

ORIGINAL ARTICLE

Comparison of Manual and Rotary Root Canal Instrumentation: Self-reported Experiences of Undergraduate Dental Students in a Nigerian University

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ABSTRACT

Introduction: Undergraduate endodontic training focuses on mastering techniques and advances in root canal treatment. Despite its importance, students often find clinical endodontics and complication management challenging, necessitating continuous training in modern techniques.

Aim: To compare the practical experiences and efficiency of manual versus rotary root canal instrumentation techniques among undergraduate clinical dental students.

Methodology: This descriptive observational study recruited consenting final-year (600 level) dental students at the University of Ibadan. Using extracted adult first lower molars, participants performed access cavity preparation (T1), followed by biomechanical instrumentation; manual instrumentation using step back technique (T2) and rotary instrumentation using Protaper universal filing system (T3). Data were analysed using descriptive statistics, independent-t tests used to compare gender and time to perform instrumentation, with significance set at $p \leq 0.05$.

Result: Twenty-one students (mean age 25.4 ± 1.7 years) participated. Mean time for access cavity preparation (T1) was 42.1 ± 30.9 minutes. Rotary instrumentation (T3: 20.1 ± 7.2 minutes) was significantly faster than manual instrumentation (T2: 29.7 ± 10.3 minutes). No significant gender differences were observed for T2 ($p = 0.175$) or T3 ($p = 0.331$). Regarding perceptions, 52.4% found rotary files more flexible, and 57.1% reported no challenges using rotary systems, compared to only 23.8% for manual files. Furthermore, students expressed higher confidence in rotary (57.1%) than in manual instrumentation (9.5%).

Conclusion: Rotary instrumentation was found to be faster, perceived as easier, and preferred by the majority of undergraduate students. Integrating rotary techniques earlier in the curriculum may enhance student confidence and clinical efficiency.

Keywords: root canal preparation, rotary instrumentation, biomechanical preparation, endodontic training, laboratory endodontics

INTRODUCTION

The adequacy of the cleaning and shaping of root canals has been identified as a significant factor that affects the success rate of root canal therapy.¹ This is because cleaning and shaping the root canal helps remove necrotic and vital

pulp tissue and creates space for the desired tapered cone configuration of the canal, which enhances adequate irrigation of the root canal.² Studies have shown that good treatment outcomes are seen when the root canal is obturated 0-2 mm from the radiographic apex.³ With this,

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it can be said that good instrumentation of the root canal has a role to play in the actual outcome of the treatment, though the root canal anatomy is a constant factor to consider when root canal therapy (RCT) is being contemplated.^{1,3} Of note is the apical third region of the canals stated to pose difficulty in cleaning and shaping when the anatomy is complex.⁴

The introduction of nickel-titanium (NiTi) rotary instruments has made root canal cleaning and shaping easier compared with traditional hand instrumentation. Files, and nickel-titanium (NiTi) rotary files were designed with high flexibility permitting close adaptation of the instrument to the root-canal walls.² Nickel Titanium (NiTi) alloys are known to be biocompatible, super elastic and with good shape memory.⁵ However, their main disadvantage is the unexpected fracture of the instrument seen, which may arise from the instrument's torsional or flexural fatigue.⁶ The grinding process adopted for manufacturing the NiTi files has also been implicated in predisposing these instruments to fractures.⁷ The processing leaves micro cracks within the alloy, making the NiTi instruments fracture when subjected to stress.⁷ The morphology of the root canal (especially curved canals), frequency of file re-use, rotational speed and torque applied have been identified as factors that may increase the risk of NiTi files fracture.⁶

As a precautionary measure, using the NiTi instruments in a safe manner is essential to prevent fractures within the canal. Because of this, Martins et al.⁸ advocated that adequate exposure on the use of rotary instrumentation should be included in the training of dental students to boost their confidence in its usage, knowing fully well that instrument fracture is commoner among individuals with fewer years of experience.⁹ Therefore, clinical laboratory training is an essential component of the undergraduate syllabus, and it should be aimed at providing a foundation for effective clinical practice.¹⁰

In a previous study by Murray and Chandler¹¹ among a group of dental students in New Zealand, it was reported that the students found endodontics as a course and endodontic procedures difficult.¹¹ A Nigerian study¹² also reported that undergraduate dental students showed low confidence level in performing endodontic procedure and also reported low confidence in management of possible

complications that may arise from endodontics. Difficulty in performing endodontics has also been reported among practitioners due to complexity of the procedure and inadequate exposure during training.^{8,13} This further confirms the need for laboratory endodontic training of undergraduate and even postgraduate students. An experimental study on three groups of students who prepared simulated root canals on endo blocks using the WaveOne instrument showed that smooth tapered canal preparations were produced within a short time irrespective of the operator's experience who prepared the canals.¹⁴

Although, rotary instrumentation of canals has been accepted widely in developed countries, the training at undergraduate level in African region and specifically in Nigeria is still lacking. Furthermore, previous studies have also reported the relevance of getting feedbacks from students to maximize their clinical teachings and skills acquisition.¹⁵ However, to the best of our knowledge, there is a dearth of studies on the predisposition of dental students to rotary instrumentation training in the African region. Therefore, there is a need for the evaluation of the perception of the undergraduate students on the use of rotary instrumentation as compared to conventional manual instrumentation of the root canals as this will help their trainers and clinical instructors improve the training curriculum and tailor it to their needs, thereby boosting dental students' learning experience and clinical competency.

With the laboratory exposure to both methods of root canal instrumentation, they can also be better prepared for clinical practice because of the increasing burden of untreated dental caries globally,¹⁶ which may likely cause a future increase in demand for endodontic treatment. Adequate preparation of dental students on the use of rotary instruments, considering its advantages, will enable them to meet up with the global practice and the foreseen increased endodontic needs of the populace.

Thus, this study aimed to evaluate the perception of Nigerian undergraduate dental students about rotary instrumentation of the canal in comparison to the manual in the preparation for their clinical training in endodontics.

The study therefore, compared the practical experiences on root canal instrumentation techniques among the

undergraduate clinical dental students. Also, the time taken in completion of root canal preparation with manual and rotary techniques of biomechanical preparation was compared as well as the preferences of the undergraduate clinical dental students on their choice of root canal preparation method.

METHODOLOGY

Study Design: An observational cross-sectional study

Study setting: The study was carried out among the final year (600 level) clinical students. The study was conducted at the Laboratory of the Conservative Dentistry Unit of the Department of Restorative Dentistry, University of Ibadan. A total enumerative sampling technique was employed. All the final year dental students undergoing their clinical rotations at the centre who consented to participate were recruited for the study. Ethical approval was sought from the UI/UCH ethical board (UI/EC/22/0098). The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies. Informed consent was taken, and those willing to participate in the study performed the root canal preparations on extracted teeth using both methods.

The students received special teaching and demonstration sessions on the use of both manual and NiTi rotary instrumentation carried out by academic staff / endodontics specialist from the Department of Restorative Dentistry of the Institution.

Hands-on training on all the stages of root canal treatment (RCT) was done for 2 hours. This training included rubber dam application, access cavity preparation, working length determination using apex locator, biomechanical preparation, and obturation. Two methods of biomechanical preparation were taught; the manual/hand instrumentation using K-files (Premier Dental) and the rotational (rotary) instrumentation using Protaper universal rotary (Dentsply) filing system.

Thereafter, the participants performed each stage of the RCT on extracted lower molars mounted on phantom head with paraffin wax. The extracted mandibular first molars included were teeth with straight roots or minimal root

curvature. Teeth with calcification, difficulty in assessing the canals, and those previously root filled were excluded.

The participants were timed at each stage of the preparation. First timing (T1) was the time for access cavity preparation i.e time spent from the placement of bur on the tooth till the location/identification of the canals. On locating the canals, the number of canals in each tooth were recorded and the participant balloted for the canal to perform the manual instrumentation on, between the mesio-lingual(ML) and Mesio-buccal (MB) canals.

The working length of the canal to be prepared was determined followed by the biomechanical preparation. The time taken to complete the biomechanical instrumentation was recorded as T2. Thereafter, the participants performed the rotary method of biomechanical instrumentation on the second canal in the mesial root, and time to complete the rotary instrumentation was T3.

The step back technique of manual instrumentation was employed with apical preparation done to size 25 file and coronal to size 40 file, while the rotational instrumentation made use of the crown down technique. Glide path was prepared to size 15 file after which, the file sequencing SX, S1, S2, F1, F2 for Protaper universal at the speed of 300 rpm and torque of 1.5 Newton/cm (N/cm) was used for the rotary instrumentation and completed with F2 (0.25 taper). Each participant performed the instrumentation on the canals separately at intervals of one hour to avoid recall bias and fatigue.

On completion of the preparation of each canal, the cold lateral compaction technique was used to obturate (time for obturation was not considered).

Afterwards, a semi-structured, self-administered questionnaire which had been pre-tested among residents, and validated by experienced Conservative Dentists/Specialists at the Faculty of Dentistry, University of Ibadan, was used to assess the participants' perception about the use of rotary instruments compared to their experience using manual instrumentation method.

The opinion on property of the instruments (files), the outcome of the laboratory training on ease of performance of root canal instrumentation and the challenges were assessed. Also, the overall confidence of performing either

of the methods were assessed with a 4-point Likert's scale and the more preferred method and reasons were assessed.

Data Analysis: Data were analyzed with IBM Statistical Product and Service Solution (IBM SPSS) version 25. Descriptive analysis was done to report frequencies of responses on challenges and opinion and means of time taken to perform the instrumentation. Independent sample t-test was used to compare the time taken for procedure between gender. Level of significance was set at $p \leq 0.05$.

RESULT

Twenty-one students (10 males, 11 females) participated in and completed the laboratory training program, which involved exposure to both manual and rotary techniques of biomechanical preparation of root canal system. The participants were within the age range of 23 and 30 years with mean age of 25.4 ± 1.7 years.

Table 1: Time taken in performing manual and rotary instrumentation

	No of participants	T2 (minutes)	T3 (minutes)
Male	10	32.9± 10.9	18.4±5.9
Female	11	26.7±9.2	21.6±8.2
Total	21	29.7±10.3	20.1±7.2
p-value		P=0.175	P=0.331

The average time taken (T1) for access preparation and location of the canals in the lower molar teeth by the participants was 42.1 ± 30.9 minutes. The time taken (T2) for manual instrumentation/ biomechanical preparation was 29.7 ± 10.3 minutes, while the mean time taken for rotary instrumentation (T3) was 20.1 ± 7.2 minutes. Table 1

When gender was considered, the mean time (T2) for manual instrumentation was higher in males (32.9 ± 10.9) than females (26.7 ± 9.2) but was lower for males (18.4 ± 5.9) in rotary instrumentation time (T3) when compared to females (21.6 ± 8.2). These were, however, not statistically significant (T2: $F = 0.103, t = 1.41, p = 0.175$; T3: $F = 0.874, t = -0.998, p = 0.331$) Table 1

Table 2 shows the opinions of the participants on the methods and property of the files. The majority (19, 90.5%) claimed the rotary method was faster and the majority (17, 81%) also believed this method cleaned the canals better. A higher number (14, 66.7%) of the participants believed the rotary instrumentation was very easy to perform, while 11 (52.4%) felt the rotary files were more flexible, and only 3 (14.3%) opined that it can fracture more than the stainless-steel manual files.

Of the participants, 12 (57.1%) felt they had no challenges with using rotary, while only 5 (23.8%) claimed such for

Table 2: Participants opinion on the methods of biomechanical instrumentation

Variables	Yes		No		I don't know		Total			
	N	%	N	%	N	%	N	%		
Do you think using rotary instrumentation with NiTi files was faster?	19	90.5	1	4.8	1	4.8	21	100		
Do you think you were able to clean the canal(s) better with rotary compared to using the hand-held files?	17	81	3	14.3	1	4.8	21	100		
How easy was it to use the rotary instruments for root canal cleaning and shaping?	14	66.7	7	33.3	0	0	0	0	21	100

Opinion on properties of the endodontic files

Variable	YES		NO		I don't Know		Total	
	N	%	N	%	N	%	N	%
Do you think the rotary files are more flexible than the SS files	11	52.4	9	42.8	1	4.8	21	100
Do you think rotary instrument can fracture more easily than SS files	3	14.3	18	85.7	0	0	21	100

Table 3: Challenges reported with the instrumentation

Challenges	Rotary Instrumentation		Manual Instrumentation	
	N	%	N	%
None	12	57.1	5	23.8
File breakage/file separation	2	9.5	2	9.5
Files not flexible	1	4.8	5	23.8
Files too flexible	1	4.8	2	9.5
Slow	0	0	4	19.1
Fear of breaking files and others	5	23.8	3	14.3
	21	100	21	100

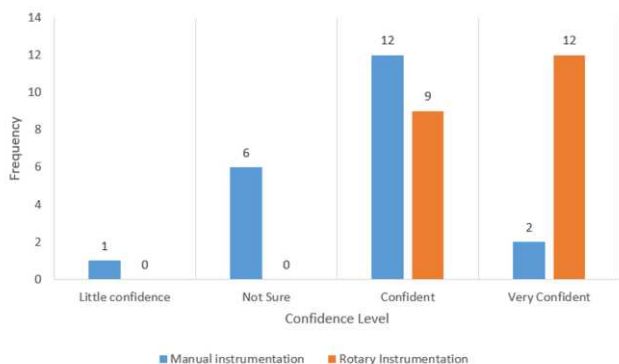


Figure 1: Comparison of participants' level of confidence in performing the manual and rotary root canal instrumentation.

manual method of instrumentation. More students (5, 23.8%) were afraid of breaking files while using the rotary when compared to only 3 that reported fear when using the manual files. Other challenges expressed are shown in table 3.

Only 2(9.5%) of the participants claimed they were very confident with manual instrumentation while 6 (28.6%) were not sure of their confidence. However, a higher proportion (12, 57.1%) claimed they were very confident with rotary instrumentation. Figure 1

Furthermore, all the participants showed a preference for rotary instrumentation while only 14 (66.7%) would consider manual instrumentation alone. Among the reasons given for the preference was the ease of carrying out the rotary instrumentation.

DISCUSSION

This study exposed the final year dental undergraduate clinical students to the two methods of biomechanical preparation of the root canal; a major aspect of root canal procedure, and also assessed their view on the comparison of the two methods; manual and rotary biomechanical instrumentation of the root canal.

The majority of the participants (52.4%) were of the opinion that the rotary files were more flexible than the stainless-steel files. This was similar to the findings of Kwak et al.,¹⁷ who studied the preferences of dental undergraduate students immediately after their first exposure to both manual and rotary instrumentation. In addition to flexibility, findings of Kwak et al.,¹⁷ also adjudged rotary files to be superior to stainless steel files in terms of ease of use, cutting efficiency, safety, and mean instrumentation time.

All the participants showed a higher preference for rotary instrumentation. This was in particular due to the ease of carrying out rotary instrumentation. This is in contrast to a study¹⁸ among Pakistani dental house officers whose majority preferred stainless steel manual instruments to rotary files, probably as a result of fear of possible instrument separation. Also another study¹⁹ carried out among final year students of a Brazilian school found that the participants were more confident with manual instrumentation, probably because they had been used to it before being exposed to rotary systems. The same study found an increase in confidence level after instrumentation of the first canal with rotary files.

The majority of the participants in the present study claimed they were very confident carrying out rotary instrumentation. This is similar to a study²⁰ in which both final year students and dental interns showed high level of confidence. Confidence levels are expected to increase as training and clinical experience progresses.^{20,21}

The mean time taken for rotary instrumentation was shorter than for manual instrumentation. This is similar to results of previous studies.²²⁻²⁴ This may be related to the fact that rotary NiTi files are more flexible with greater taper and can easily negotiate curved canals within a short time and without so much effort on the side of the operator, thereby preserving the natural anatomy of the canal. In contrast to the findings of the present study, Salles et al¹⁹ found out that canal instrumentation with rotary systems took longer time than manual instrumentation among final year dental students who had become accustomed to manual instrumentation before their first exposure to rotary systems. Though rotary instrumentation of the canal is a hybrid procedure which requires glide path with manual instrumentation first, it may still be faster than manual instrumentation.^{23,24}

The majority of the participants claimed they had no challenges using rotary instruments for canal cleaning and shaping. However, few of them encountered difficulties during the stage of biomechanical preparation. The problem encountered was majorly file separation. This is in contrast to a previous study²⁵ in which apical perforation was the most common error encountered followed by instrument separation. It is also in contrast to other previous studies^{26,27} in which ledge formation was the major difficulty encountered. The number of file separation was found to be the same for both instrumentation techniques. This is contrary to the findings of a previous study¹⁹ which found less procedural errors with the use of rotary systems. In fact, Leonardi et al²² reported that there was no procedural error reported by their study participants using

rotary system. This could however be attributed to the fact that the participants worked on incisors with single straight and wider canals.

Finally, the participants had preference for rotary instrumentation due to its ease of operation. They also found laboratory exposure on endodontic training as a step to improving learning acquisition of clinical skills, while building confidence in patient care.

STRENGTH AND LIMITATIONS

This study's strength is in the laboratory endodontic training to improve undergraduates' clinical skill acquisition. This is a method of training that is yet to be well established in our clime. However, the limitations include the low sample size, although a total enumerative sample size technique employed to include all the eligible final year students. The single centre design also limits the generalizability of the study findings. Furthermore, the reliance on the self-report by the participants is also a limitation in this study.

RECOMMENDATIONS

Early exposure to endodontics practical sessions through laboratory training should be adopted as part of the curriculum in dental schools in our environment to improve skill acquisition and confidence of students in endodontic training and practice.

CONCLUSION

This study observed that rotary root canal instrumentation was perceived as easier, faster and more preferable by the participants. However, confidence can only be gained with more exposure to the technique of instrumentation.

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