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Original Research Article

Comparative analysis of the effectiveness of instrumentation with manual stainless steel and NiTi files in the endodontic treatment

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Abstract

Objective: The aim of this study was to assess the effectiveness in instrumentation and the main differences between the manual systems K and M. **Material and methods:** Forty Type IV Vertucci standardized lower molars, considering the degree of curvature, were divided into 2 groups (n=10): M Files and K-File Files. After biomechanical preparation, the teeth were filled using the Tagger Hybrid technique. Digital radiographs were taken in the buccolingual and mesiodistal directions, and the quality of the filling was determined by three calibrated and blinded evaluators using a 4-point scoring system. The instrument fracture index was also recorded. The obtained data were subjected to Mann-Whitney tests ($p<0.05$). **Results:** In the analysis conducted by experienced professionals, a higher radiographic quality of obturation was observed in the M file group compared to the K-file group ($p<0.05$). Regarding the perception of undergraduate students regarding the difficulty of procedures, a greater difficulty was observed in preparing molars with K-Files compared to M Files ($p<0.05$). A higher percentage of fractured K-Files was observed compared to M Files. **Conclusion:** M Files provided less difficulty in preparing molars for undergraduate students, had a lower incidence of fracture, and favored better radiographic quality of obturation.

Introduction

Endodontics is the scientific discipline aimed at studying the morphology of the root canal system and the pulp tissue as a whole, from physiology to pathologies, including prevention, treatment, and healing of periapical tissues [30].

Endodontic treatment is conducted with the objective of restoring teeth with pulpal involvement and involves a series of processes, from access to the obturation of root canals [28]. The chemical-mechanical preparation is one of the most critical stages of this treatment, involving the removal of pulp tissue, cleaning, shaping, and decontamination through the mechanical action of endodontic instruments along the canal walls and the chemical action of irrigating agents [11]. Therefore, the use of instruments that effectively remove organic and inorganic deposits from the canal interior is necessary [9, 14, 26].

During undergraduate studies, the preference for manual instrument systems has been attributed to their lower cost and the absence of the need for investment in endodontic motors for their use [4, 19, 20, 27, 34]. Among these manual systems, K-type endodontic files (Kendo, Munich, Germany), made from a stainless steel alloy without any thermal treatment, have been the first choice [4]. However, these files exhibit greater rigidity, posing challenges in adapting to curved canals, often resulting in deviations and step development during instrumentation [24].

Conversely, the development of heat-treated nickel-titanium (NiTi) files in endodontics has significantly increased the success rate of endodontic treatment [29]. These instruments demonstrate improved mechanical behavior, flexibility, and resistance to cyclic fatigue compared to conventional NiTi instruments, enabling centralized preparation in curved canals [6, 12, 23].

Among the various heat treatment options, the controlled memory (CM) wire, introduced in 2010, represents the first thermomechanically treated NiTi endodontic alloy without superelastic properties at room and body temperature [18]. This feature allows the instrument to be safely used in the treatment of teeth with more complex morphologies [35].

Within the CM heat-treated NiTi systems, M files (Easy Equipamentos Odontológicos, Belo Horizonte, MG, Brazil) stand out. This manual instrument system was developed to cater to general practitioners and dental students without rotary motors, aiming to address complex cases and reduce errors in preparation when performed by less experienced professionals.

In light of these considerations, the execution of the present research became pertinent and necessary. The objective of this study was to compare the modeling effect of K-File and M files on obturation results, evaluating the presence of spaces in the obturation material. The null hypothesis is that there is no difference between the two evaluated file systems.

Material and methods

Sample size calculation

For sample size calculation, the G*Power v3.1 software for Mac (Heinrich Heine, Universität Düsseldorf, Dusseldorf, Germany) was employed, and the Wilcoxon-Mann Whitney test from the T-test family was selected. An alpha error of 0.05, a beta power of 0.80, and an N2/N1 ratio of 1 were set. A total of 10 specimens per group were indicated as necessary to detect statistical differences.

Specimen selection

Prior to its execution, this study was reviewed and approved by the Ethics Committee for Research on Human Subjects (No. 58779122.0.0000.5159). Radiographs were taken in the mesio-distal and vestibulo-lingual directions (Fona CDR Elite, DMM Brasil, Bandeirantes, PR, Brazil) for the initial sample selection. Forty intact human mandibular molars with Type IV mesial canals according to Vertucci [32], standardized for length and curvature degree (20-35º) determined by the Schneider method [26], were chosen.

Determination of working length

Access to the pulp chamber was achieved using diamond burs at high speed under cooling. Canal exploration was performed with a K-file #10 (Dentsply Maillefer, Baillnages, Switzerland) for initial recognition of its internal anatomy. After this initial recognition, the working length was determined under x30 magnification with a stereomicroscope (Carl Zeiss Vision GmbH, Hallbergmoos, Germany). A K-file #10 (Dentsply Maillefer) with a rubber stop was inserted into the

canal until its tip was visible at the apical foramen. At this point, the rubber stop was positioned at the incisal edge of the tooth, the instrument was removed from the canal, and the measurement between the instrument tip and the stop was recorded. This measurement was considered the total length of the tooth, and the working length (WL) was determined by subtracting 1mm from this measurement. The apical foramen was sealed externally with utility wax to prevent leakage during irrigation or canal obturation.

Group distribution

For group distribution, teeth were paired based on the degree of curvature, as determined by radiographs, after performing statistical analysis and confirming homogeneity between the groups (Shapiro-Wilk; $p > 0.05$). The 40 teeth were divided into 2 groups (n=20) and instrumented according to the following protocol:

M File (Bassi Endo, Belo Horizonte, MG, Brazil): The selected instruments had a taper of 0.03. Rotary movement with continuous rotation in a 360º clockwise direction with gentle apical pressure was applied for instrumentation until the instrument with a diameter of 35 was reached. Subsequently, the teeth were irrigated with 5 ml of 2.5% Sodium Hypochlorite (Asfer, São Caetano do Sul, SP, Brazil), 3 ml of 17% EDTA (Biodinâmica, Ibiporã, PR, Brazil), and 2.5% Sodium Hypochlorite, with solutions agitated using Easy Clean (Bassi Endo), activated by continuous rotation for 30 seconds. This process was repeated 3 times.

K File (Dentsply Maillefer): Using the Crown-Down technique, the cervical and middle thirds were prepared with Gattes-Glidden drills #1, #2, and #3 (Dentsply Maillefer). In the apical third, the procedure was performed with K-files, with the K35 file as the memory instrument, following a progressive scaling. Finally, the teeth were irrigated with 5 ml of 2.5% Sodium Hypochlorite (Asfer), 3 ml of 17% EDTA (Biodinâmica), and 2.5% Sodium Hypochlorite using a disposable 5 ml syringe (Ultradent Products Inc., South Jordan, UT, USA) and a 30-gauge needle (MK Life, Porto Alegre, Rio Grande do Sul, Brazil). This process was repeated 3 times.

For the biomechanical preparation of the teeth, the root canal was filled with 5 ml of 2.5% NaOCl, and instrumentation was performed with the corresponding system for each group. After each instrument reached the working length (WL), it was removed from the canal and cleaned with sterile gauze. Patency was maintained with a K-file #10 (Dentsply Maillefer), and the canal was irrigated with 5 ml of 2.5% NaOCl using a disposable 5 ml syringe (Ultradent Products Inc.) and a 30-gauge needle (MK Life). A total of 70 ml of irrigating solution was used in each root canal. The number of fractured files during instrumentation was recorded.

The preparation of all root canals was performed by five undergraduate students who had never conducted endodontic treatment on molars before.

Obturation of specimens

The specimens were obturated using the Tagger Hybrid Technique, adapting the main cone with a diameter of 35 and taper of 0.02 to the root canal, along with FF accessory cones, followed by condensation of Gutta-Percha (MK Life) with McSpadden #50 (MK Life). The obturation cement used was AHplus (Dentsply Maillefer).

Assignment of scores for evaluation

After obturation, digital radiographs based on the Clark Technique were taken, and the obturation quality was analyzed by three experienced and calibrated professionals. To assign scores, they assessed whether the necessary radiographic characteristics of endodontic treatment were achieved. A scale from 1 to 5 was used, where 1 corresponds to unsatisfactory obturations and 5 to satisfactory obturations (figure 1).

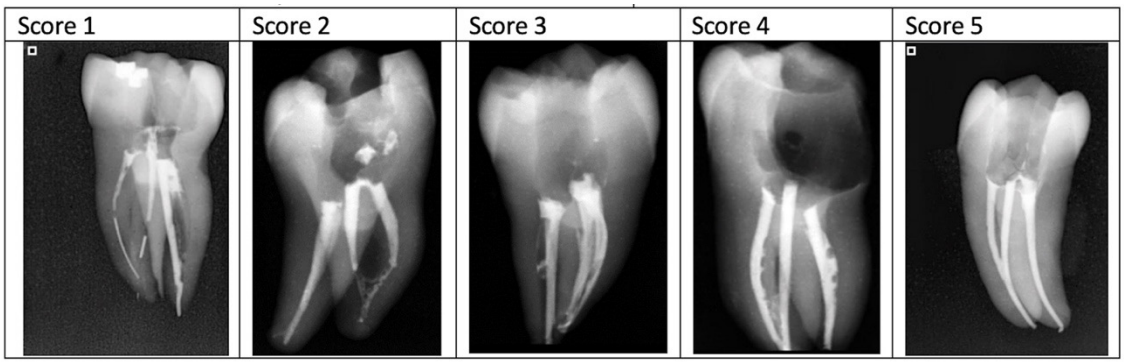

Figure 1 – Representative radiography photos of obturation quality scores: 1) unsatisfactory obturation; 2) more than 60% voids in the obturation material; 3) 30-60% voids in the obturation material; 4) less than 30% voids in the obturation material; 5) satisfactory obturation

Additionally, the students responsible for the experiments also assigned scores from 1 to 5 based on the level of difficulty in working with each of the manual systems. They judged their perceptions as students according to the procedure required by each file.

Statistical analysis

The reliability of three experienced professionals in classifying the radiographic quality of obturation ranged from good to excellent (Kappa coefficients ranged from 0.59 to 0.82). Descriptive analysis was conducted to compare the percentage of fractured files during instrumentation between groups. The Mann-Whitney test was employed to compare scores given by experienced professionals for radiographic obturation quality and scores assigned by students regarding the level of difficulty of procedures between the K File and M File groups (α=5%) (GraphPad Prism, San Diego, United States).

Results

The median and quartiles of scores assigned by the three experienced professionals regarding the radiographic quality of obturation and scores assigned by students regarding the difficulty of procedures can be visualized in table I.

Table I – Median, first and third quartile of scores assigned to the quality of work and difficulty of the procedure

Evaluated parameters	K File			M File		
	25%	Median	75%	25%	Median	75%
Radiographic quality of obturation	1	2[a]	2	3	4[b]	5
Difficulty of the procedure	5	5[a]	5	1	2[b]	2

Different letters indicate statistically significant differences between groups for the same evaluated parameter (Mann-Whitney test; $p<0.05$)

The percentage of fractured files during the instrumentation of mandibular molars by undergraduate students is presented in table II.

Table II – Percentage of fractured files during the instrumentation of mandibular molars by undergraduate students

Evaluated parameters	K File	M File
Percentage of fractured files	60%	15%

In figure 2, initial and post-instrumentation, irrigation, and obturation digital radiographs of simulated canals with K Files and M Files can be observed.

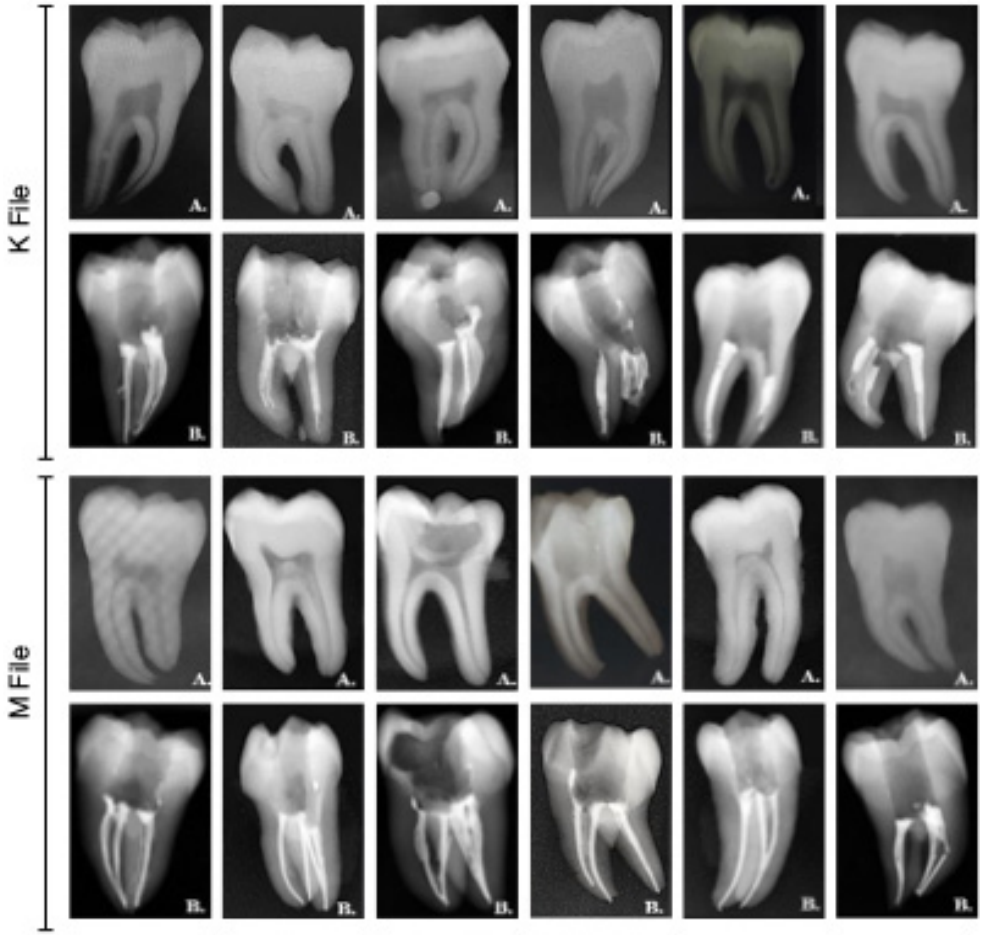

Figure 2 – Representative initial radiography photos (A) and after obturation (B) of the K File and M File groups

Discussion

This study aimed to assess the radiographic quality of obturation in lower molar canals according to three experienced professionals using K Files and M Files, as well as the perception of instrument difficulty by undergraduate students and the percentage of file fractures. Based on the results, the null hypothesis can be rejected as there was a statistically significant difference between the K File and M File groups in the analysis of obturation quality and procedure difficulty.

K Files, made from stainless steel, exhibited low flexibility, resulting in high rates of file fractures during root canal instrumentation [27]. Handling and instrumentation become more challenging due to the various steps and protocols required for endodontic treatment with this type of metal alloy [1].

In this study, the fracture rates of K Files were 60%, compared to 15% for M Files, made from NiTi. Figure 2 shows initial radiographs and post-chemical-mechanical preparation and obturation of lower molars. The higher fracture rate in the apical third of K Files may be associated with more pronounced curvatures and alterations in the original path of the root canal [18]. This result could be attributed to lower flexibility, square-shaped cross-sections, and activation with variable torques in K Files, requiring significant skill from the professional [7].

Stainless steel instruments were predominantly used for endodontic instrumentation for many years [13]. However, with advances and investments in new technologies, they started to be replaced by NiTi instruments [5] due to better physical behavior and lower chances of fracture [15].

A scoring system from 1 to 5 was used to classify the radiographic quality of obturations by three experienced professionals, following an adequate calibration process [16]. The obtained Kappa values, ranging from 0.59 to 0.8, indicate agreement among examiners, crucial for the reliability of results [17].

The results of this study indicate that instrumentation with M Files resulted in better

quality of root canal obturation ($p<0.05$). NiTi files, due to the thermal treatment they undergo, increase their flexibility and memory during operation [2]. This memory feature allows the file to follow the curved canal without structural changes, contributing to better file and procedural performance [8, 21]. These findings reinforce the conclusion of this study that better modeling of the root canal leads to improved radiographic obturation quality.

One of its main advantages is the thermal treatment it undergoes, providing greater memory control, always returning to its initial position without distortion, avoiding perforations or deviation from the canals [31]. The M file has a cross-sectional design with CM (Control Memory) thermal treatment, ensuring greater memory control, always returning to its initial position without distortion, thereby preventing perforations or canal deviation. This results in extremely centered and controlled preparations [22].

Efficient root canal instrumentation should create defined apical stops, smooth canal walls, and good flow and taper after preparation [25], and it should be performed safely and effectively by any operator [10, 14]. In the present study, the perception of dental students indicates greater technical ease with M files ($p<0.05$), which is consistent with other studies [33].

The results of this study reveal that NiTi M files should be considered for use in undergraduate clinics, as they prove to be a safe option that allows for easier preparation with a lower chance of errors.

This study has limitations due to its laboratory nature and the restriction to only one anatomical type of root canal. However, given the lack of randomized clinical studies, in vitro laboratory research gains relevance. Therefore, caution and discernment are crucial when applying the results of this study in a clinical context.

Conclusion

Based on the methodology of this study and the results obtained, it can be concluded that M files, due to their greater flexibility, facilitate cleaning and shaping in canals with more complex anatomies for less experienced professionals, resulting in better radiographic obturation quality and lower instrument fracture rates.

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