Patterns of Root Canal Instrumentation in a Nigerian Teaching Hospital: A Retrospective Cross-sectional Study

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ABSTRACT

Background: Root canal treatment (RCT) is a cornerstone of restorative dental practice, and the choice of instrumentation system may influence clinical outcomes. Despite global advances in rotary nickel-titanium (NiTi) technology, manual instrumentation persists in many resource-constrained teaching environments. This study evaluated the types of instrumentation and techniques used in RCT across different caregiver designations at a tertiary teaching hospital in Nigeria.

Methods: A retrospective cross-sectional study was conducted involving 357 RCT cases performed at University College Hospital, Ibadan, from January 2020 to December 2022. Data were extracted from standardized endodontic records using a structured form. Variables included caregiver designation (resident, house officer, consultant, student), instrumentation type (manual, rotary, combined), and technique (step-back or crown-down). The association between caregiver designation and instrumentation type was assessed using chi-square analysis, with significance set at $p \leq 0.05$.

Results: Residents performed the majority of procedures (88.2%). Manual instrumentation was used in 353 cases (98.9%), while rotary and combined techniques were each used in 2 cases (0.6%). The step-back technique predominated (97.8%). A statistically significant association was found between caregiver designation and instrumentation type ($p < 0.001$).

Conclusion: Manual instrumentation remains overwhelmingly dominant at this teaching hospital, with rotary NiTi systems confined to more experienced clinicians. Targeted strategies to integrate rotary instrumentation into undergraduate and postgraduate curricula are urgently needed.

Keywords: Root canal treatment; rotary instrumentation; nickel titanium; manual instrumentation; caregiver designation; endodontics; Nigeria

INTRODUCTION

Root canal treatment (RCT) remains a cornerstone of restorative dental practice, serving as the primary means of preserving teeth affected by pulpal and periapical disease. The effectiveness of RCT depends largely on meticulous canal debridement, shaping, and obturation—processes that have evolved substantially with the introduction of rotary nickel-titanium (NiTi) instruments and evidence-based irrigation protocols.[1,2] These innovations have revolutionized endodontic care by enhancing cleaning efficiency, reducing procedural errors, and improving treatment predictability.[3,4]

Despite these advances, manual or conventional instrumentation techniques remain prevalent in many dental institutions, particularly in low- and middle-income countries (LMICs).[5] Manual step-back techniques, long established in endodontic education, are considered reliable for developing tactile sensitivity and procedural control among trainees.[6] However, the global trend toward mechanized instrumentation reflects an ongoing shift toward efficiency, standardization, and reduced operator fatigue.[7]

Multi-country studies have demonstrated that the adoption of rotary and reciprocating systems varies significantly across geographic and institutional contexts. Piñas-Alonzo et al.[7] found that in Spain and Latin America, postgraduate trainees were far more likely to employ rotary systems than undergraduate students, indicating an experience-related gradient in technology adoption. Similarly, Raftu et al.[4] reported that while rotary instrumentation reduces procedural mishaps and working time, its uptake in dental schools is constrained by equipment costs, limited training, and inadequate curricular integration.

In many African and Asian teaching hospitals, manual instrumentation continues to dominate owing to cost barriers, limited access to NiTi files, and the perception that rotary systems require advanced clinical proficiency.[5,8] The persistence of manual approaches also underscores the pedagogical emphasis on mastering fundamental endodontic principles before progressing to mechanized systems.[1] Nevertheless, this conservative approach may inadvertently slow the adoption of contemporary, evidence-based techniques that improve treatment outcomes.

Understanding the distribution of RCT instrumentation practices across caregiver levels is essential for identifying educational gaps and informing curriculum reform. This study, therefore, aimed to evaluate the types of instrumentation and techniques used in RCT procedures across different caregiver designations in a tertiary teaching hospital in Nigeria and to examine the association between clinical experience level and instrumentation choice.

METHODS

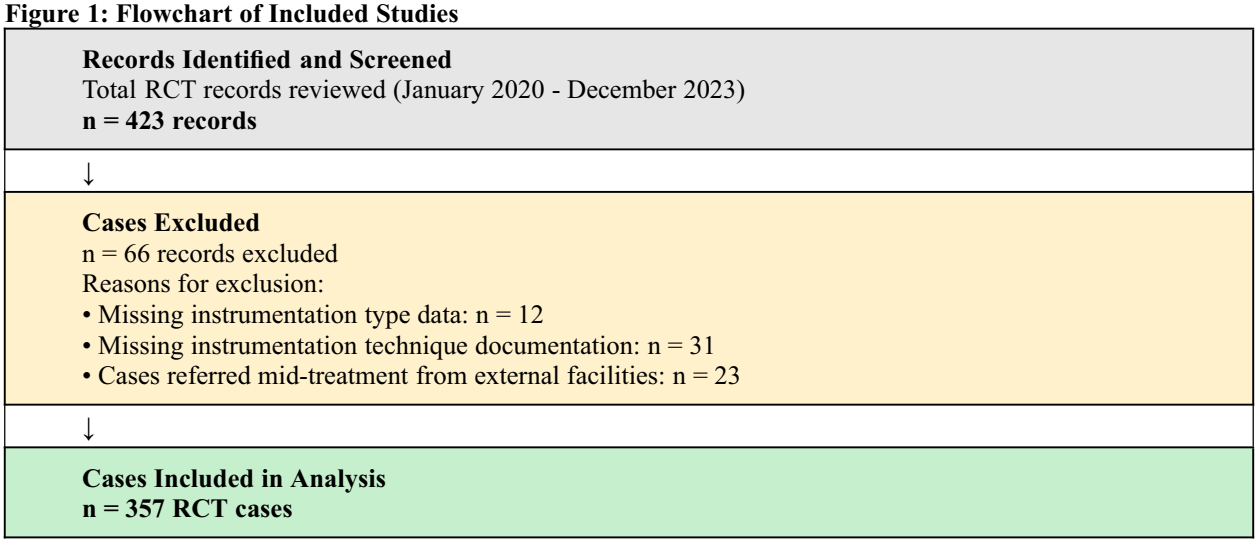
Study Design and Setting

This retrospective cross-sectional study was conducted at the Department of Restorative Dentistry, University College Hospital (UCH), Ibadan, Nigeria—a tertiary institution that serves as both a major referral center and a clinical training site for undergraduate students, house officers, residents, and consultants. The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.[9]

Study Population and Eligibility Criteria

Clinical records of all 423 patients who underwent RCT within the defined study period (January 1, 2020, to December 31, 2023) were screened. Cases were eligible for inclusion if they contained complete documentation of caregiver designation, type of instrumentation used, and instrumentation technique applied. Records were excluded if they were incomplete, lacked instrumentation details, or represented cases referred mid-treatment from external facilities. Following eligibility screening, 357 RCT cases met the inclusion criteria and were included in the final analysis using a total enumeration approach. The study participant flow is presented in Figure 1.

Figure 1: Flowchart of Included Studies



Data Collection and Reliability Assessment

Data were extracted retrospectively from standardized endodontic treatment records using a structured data collection form developed specifically for this study. Two calibrated investigators independently reviewed all records to ensure consistency and reduce extraction bias. Prior to full-scale data extraction, a pilot review of 20 randomly selected cases was conducted to standardize variable interpretation and coding. Inter-examiner reliability was assessed using Cohen's kappa coefficient, with $\kappa \geq 0.80$ considered indicative of substantial agreement.[10] Discrepancies were resolved through discussion and consensus.

Study Variables and Operational Definitions

The **primary outcome variable** was the type of root canal instrumentation used, categorized as:
(i) **manual/conventional instrumentation** – use of stainless steel hand files with conventional canal preparation techniques;
(ii) **rotary instrumentation** – engine-driven NiTi file systems; or
(iii) **combined manual and rotary instrumentation**.
The **secondary outcome variable** was the instrumentation technique, classified as step-back or crown-down.
The **independent variable** was caregiver designation, categorized as:

Residents (postgraduate dental clinical trainees, junior or senior)
House officer (newly graduated doctors undergoing a one-year compulsory internship)
Consultant (specialist endodontists)
Student (undergraduate dental students)

Sample Size Consideration
All eligible RCT cases performed during the study period were included (total enumeration), resulting in a final sample of 357 cases. This approach minimized sampling bias and ensured sufficient statistical power to detect associations between caregiver designation and instrumentation type at a 5% significance level.

Statistical Analysis
Data were entered and analyzed using IBM SPSS Statistics (Version 26; IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as frequencies and percentages for categorical variables. Associations between caregiver designation and instrumentation type were assessed using the chi-square (χ^2) test of independence; Fisher's exact test was applied where expected cell counts were fewer than five. Statistical significance was set at $p \leq 0.05$. The strength of association was evaluated using Cramér's V, interpreted as small (0.1), moderate (0.3), or large (≥ 0.5).[11]

Ethical Considerations
Ethical approval was obtained from the University of Ibadan/University College Hospital Ethics Review Committee (UI/EC/25-0541). As the study involved retrospective analysis of anonymized patient records, the requirement for individual informed consent was waived in accordance with institutional and national ethical guidelines. All data were handled in strict confidence and in compliance with the ethical principles outlined in the Declaration of Helsinki.[12]

Bias Control and Study Validity
Internal validity was enhanced through standardized data extraction procedures, pre-study investigator calibration, and independent duplicate record review. Inclusion of all eligible cases during the study period reduced selection bias. Nonetheless, given the retrospective design, findings remain dependent on the accuracy and completeness of clinical documentation, and unmeasured confounding variables cannot be entirely excluded.

RESULTS

Study Population Characteristics
A total of 357 RCT cases performed between January 2020 and December 2023 were included in the analysis. The distribution of cases by caregiver designation is presented in Table 1.

Table 1. Distribution of Root Canal Treatment Cases by Caregiver Designation (N = 357)

Caregiver Designation	Number (n)	Percentage (%)
Residents	315	88.2
Consultants	23	6.4
House officers	12	3.4
Students	7	2.0
Total	**357**	**100.0**

Instrumentation Type
Manual instrumentation was used in 353 cases (98.9%), while rotary instrumentation and combined approaches were each employed in only 2 cases (0.6%). The distribution of instrumentation types is presented in Table 2.

Table 2. Type of Root Canal Instrumentation Used (N = 357)

Instrumentation Type	Frequency (n)	Percentage (%)
Manual/conventional	353	98.9
Rotary (NiTi)	2	0.6
Manual and rotary (combined)	2	0.6
Total	**357**	**100.0**

Instrumentation Technique
The step-back technique was predominant across all groups, being employed in 349 cases (97.8%), while the crown-down technique was used in only 8 cases (2.2%). The distribution of instrumentation techniques is presented in Table 3.

Table 3. Distribution of Instrumentation Technique (N = 357)

Instrumentation Technique	Frequency (n)	Percentage (%)
Step-back	349	97.8
Crown-down	8	2.2
Total	**357**	**100.0**

Association Between Caregiver Designation and Instrumentation Type

Among residents, manual instrumentation was used in 313 cases (99.4%), with rotary instrumentation accounting for 1 case (0.3%) and combined approach in 1 case (0.3%). All cases performed by house officers (12) and students (7) utilized manual instrumentation exclusively. Among consultants, manual instrumentation was used in 21 cases (91.3%) and rotary instrumentation in 2 cases (8.7%). Fisher's exact test revealed a statistically significant association between caregiver designation and instrumentation type ($p < 0.001$). The distribution of instrumentation types by caregiver designation is presented in Table 4.

Table 4. Association Between Caregiver Designation and Instrumentation Type (N = 357)

Designation	Manual n (%)	Rotary n (%)	Combined n (%)	Total n	% of Total
Residents	313 (99.4)	1 (0.3)	1 (0.3)	315	88.2
Consultants	21 (91.3)	2 (8.7)	0 (0.0)	23	6.4
House officers	12 (100.0)	0 (0.0)	0 (0.0)	12	3.4
Students	7 (100.0)	0 (0.0)	0 (0.0)	7	2.0
Total	**353 (98.9)**	**2 (0.6)**	**2 (0.6)**	**357**	**100.0**

Fisher's exact test: $p < 0.001$, indicating a statistically significant association between caregiver designation and instrumentation type.

DISCUSSION

Findings

This study examined the distribution of root canal instrumentation techniques and their association with caregiver designation at a tertiary teaching hospital in Nigeria. The findings demonstrate an overwhelming reliance on manual instrumentation (98.9%) and the step-back technique (97.8%), with rotary NiTi systems accounting for only 1.2% of procedures when rotary-only and combined-use cases are aggregated. A statistically significant association was identified between caregiver designation and instrumentation type ($p < 0.001$; Cramér's $V = 0.20$), with rotary systems used exclusively by residents and consultants. The near-exclusive reliance on manual instrumentation observed in this study is consistent with reports from other similar settings.[5,8] Alshahrani[7] and Makanjuola et al.[5] documented similar patterns in Saudi Arabia and Nigeria, respectively, attributing the persistence of manual techniques to financial barriers, limited NiTi file availability, and concerns about file fracture among less experienced operators. In the present study, this pattern likely reflects a combination of institutional procurement constraints and a curriculum that continues to prioritize fundamental hand-instrumentation skills.

At the global level, however, this finding stands in stark contrast to prevailing practice in Western Europe and North America, where rotary and reciprocating NiTi systems have become the standard of care in both undergraduate and postgraduate training.[13,14] Peters[1] and Plotino et al.[13] demonstrated the superior flexibility, shaping ability, and efficiency of NiTi rotary systems compared with stainless steel hand files. Heat-treated alloys have further enhanced cyclic fatigue resistance and flexibility[15,16] and are now recommended as first-line systems in contemporary endodontic curricula.[17] The dominance of the step-back technique (97.8%) in this cohort reflects continued adherence to a traditional, apically directed preparation approach. Crown-down or cervical pre-flaring strategies, which are widely advocated with rotary NiTi systems to enhance coronal access, reduce apical extrusion of debris, and facilitate irrigant penetration,[13] were virtually absent from this dataset. The European Society of Endodontology (ESE) guidelines acknowledge that step-back preparation remains an acceptable method when performed under appropriate aseptic and irrigation protocols, particularly in settings where rotary systems are unavailable.[17]

However, several investigations have demonstrated that the step-back technique with stainless steel files may result in greater canal transportation, ledging, and apical zip formation compared with crown-down NiTi approaches.[13] Inadequate coronal pre-flaring also limits irrigation effectiveness and may compromise long-term treatment outcomes. These data underscore the need for progressive curricular reform to incorporate crown-down techniques alongside rotary instrumentation training in Nigeria, from undergraduate through postgraduate levels. The statistically significant association between caregiver designation and instrumentation type is consistent with evidence from comparable studies.[8,14] In the present study, the use of rotary systems was confined to residents (0.3%) and consultants (25.0%), with no uptake among house officers or students. Piñas-Alonzo[7] and Tanalp and Güngör[13] similarly found that postgraduate trainees and specialists were substantially more likely to employ rotary systems than undergraduates or junior clinicians, suggesting that access to advanced instrumentation increases with training level and clinical seniority.

Experience-related differences may also reflect concerns about file separation risk. Although modern heat-treated NiTi alloys have significantly reduced the incidence of instrument fracture,[15,16] operator experience, appropriate torque-controlled motor use, and glide-path preparation remain critical determinants of safety.[18] In institutional hierarchies, restrictions on rotary system use by junior clinicians may therefore be both deliberate and clinically prudent, although they simultaneously limit trainee exposure to contemporary techniques.

Implications

The findings of this study have significant implications for endodontic education and clinical service delivery in Nigerian teaching hospitals. The near-total absence of rotary NiTi instrumentation, particularly among undergraduate students and house officers, reflects a training gap that may perpetuate the use of less efficient techniques in clinical practice beyond the teaching hospital setting. Given the documented benefits of NiTi systems—including reduced working time, superior canal shaping, and decreased procedural errors.

Pragmatic strategies to facilitate this transition may include staged introduction of rotary systems in pre-clinical simulation laboratories, the use of single-file systems (which reduce the per-case cost of NiTi instrumentation), and the development of structured competency frameworks for rotary instrumentation at both undergraduate and postgraduate levels. Collaborative procurement models and support from professional bodies such as the Nigerian Dental Association, the National Postgraduate Medical College of Nigeria (NPMCN), and the West African College of Surgeons (WACS) could help address the cost and equipment access barriers identified in this and related studies.[6,19]

Trade-offs (Limitations)

This study has several limitations that warrant acknowledgment. First, the retrospective design means that findings are dependent on the accuracy and completeness of clinical record-keeping, which may have varied across caregiver groups. Second, data were collected from a single tertiary institution, which may limit generalizability to other Nigerian dental schools and teaching hospitals. Third, the cross-sectional nature of the study precludes causal inference regarding the relationship between caregiver designation and instrumentation type.

Take-home (Conclusion)

Manual instrumentation and the step-back technique remain overwhelmingly predominant in root canal treatment at this Nigerian tertiary teaching hospital, with rotary NiTi systems confined almost exclusively to residents and consultants. A statistically significant association between caregiver designation and instrumentation type was identified, consistent with experience-related gradients observed in comparable global studies. These findings highlight a critical educational gap and underscore the urgent need for structured integration of rotary NiTi instrumentation into both undergraduate and postgraduate endodontic curricula in Nigerian dental schools.

Expectations for Future Research

Future multicenter prospective studies with standardized data collection instruments would strengthen the evidence base in this area. Further studies exploring the reasons for non-use of rotary instrumentation in this setting are advocated.

RECOMMENDATIONS

1. **Curriculum Integration:** Dental schools in Nigeria should develop structured competency frameworks that introduce rotary instrumentation progressively across undergraduate and postgraduate curricula. Preclinical simulation laboratories should incorporate rotary techniques before clinical application, with competency assessments ensuring safe independent practice.
2. **Equipment and Access:** Institutional leaders and professional bodies such as the Nigerian Dental Association, NPMCN, and WACS should explore collaborative procurement models for NiTi files and rotary motors, leveraging bulk purchasing to reduce per-case costs. Single-file rotary systems offer reduced material costs and should be investigated as alternatives to multi-file approaches.
3. **Training and Mentorship:** Postgraduate residents and consultants who have demonstrated competency with rotary systems should be designated as clinical mentors and trainers for junior staff. Structured mentorship programs and supervised clinical experience with rotary instrumentation should be integrated into house officer and student curricula.
4. **Institutional Policy:** Teaching hospital leadership should develop clear, evidence-based clinical protocols that permit graded access to rotary instrumentation based on demonstrated competency rather than administrative designation alone. Safety protocols should address concerns regarding instrument separation through standardized glide-path preparation, appropriate motor settings, and pre-clinical simulation-based training.
5. **Evidence Dissemination:** Faculty should ensure that trainees understand the contemporary evidence supporting rotary instrumentation, including published guidelines from the European Society of Endodontology and the International Endodontic Association. Journal clubs and case-based learning sessions should feature studies comparing manual and rotary approaches.

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