measured with a chronometer. Even the time taken for instrumentation exchange was considered.

Evaluation of cleaning efficacy

Cleaning efficacy was evaluated by examining the amount of ink removed from canals by each system after instrumentation. The samples were placed separately in a jar with lid containing 10% chloridric acid for 3 days and renewed every 24 h until completely decalcified. They are washed under running water for 8 h for complete acid removal and dehydrated in 70% and 90% alcohol for 16 (changed after every 8 h) and 3 h, respectively (changed every hour). After dehydration, the teeth were placed in methyl salicylate till they appeared transparent. The cleared teeth were analyzed under stereomicroscope (Olympus, 10× magnification) for remaining traces of India ink in coronal, middle, and apical third of the canals. The scoring criteria used were as follows:

• Score 0: total clearing (canal was completely clean)
• Score 1: more than 50% ink removal (traces of ink in some areas)
• Score 2: less than 50% ink removal (remnants of ink found on some walls in some areas)
• Score 3: no ink removal (appreciable amount of ink present).

Evaluations were done by blinded clinician who is unaware about the preparation protocol and groups.

Statistical analysis

Descriptive statistical analysis was done using IBM Statistical Package for the Social Sciences Ver. 17.0 (Armonk, NY, USA). Inter and intra group comparisons were made using post hoc Tuckey and one-way Kruskal–Wallis ANOVA tests, respectively. A probability value of $P \leq 0.05$ was set for statistical significance and a value of $P \leq 0.000$ for statistically highly significant relation.

Results

Although certain amount of ink remaining was observed with all the three techniques, the mean amount of ink remaining with single file system SAF (Group I – 1.5000 ± 0.52) was less compared with the other two techniques Protaper rotary (Group II – 2.5000 ± 0.52) and Hand K-files (Group III – 2.9000 ± 0.52) and this difference was statistically highly significant ($P = 0.000$) [Table 1]. On inter group comparison using post hoc Tuckey's test, a statistically highly significant difference in the root canal cleaning efficacy was observed between both SAF (Group I) and Protaper Universal (Group II) ($P = 0.000$) and SAF (Group I) and Hand K-files (Group III) ($P = 0.000$) However, there was no significant difference in root canal cleaning efficacy between Protaper Universal (Group II) and Hand K-files (Group III) ($P = 0.154$) [Table 2]

Discussion

Considering the advantages with rotary Ni–Ti files, their application may perhaps be more suitable in children who exhibit behavior management problems.[7-9] However, compromising and ignoring the natural 3D shape, rotary Ni–Ti files are centered within root canals, clean and shape with round cross-sections leaving unclean areas and potentially infected tissue in fins and isthmuses of root canals of primary teeth.[10] These rotary files increase the chance of lateral perforations in ribbon-shaped curved primary root canals, pose the shortcoming of canal transportation, ledge formation, and instrument separation when used aggressively. Furthermore, the longer rotary files might result in apical foramen enlargement thereby having over obturation. In addition, limited mouth opening of children negate the use of longer rotary files in primary root canals.[11] To overcome these drawbacks and for adaptation of the file to the irregular morphology of root canals, a new file system called SAF has been introduced. No literature has so far reported regarding its use in primary teeth that led to the conceptualization of present study.

In the present study, the Protaper Ni–Ti rotary files were used with a protocol suggested by Kuo et al. [6] that is, a combination of one manual file and two rotary Protaper files, SX and S2. SX file is an auxiliary shaping file used for the early coronal enlargement and obtaining a straight-line access that made the root canal preparation more efficient as well as avoids the lateral perforation and over instrumentation of inner root structure of the middle and apical

third. SX file is followed by S2 file that is a shaping file used for the preparation of apical one-third of the canal.

Table 1: Intragroup comparison of root canal cleaning efficacy among the three techniques

Group	Sample (*n*)	Amount of ink remaining (Mean±SD)	*P*
Group I (SAF)	20	1.5000±0.52	0.000 HS**
Group II (Protaper)	20	2.5000±0.52	
Group III (Hand K-files)	20	2.9000±0.52	

SD=Standard deviation; HS**=High statistical significance

Table 2: Intergroup comparison of root canal cleaning efficacy among three techniques

	Group I vs II, SAF vs Protaper	Group I vs III, SAF vs Hand K-files	Group II vs III, Protaper vs Hand K-files
Mean difference± standard error	-1.00000	-1.40000	-0.40000
P	0.000 HS*	0.000 HS*	0.154 NS

HS**=High statistical significance, NS=No statistical significance

Dying and clearing method used in current study is based on four score criteria evaluation under stereomicroscope as practiced by Silva et al. [1] In this method, the teeth were made transparent by decalcification, dehydration, and finally immersing in methyl salicylate, so that the pulp space and canal walls could be observed and evaluated three dimensionally. Moreover, the clearing method has an advantage of simplicity and reveals results within few days in comparison with other methods like debris removal method

The observations of the study revealed no difference in cleaning efficacy between rotary Protaper and manual instrumentation technique in similarity to that reported by Silva et al. and Schafer et al. [1,12] Contrarily, Katge et al.[13] reported better primary root canal cleaning efficacy with Ni–Ti rotary instruments compared with manual instrumentation.

Root canal cleaning efficacy with SAF was found to be superior when compared with other two techniques in current trial. This result was in unison with that demonstrated by Ruckman et al. [14] The superior cleaning efficacy might be because of the compressibility and flexibility of SAF files along with continuous flow of irrigation provided throughout the procedure. Furthermore, the 3D adaptation of SAF file to the root canal wall facilitates effective cleaning and shaping in which uniform layer of dentin is removed around the entire perimeter of canal, thus avoiding unnecessary excessive removal of sound dentin

The SAF operates in a totally different manner than syringe and needle irrigation. The hollow file of SAF is operated with continuous irrigation provided by a special device VATEA irrigation pump. The chosen irrigation fluid enters the file through a free-rotating hub and is continuously replaced throughout the procedure. This provides a fresh, fully active supply of sodium hypochlorite and results in better debris removal. No positive pressure is developed in the root canal because the solution always easily escapes through openings in the lattice of the file. This reduces the risk of forcing the irrigation solution beyond the apex which may potentially cause a sodium hypochlorite accident. Thus, the combination of scrubbing action with continuous flow of fresh, fully chemically active sodium hypochlorite results in highly effective cleaning of the canal walls.[5] Siqueira et al.[15] reported that the SAF system was significantly more effective in disinfecting oval canals compared with rotary instrumentation and needle irrigation. These were attributed to the continuous irrigation

feature of the system and agitation created by in and out movement of the file.

The major difference between SAF and the rotary files is the mode of action. Rotary files have blades of one design or other that aggressively machine the root canal by cutting the dentin. The SAF, on the other hand, does not haveblades and instead removes dentin using pecking motion. Thus, the mode of action of the SAF does not create any significant stress during biomechanical preparation of root canal and it allows preservation of the integrity of radicular dentin by avoiding both unnecessary, excessive removal of sound dentin and formation of micro cracks in the radicular dentin.[5] This factor is of paramount significance in primary teeth endodontics as the primary teeth root dentin is softer and less dense compared with the permanent teeth. Primary root dentin is nearly half as thick as permanent dentin and lacks interglobular dentin, making it easy to cut with thicker rotary files, potentially causing lateral perforations and canal transportations.[11] These complications can be avoided by using SAF files because of their compressible structure and mode of action.

Metzger et al.[5] emphasized that most rotary file systems involve the identification and gradual instrumentation of the widest part of the canal using several files of increasing diameter, creating a wider canal with a round cross section. In contrast, the SAF file contacts all points of the inner canal wall due to the compressible and expansive structure of the lattice and removes dentin with a back and forth grinding motions. Furthermore, Hof R et al. stated that machining action by rotary files may reduce the thickness of remaining dentin, thereby increasing its susceptibility to fracture which does not occur with SAF files.[16]

Based on observations of present study, SAF design is a newer approach for cleaning and shaping of root canals. Its three-dimensional adaptation and compressible design that allows the minimal, even removal of dentin all around the root canals coupled with continuous irrigation are the most desirable features in the instrumentation of thin, tortuous, and ribbon-shaped root canals of the primary teeth.

Furthermore, SAF gives a better cleaning efficacy of primary root canals at a quicker pace where the time, cooperation, and behavior management of child plays an important role in treating an anxious child in dental office.

Hence, SAF can be a game changer in primary teeth endodontics. However, further clinical trials with large sample size involving both single- and multi-rooted primary teeth need to be carried out to authenticate its cleaning advantages.

Conclusion

Based on the observations of the present study, following conclusions were drawn. • SAF showed superior root canal cleaning efficacy compared with Protaper Universal and Hand K-files. • There was no difference in root canal cleaning efficacy between rotary Protaper Universal and Hand K-files. • SAF can be used as better adjunct in root canal preparation of primary test.

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Conflicts of interest

There are no conflicts of interest.

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