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Obturation Quality after Pulpectomy Treatment in Primary Molars using Different Preparation Techniques

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INTRODUCTION

Pulpectomy is the preferred treatment option to preserve primary teeth with pulpal necrosis or irreversible pulpitis.[1] Primary teeth guide the eruption of permanent teeth and act as natural space maintainers in the dental arch.[2] Primary teeth also aid in chewing, prevent speech problems and aberrant tongue movement, improve aesthetics, and prevent psychological effects due to premature tooth loss. The retention of primary teeth is therefore of paramount importance.[3] Pulpectomy treatment in primary molars is challenging due to complex internal anatomy and morphology, and due to the process of physiological root resorption.[4] The outcome and overall success of pulpectomies are often considered unpredictable and depend on various treatment- and patient-related factors.[5] Dental practitioners might therefore refrain from performing these treatments despite the importance of preserving primary teeth.

The objective of pulpectomy treatment is to completely remove residual necrotic material, vital tissues, debris, and infected dentine from the root canal system and replace this with inert obturation material.[6] During the pulpectomy procedure, dental practitioners have to create space for instrumentation, attain an ideal shape for irrigation and obturation while retaining the integrity of the root and preserving dentine.[7] For pediatric patients, root canal preparation is usually performed using manual stainless steel (ss) K-files, and to a lesser degree, rotary nickel-titanium (NiTi) files.

The use of manual ss K-files has been the "gold standard" for preparing root canals during pulpectomy treatment in children.[8,9] However, preparation with hand instruments is time consuming and iatrogenic, procedural accidents such as canal transportation, ledging, zipping, and apical blockage often occur due to the inflexibility of ss K-files.[10] To overcome these challenges, much attention has been given to other options such as NiTi rotary and reciprocating instruments for treating primary teeth. The advantages of NiTi instruments include increased flexibility, super elasticity, a significant reduction in preparation times, and better anatomically shaped root canals.[11]

In pulpectomy treatment, high quality obturation often determines the long-term success of the procedure. As the aim of pulpectomy is to fill the root canal with inert obturation material, high quality obturation implies optimal filling without under filling or overfilling.[12] The ideal obturation material for primary teeth should have the same resorption rate as that of the original root, be anti-bacterial, be harmless to the permanent tooth germ and surrounding tissues, and also resorb if extruded through the apex.[13] In this study, the authors wanted to evaluate the shaping ability of different instrumentation types with a high degree of reliability. Vitapex (Neo Dental Chemical Products Co., Ltd, Tokyo, Japan), a premixed calcium hydroxide and iodoform paste, was chosen as the obturation material.[13]

In pediatric patients, pulpectomy treatment is often avoided due to the complexity of the procedure and the need for longer chair times when using manual instruments. In a previous study, the authors compared the preparation times when using ss K-files (ISO size 20-35), the rotary ProTaper Gold SX file (Dentsply Sirona, Ballaigues, Switzerland), and the reciprocating WaveOne Gold Medium file (Dentsply Sirona) and found that manual preparation was much slower than when using rotary or reciprocating files. In this study, the authors compared the obturation quality with Vitapex as obturation material, between different canal shaping instruments. Canal shaping was done with manual ss K-files (ISO size 20-35), the rotary ProTaper Gold SX file, and the reciprocating WaveOne Gold Medium file.

The objective of this study was to evaluate and compare the obturation quality of the canals after canal preparation using the three different file systems to give recommendations on which file system resulted in the best obturation quality.

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METHODS

The study was approved by the Research Ethics Committee, Faculty Health Sciences, University of Pretoria in June 2019 (Reference nr: 272/2019) and in accordance with the Helsinki Declaration of 1975, as revised in 2000. The teeth used for the study were teeth extracted from human patients as part of a comprehensive treatment plan for each individual patient and not for the purpose of this study. Parents gave informed consent for the extractions.

In this ex-vivo, randomised comparative cross-sectional study, 60, extracted, human, primary mandibular second molars were selected, of which the mesiobuccal canals were prepared. The inclusion criteria were root canals clearly visible on pre-preparation digital radiographs, roots that were intact and measured 8 mm or more from the cemento-enamel junction, and an apical foramen size of no bigger than 0.3 mm.[10] Teeth with sclerosed mesiobuccal canals or canals that had been previously accessed endodontically were excluded.[10]

Sixty root canals were randomly divided into three instrumentation groups (K-file, ProTaper Gold SX, and the WaveOne Gold Medium groups) using Research Randomizer software (n = 20).

The teeth were coded and placed in a simulated jaw to replicate the clinical setting. Before access cavity and canal preparations, periapical pre-operative radiographs were taken. Coronal access was prepared using a high-speed hand piece and a diamond fissure bur. An Endo-Z bur (Dentsply Sirona) was used to ensure straight-line access to all root canals. The teeth were then removed from the simulated jaw and a size 10 ss K-file was used to locate the mesiobuccal canals and negotiate to patency. One mm was subtracted from the length of the canal measured to the major apical terminus under 10 times magnification using a dental operating microscope (Zumax Medical Co, Ltd, Suzhou, China) to determine working length.[14] The teeth were placed back into the simulated jaw and an initial size 10 ss K-file was moved in and out of the root canal with amplitudes of 1–2 mm up to working length for all 60 root canals to create an initial, manually reproducible micro glide path. A size 15 ss K-file was used in a similar manner once the size 10 ss K-file moved more freely up to working length. A final reproducible glide path was confirmed when the size 15 ss K-file could reach full working length, pulled back 4 mm and pushed back with light finger pressure without any interference or blockages.[14] After the glide path was confirmed, preparation of root canals was performed using one of three different instrumentation types.

K-file group: Root canal preparation was done by the conventional step-back method using pre-curved ss K-files from size 20 to 35 up to working length with the quarter-turn-pull technique (n = 20).

ProTaper Gold SX group: Root canal preparation was done using the ProTaper Gold SX file with rotation up to working length according to manufacturer's instructions (n = 20).

WaveOne Gold Medium group: Root canals were enlarged using the WaveOne Gold Medium file with reciprocation up to working length according to the manufacturer's instructions (n = 20).

The 40 mesiobuccal canals that were prepared using the rotary and reciprocating files, were all prepared using a 16:1 speed reducing hand piece (X-Smart Endo motor, Dentsply Sirona). Throughout the instrumentation process, each canal was irrigated with 5 ml of 3% sodium hypochlorite solution, and RC Prep (Premier, Pennsylvania, USA) was used as a lubricant. The flutes of the files were cleaned of debris after each insertion. The rotary and reciprocating files were used only once to prepare the canal before being discarded.

After final irrigation, the canals were dried with matching paper points. After canal preparation, a bubble of red wax was placed around the apex of each root to create a halo space around the apex, preventing unnecessary extrusion of the obturation material through the apex. The roots were then mounted in plaster moulds to obturate the prepared canals.[15] Obturation was done with Vitapex according to the manufacturer's instructions. A post-operative digital radiograph was taken to evaluate obturation quality. An adjusted scoring system was used to evaluate the obturation quality for each canal based on previous methods described in literature.[16-18] Two evaluators blinded to the groups assessed the presence of voids and extent of fill based on the following criteria to limit bias and ensure reliability of results.

Presence of voids:

Score 1: Entire canal perfectly filled, well adapted to the root canal with no voids
Score 2: Imperfectly-condensed root canal filling with irregularities of less than 0.25 mm
Score 3: Imperfectly-condensed root canal filling with irregularities of 0.25–1 mm
Score 4: Poorly-condensed root canal filling with irregularities of more than 1 mm

Extent of fill:

Grade A: Less than half of the root canal length was filled
Grade B: More than half the root canal length was filled but not optimal
Grade C: Optimal filling (canal filled to within 0–1 mm from the apex)
Grade D: Overfilling of the root canal to an acceptable standard (< 1 mm through the apex)
Grade D+: Extreme overfill, not acceptable (> 1 mm through the apex)

The presence of voids (Score 1–4) and the extent of fill (Grade A–D+) were combined to grade obturation quality (Table 1). Each tooth was graded as "good", "average", "poor" or "failed" (Figure 1).

STATISTICAL ANALYSIS

The analysis was descriptive and inferential, and all analyses were performed using SAS (SAS Institute Inc, Cary, NC, USA), Release 9.4. The obturation outcomes ("good", "average", "poor" or "failed") were compared between the three instrumentation groups using the Fisher Exact test.

RESULTS

The obturation outcomes observed across the three instrumentation groups differed significantly ($p = 0.016$). This was followed up by pair wise comparisons for each obturation outcome.

The proportion of "good" obturation outcomes observed with the ProTaper Gold SX group (65%) was significantly

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Table 1: Scoring criteria for obturation quality in pulpectomy of primary molars

Obturation quality score	Presence of voids (1–4) + extent of fill (A–D+)
Good	1C, 2C, 1D, 2D
Average	3C, 4C, 3D
Poor	1B, 2B, 3B, 4D
Failed	1A to 4A, 1D+ to 4D+, 4B

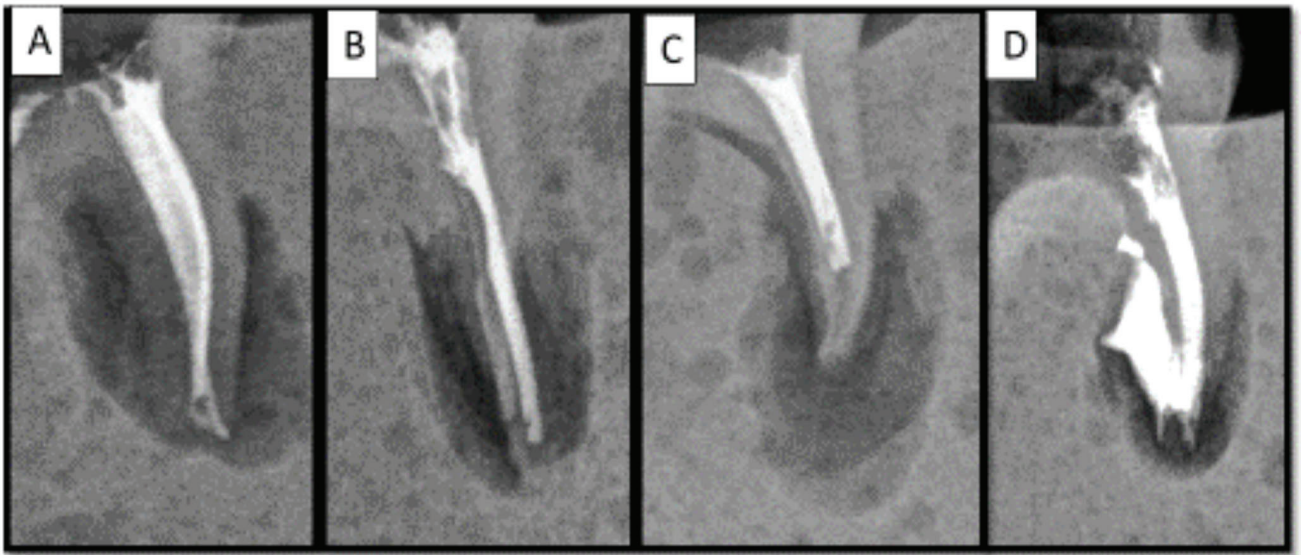

Figure 1 A-D: Obturation quality score: Good (A), Average (B), Poor (C) and Failed (D).

higher than observed in the K-file group (25%, p = 0.025) but was similar to the proportion of "good" outcomes observed in the WaveOne Gold Medium group (55%, p = 0.748). The proportion of "average" obturation outcomes was similar across the three groups (Table 2). The proportion of "poor" obturation outcomes was significantly higher in the K-file group (40%) than that observed in the ProTaper Gold SX group (5%; p = 0.020). No other significant differences were observed (Table 2).

DISCUSSION

In this study, obturation quality was assessed. Three different preparation instrumentations were used to prepare root canals during pulpectomy treatment. The authors found that manual preparation resulted in more "poor" obturation outcomes than the outcomes observed using rotary files. These findings are similar to the results of several other studies.[3,9,19,20] No significant differences in obturation quality were observed when comparing rotating or reciprocating files in the preparation of primary teeth.

Obturation quality is a key factor that influences the long term success of a pulpectomy.[21] The quality depends on effective mechanical cleaning and shaping of the root canal. During canal preparation, it is essential to remove micro-organisms, debris and residual pulp while preserving the original shape of the canal.[22-24] The prognosis of a pulpectomy also depends on the length of the root canal filling [12,24,25] and the presence and size or absence of obturation material voids.[17,20] The presence of voids can lead to leakage and the possibility of retained micro-organisms leading to reoccurring abscess formation and periapical disease after treatment.[17,26] Under instrumentation or extreme overfilling of root canals have also been proven to cause treatment failure.[3,22] Whereas optimally

Table 2: Obturation quality observed following root canal preparation using three different instrumentation types

Obturation quality	Frequency (%)		
	K-file group	ProTaper Gold SX group	WaveOne Gold Medium group
Good	5 (25)[a]	13 (65)[b]	11 (55)[b]
Average	4 (20)[a]	2 (10)[b]	0[b]
Poor	8 (40)[a]	1 (5)[b]	3 (15)[b]
Failed	3 (15)	4 (20)*	6 (30)
Total	20 (100)	20 (100)	20 (100)

Mean values with different superscript numbers were statistically different at p value <0.05

*2 of these failed cases were lateral perforations caused by the preparation technique.

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filled or slightly overfilled root canals have been proven successful when obturating with a resorbable paste, such as Vitapex.[13,27]

Ultimately, endodontic obturation aims to create a bacteria-tight seal from the coronal opening of the canal to the apical termination.[12] Endodontic failures usually occur when bacteria persist in the root canal, filling is inadequate due to poorly shaped/cleaned root canals, materials overflow through the apex, poor coronal seal, unprepared canals, and procedural errors.[23] Overfilling of root canals is a common finding, especially when root resorption has already started to take place. Excessive overfilling of root canals can lead to the irritation of the surrounding periapical tissues and cause deflection of the permanent successor. Deflection of the permanent successor defeats the purpose of a pulpectomy, which is to maintain function and space, by not extracting the primary tooth, and allowing normal growth and physiological root resorption.[13]

Different techniques have been proposed for mechanical preparation of root canals, although manual filing is still considered the "gold standard." Manual filing using ss K-files however has limitations, as these files are more rigid causing aberrations, irregularities, and ledges in the root canal making optimal obturation difficult.[28] The findings of this present study are in agreement with many other studies[10,11,20,28], as the authors also found that manual ss K-files resulted in inferior obturation quality than that observed with other instrumentation groups. These include rotary and reciprocating files. To improve obturation quality, dental practitioners may prefer to prepare canals with rotary or reciprocating file systems.

NiTi rotary files create a predetermined conical shaped canal. These files are specifically designed to be super flexible to closely follow the original canal shape, resulting in uniform and predictable obturation.[29] Several studies have concluded that NiTi rotary files create a smooth, predetermined, funnel-like shape without the risk of ledge formation and canal transportation.[5,30,31] The use of NiTi rotary files, designed for permanent teeth, in primary teeth raises concerns because primary teeth have narrower, curved roots, and ribbon-shaped canals increasing the risk of lateral perforation.[32] Subsequently NiTi rotary files should be designed specifically for primary teeth to prevent lateral perforations.[32] In the present study, two lateral perforations were observed, both caused by the ProTaper Gold SX file. These lateral perforations might be explained by the larger taper of the ProTaper Gold SX file, ranging from 3.5%–19%. This file has the largest taper of all the files in the ProTaper Gold system with cross-sectional diameters of 0.50, 0.70, 0.90, and 1.10 mm at D6, D7, D8, and D9 respectively and a tip size of 0.19mm.[33] Many practitioners already have endodontic armamentarium including the ProTaper Gold system which they use for pulpectomies in primary teeth to prevent additional expenses. In our study, the ProTaper Gold SX resulted in the best obturation quality with the most "good" outcomes.

Obturation quality is apparently affected by the taper and metallurgy of instruments which affects shaping and cleaning.[34] The three instruments tested in our study, included the ProTaper Gold SX, WaveOne Gold Medium, and manual ss K-files, which differed in both metallurgy and taper. Several studies have been done in primary teeth comparing manual and rotary preparation techniques to determine which technique results in the best obturation quality [3,4,20,28], but little scientific evidence is available comparing obturation quality between manual, rotary files, and reciprocating files in primary molars. Hence, these three groups were investigated in our study.

In 2014, Katge, Patil, Poojari, Pimpale, Shitoot, Rusawat [35] also investigated canal preparation using three different file systems but they only evaluated preparation times and cleaning efficacy, but not obturation quality. This is the only study, to the researchers' knowledge, that was done where a reciprocating file system was compared to manual ss K-files and a rotary file system. One case report done in 2011 concluded that the ProTaper Universal SX file (Dentsply Sirona) produced adequate chemo-mechanical preparation of canals and satisfactory obturation after shaping and disinfection.[36] The authors of the current study also tested the WaveOne Gold file system, which has a parallelogram-shaped cross-sectional diameter which limits the engagement of the file and dentine to only one or two points of contact at any given stage of canal preparation. This improves the safety of the file with less taper-lock and screw-in effect. The file's cross-sectional design also allows for more debris extrusion during canal preparation. The file is designed with a progressively decreasing percentage taper from D14–D16 to preserve dentine.[33] The WaveOne Gold file engages at a counter-clockwise angle of 150° and a clockwise disengaging angle of 30°. After three cutting cycles the file rotates one complete circle. This unique movement, according to Ruddle [33] is a major advantage due to the safety of the file when compared to continuous rotating files. The file advances more readily to the desired working length without excessive inward pressure and debris extrusion from the canal. There are four WaveOne Gold files in different sizes and lengths: small (20/07), primary (25/07), Medium (35/06), and large (45/05). According to the manufacturer, the primary (25/07) file is suitable for shaping most root canals in permanent teeth but will not be suitable for primary teeth due to the increased taper of primary canals. In this study, the Medium (35/06) file was used due to its tip size corresponding to that of the prescribed manual ss K-file size of 35.[5]

Obturation quality was assessed by using post-operative radiographs, which are two-dimensional images of three-dimensional objects. This was done in a simulated setting, and the findings of this study may differ in a clinical setting. Obturation quality is likely to be affected by a wide range of factors that were beyond the scope of this study.

Rotary and reciprocating file systems perform better than manual instrumentation in terms of obturation quality and even results in faster preparation times,[37,38] but results suggest that there is a need to create a dedicated file for pulpectomy in primary teeth. Further studies should be done thickness and cleaning efficiency as the authors of this study only evaluated the obturation quality. The file should have a smaller taper to prevent lateral perforations. More research should also be done on other file systems already used by practitioners for permanent teeth, to recommend suitable file options for pulpectomy in primary teeth.

CONCLUSIONS

Based on the results of this study, the authors conclude the following:

1. The rotary ProTaper Gold SX file showed superior obturation quality followed by the reciprocating WaveOne

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Gold Medium file and then conventional ss K-files.
2. The K-file group resulted in the most "poor" and "average" outcomes.
3. There was no significant difference in "failed" outcomes between all three groups.
4. Although further clinical studies are recommended, we conclude that both ProTaper Gold SX and WaveOne Gold Medium files might be viable instrumentation options for pulpectomy treatment in primary molars, although remaining dentine and root thickness should be carefully evaluated to avoid perforations or over instrumentation.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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CPD questionnaire on page 336

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.