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ARQUIVOS EM ODONTOLOGIA

# A micro-computed tomography assessment of root canal surface with conventional and pediatric rotary files in primary prototyped teeth

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**Aim:** This study aimed to evaluate the biomechanical preparation quality (instrumented surface i.e. percentage of canal walls touched, increase in canal volume) and instrumentation time using a rotary file developed for deciduous teeth (Sequence Baby File - SBF) and compaired to conventional manual files (K file).

**Methods:** For this in vitro study, 20 resin prototypes of mandibular deciduous molars were included in the sample, focusing on the mesial canals, totaling 40 canals. Initially, these prototypes underwent scanning via micro-computed tomography (micro-CT) and then were randomly assigned to two groups: SBF (G1) and K file (G2), with 20 canals in each group. The total instrumentation time was meticulously recorded. Following the preparation phase, a subsequent scan was conducted and the images were reconstructed and aligned with the initial scans. Utilizing the CTan® program measurements were taken concerning canal volume and the percentage of canal walls touched (surface area). Student's T-test and Mann-Whitney U test were used for statistical analysis ($p < 0.05$).

**Results:** No statistically significant differences were found in volume and surface area at the analyzed data between the two groups under study. Time was statistically significant shorter in SBF (G1) ($p < 0.05$).

**Conclusion:** The findings of this study underscore that rotary files developed for primary teeth (SBF – G1) yield comparable outcomes to K files (G2) in terms of biomechanical canal preparation, all achieved in a shorter instrumentation timeframe. These results offer an encouraging perspective for pediatric dentists considering the adoption of such system.

**Uniterms:** pediatric dentistry; pulpectomy; endodontics; x-ray microtomography.

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## INTRODUCTION

The biomechanical preparation of root canals can be carried out using manual or mechanized instruments for primary and permanent teeth[1]. Traditionally, hand files have been widely used in the endodontics of deciduous teeth. However, in recent decades, the introduction of rotary instruments in Pediatric Dentistry has gained relevance, promoted by improved instrumentation techniques and advances in file design, which aim to optimize the effectiveness of disinfection and canal shaping, while reducing clinical time and favoring more efficient care in pediatric endodontic field[2-7].

The unique anatomy of deciduous molars, characterized by thinner walls, pronounced curvatures, and internal and external topography

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that changes with the degree of root resorption, poses vulnerabilities in endodontic treatment[8,9]. These morphological challenges also complicate the use of extracted teeth for laboratory training or research samples, as their early extraction is often associated with signs of pathological resorption[10]. These anatomical difficulties highlight the need for alternatives that can accurately replicate dental structures for in vitro research. One viable alternative is the use of rapid prototyping models combined with micro-computed tomography (micro- CT), which enable the replication of complex root canal systems on a large scale, providing a homogeneous sample. These models not only support in vitro research but also enhance the efficacy of laboratory training[11,12].

In response to these complexities, the technology of micro-computed tomography (micro-CT) has been employed in in vitro studies of endodontic instruments and techniques. Micro-CT is a non-destructive tomographic technique that allows for the quantitative evaluation of changes in both the internal and external structures of teeth, providing detailed three-dimensional images. This tool has proven to be crucial, as it allows for precise visualization of the anatomical features of deciduous molars, facilitating the adaptation of endodontic instruments and the evaluation of treatment techniques' effectiveness[13-15].

Several technological advancements and instrument innovations happened in the realm of endodontics, rotary systems and nickel-titanium (NiTi) files with superior efficacy in cleaning and shaping root canals. However, it is important to recognize that these systems were originally designed for permanent teeth[16]. There is limited literature about mechanized files developed specifically for deciduous teeth. Therefore, the aim of this study was to evaluate the quality of biomechanical root canal preparation in prototyped primary teeth by analyzing the instrumented surface (percentage of canal walls touched) and the increase in canal volume, as well as the instrumentation time. The study hypothesis is that rotary instruments specifically developed for primary teeth promote a more efficient and conservative instrumentation compared to manual files.

## MATERIALS AND METHODS

The sample size calculation adopted a significance level of 5% and a power of 90% (G*Power - v3.1.9.2, University of São Paulo, Brazil), with a standard deviation of 1.13mm, according to the study of Barasuol et al.[17]. Thus, 20 prototyped teeth were employed, divided into two groups (10 tooth per group), totaling 20 root canals in each group.

Mesial canals of the mesial root from a prototyped deciduous mandibular molar (#75 - Denarte, São Paulo, SP, Brazil) was used as the unit of study.

The mesiolingual and mesiobuccal canals were instrumented in each group according to the type of file, which is detailed in the following paragraphs. In each group, the mesiobuccal canal was instrumented first, followed by the mesiolingual canal, in order to standardize the instrumentation sequence.

### *MICRO-CT SCANNING*

All resin prototypes teeth were initially scanned in a micro-CT scanner (SkyScan 1174v2, Bruker: micro-CT, Kontich, Belgium) with a resolution of 19.7µm and the X-ray tube operated at 50kV and 800mA. The scan was performed with a rotation of 360° around the vertical axis, with a 1.0º step of rotation and resolution of 10124 x 1034.

### *CANAL PREPARATION*

A single operator, previously trained and calibrated, performed all the instrumentation and irrigation procedures.

The prototypes were divided into 2 groups, access cavities were prepared in both groups using high-speed diamond burs. The working length (WL) was determined with a 2.0mm short of the apical foramen:

- G1 - rotary file developed for deciduous teeth (Sequence Baby File): The canals were prepared with the rotary files for use in deciduous teeth - Sequence Baby File – ''SBF'' (MK - life Medical and Dental Products, Porto Alegre, RS, Brazil) at continuously rotating. We used file #17.08 for opening the cervical third and files #20.04, #25.04, and #30.04 for instrumentation of the entire working length. The E-Connect S motor (MK - life Medical and Dental Products, Porto Alegre, RS, Brazil) with 1.5N/cm torque and speed of 375rpm was used. The instrumentation protocol was performed according to the study by Souza et al., 2023,
- G2 – conventional manual file (K): The root canals were instrumented with Kerr - ''K'' files (Dentsply Maillefer – Dental Products, Ballaigues,

Switzerland) using the conventional step back technique, employing a balanced force for the mechanical preparation of the root canals. We use ‘‘K” type file #10 for canal exploration and ‘‘K” type #15, #20, and #25 files for the manual instrumentation of the apical third and ‘‘K” #30 file for the manual instrumentation of the cervical third, with a 1mm setback for the cervical third.

Canal irrigation was performed with 2ml of saline solution at each file exchange.

A stopwatch counted the effective instrumentation time from the insertion of the first file in the root canal to the last used, stopping in the file changes times. After instrumentation, all samples were scanned again in micro-CT, maintaining the same parameters of the initial scan.

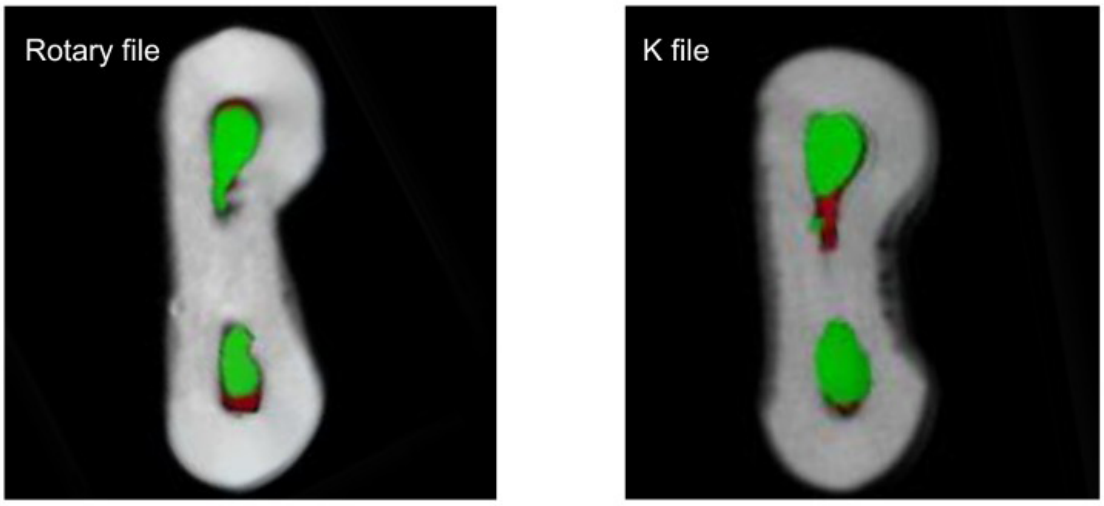
### *COMPARATIVE ANALYSIS OF POST-INSTRUMENTATION IMAGES*

Initial and final images were reconstructed three-dimensionally using NRecon® software (v1.6.9, Bruker, Kontich, Belgium), with post-alignment corrections and optimized ring- artifact corrections as necessary. Smoothing and beam-hardening adjustments were set at 10% and 60%, respectively and the 3D models of the pre- and postoperative images were co-registered with an accuracy greater than 1 voxel (DataViewer®, v1.5.1.2, Bruker, Kontich, Belgium).

Using the CTAn-v.1.14.4 software (Bruker: micro-CT), the scans were segmented to allow for the quantification of the root canal. The percentage increase in volume ($mm^3$) was calculated by subtracting the initial volume from the volume after instrumentation ($mm^3$). Pre- and post-instrumentation images were overlaid, and the values were subtracted. The calculation for the percentage of touched walls was performed by comparing the number of static voxels with the total number of surface voxels Arias et al.[18].

The 3D models were overlaid in the CTvol software (Bruker, Kontich, Belgium), and a color scheme was established: red for the initial root canal volume and green for the post-instrumentation volume, as demonstrated in Figure 1.

**Figure 1.** Superimposition of the images before (red color) and after (green color) instrumentation of the canals, indicating the measurement areas (volume and surface area).




### *STATISTICAL ANALYSIS*

Statistical analyses were conducted using SigmaPlot® 12.0 (Systat Software, 2011) and Jamovi® 2.3.28 software. Data with a normal distribution were analyzed using Student’s T-test, while data without a normal distribution were analyzed using the Mann-Whitney test.

## RESULTS

The increase in root canal volume did not show statistically significant differences ($p = 0.352$) between the two groups, with a smaller volume increase in the Sequence Baby File group (G1) compared to the conventional manual files (G2 - K group), showing a lower median in the Sequence Baby File group than in the K group as demonstrated in Table 1.

**Table 1.** Median and interquartile range of percentage volume increase (mm³). (n = 40)

| Group | Median | 1º Q | 3º Q |
|---|---|---|---|
| G1 | 11.0 | 3.71 | 20.8 |
| G2 | 14.6 | 9.24 | 25.3 |

G1 - rotary file developed for deciduous teeth (Sequence Baby File - SBF) G2 conventional manual hand files (K files)
Mann-Whitney test (p = 0,352).

Observing Table 2, we can note that the increase in percentage of touched dentin walls also did not present a statistically significant difference between the groups (p = 0.412). However, it is noteworthy that the rotary file developed for deciduous teeth (Sequence Baby File group – G1) exhibited a higher mean resin wear compared to the conventional manual file group (G2).

**Table 2.** Mean percentage of surface area (mm²). (n = 40)

| Group | Mean ± SD |
|---|---|
| G1 | 15.9 ± 9.96 |
| G2 | 12.6 ± 13.6 |

G1 - rotary file developed for deciduous teeth (Sequence Baby File - SBF) G2 – conventional manual hand files (K files)
T Student test (p = 0,412).

Table 3 presents the median effective instrumentation time (in seconds) between the groups, indicating that Sequence Baby File group (G1) was significantly faster (p < 0.05), with a shorter average time and less variability when compared to conventional manual file group (G2).

**Table 3.** Median and interquatile range of effective time in seconds. (n = 40)

| Group | Median | 1º Q | 3º Q |
|---|---|---|---|
| G1 | 19,6 [A] | 16.8 | 24.3 |
| G2 | 111 [B] | 78.9 | 136 |

G1 - rotary file developed for deciduous teeth (Sequence Baby File - SBF) G2 – conventional manual hand files (K files)
Mann-Whitney test (p < 0.05). Different uppercase letters superscripted in the same column indicate statistically significant differences between groups.

## DISCUSSION

The present study aimed to assess the quality of root canal instrumentation by analyzing the percentage of canal walls touched and the increase in canal volume - parameters that together provide a measure of the efficiency and conservativeness of the technique used. The increase in volume reflects the instrument's ability to shape the canal but should be interpreted in association with the percentage of canal walls touched to avoid conclusions based solely on tissue removal[18]. These comparisons were made using micro-computed tomography (micro-CT) analysis. This methodology allows for a three-dimensional evaluation of the standardized root canal anatomy, enabling both qualitative and quantitative assessment of the data without bias in the result analysis[11].

The increase in canal volume after instrumentation is considered in this study as a complementary parameter to assess the quality of canal preparation, as it reflects the extent of dentin removal and the instrument's ability to modify the internal anatomy. However, an excessive increase may indicate unnecessary wear, whereas a balanced modification - associated with a higher percentage of touched canal walls - suggests efficient and safe instrumentation[18,19].

The greater taper of rotary instruments (0.04) compared to conventional manual files (0.03) contributed to a higher percentage of touched dentin walls, resulting in balanced wear of the root canal walls post-instrumentation[19]. Consequently, correlating the higher percentage of touched walls and the lower percentage of volume increase in Group 1, which used mechanized files, the results indicate that nickel - titanium instruments preserve the original anatomy of the root canals agreeing with the study of Esentürk et al.[20] This finding is consistent with the present study, where mechanized files increased the number of touched walls while also preserving root canal volume, preventing excessive wear and avoiding iatrogenic issues such as tears and perforations[21].

The demand for technologies that make procedures faster, simpler, and more eficient thereby reducing treatment time and the number of appointments in pediatric dentistry has increased in recent years. As a result, effective working time has become a significant concern in this specialty. In clinical practice, pulpectomy should be an uncomplicated and brief procedure[21]. In this study, the comparison of effective instrumentation time between manual and rotary systems showed statistically significant differences, with the rotary system demonstrating shorter instrumentation times. This leads to more efficient pediatric care, corroborating the findings of Bonchoo et al [22] and Kalita et al [23].

This study presents some limitations that should be considered when interpreting the results. Being an in vitro study, it does not fully replicate the clinical conditions found in pediatric endodontics, such as the presence of pulp tissue remnants, moisture, patient- related variables, and anatomical variations of natural teeth[10,11,19]. These factors may influence the instrumentation behavior and cutting efficiency of the files. Therefore, further clinical studies are necessary to validate these findings under real clinical conditions.

Thus, the present study indicates that Sequence Baby File instruments could be a viable alternative for pulpectomy in primary teeth, as they demonstrated more conservative preparation compared to conventional files and required less working time, benefiting pediatric care. However, randomized clinical studies are still necessary for better understanding and applicability.

## CONCLUSION

Rotary instruments developed for primary teeth showed similar biomechanical performance comparable to manual files in terms of canal volume increase and percentage of canal walls touched. However, instrumentation time was significantly shorter with the rotary system, indicating a greater advanced operational efficiency in Pediatric Dentistry. These findings suggest that rotary instrumentation may be a promising alternative in pediatric endodontics, particularly in clinical scenarios where reduced treatment time is critical. Nevertheless, due to the limitations of the in vitro model, further clinical studies are essential to confirm the applicability of these results in real - world settings.

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## AUTHORS' CONTRIBUTIONS

- **Conceptualization**: Mariana Cristina Manoel, Bianca Katsumata de Souza, Isabela do Carmo Custodio, Letycia Accioly Simões Coelho *All authors contributed to the study conception and design by collaboratively developing the main idea and objectives of the research.*
- **Methodology**: Mariana Cristina Manoel, Bianca Katsumata de Souza, Isabela do Carmo Custodio, Letycia Accioly Simões Coelho *Material preparation, data collection, and analysis were carried out by these authors, ensuring the implementation of the research methods and approaches.*
- **Data Curation**: Mariana Cristina Manoel, Bianca Katsumata de Souza, Isabela do Carmo Custodio, Letycia Accioly Simões Coelho *These authors were responsible for organizing, maintaining, and ensuring the accuracy of the research data used in the study.*
- **Writing – Original Draft**: Isabela do Carmo Custodio
  *The first draft of the manuscript was written by Isabela, who developed the initial narrative and structure of the study's findings and discussion.*

- **Writing – Review & Editing**: Mariana Cristina Manoel, Bianca Katsumata de Souza, Isabela do Carmo Custodio, Letycia Accioly Simões Coelho
  *All authors reviewed and commented on earlier versions of the manuscript, providing critical feedback, edits, and suggestions for improvement to refine the final document.*
- **Supervision**: Mariana Cristina Manoel, Bianca Katsumata de Souza, Isabela do Carmo Custodio, Letycia Accioly Simões Coelho, Natalino Lourenço Neto, Marco Antônio Hungaro Duarte
  *All authors oversaw the progression of the research and approved the final version of the manuscript, ensuring its quality and coherence with the study's goals.*

## CONFLICT OF INTEREST

The authors have no competing interests to declare that are relevant to the content of this article.

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