EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 70, 945:950, January, 2024

Print ISSN 0070-9484 • Online ISSN 2090-2360

Conservative Dentistry and Endodontics

Submit Date : 20-11-2023 • Accept Date : 04-12-2023 • Available online: 10-01-2024 • DOI : 10.21608/EDJ.2023.249967.2789

THE EFFECT OF CONSERVATIVE VERSUS TRADITIONAL ACCESS CAVITY ON MICROHARDNESS OF NICKEL TITANIUM ROTARY FILES

Anas Ali *, Mohamed Fakhr** *and* Nihal Sabet***

ABSTRACT

Introduction: To minimize the loss of tooth structure, the conservative access cavity (CAC) preparation was suggested where preserving the peri-cervical dentin (PCD) would achieve this goal. The aim of the current study was to assess the impact of the conservative access cavity on the microhardness of controlled memory nickel titanium rotary files in comparison to the traditional access cavity (TAC).

Materials and Methods: Twenty- eight files sets of Elephant files (ElephantDent, China) and twenty- eight sets of EdgeFile X7 (EdgeEndo, USA) have been used to prepare the mesial canals of 144 mandibular first molars. Four sets from each type were used as control and 12 sets were grouped according to the access cavity type into CAC and TAC then subgrouped equally according to the number of prepared canals into 3, 6 and 9 subgroups. The molars were randomly allocated into two treatment groups (n=72) TAC and CAC groups. The Elephant and Edge 30/0.04 rotary files were subject to Vickers hardness test to assess the microhardness changes in the files.

Results: The effect of the access cavity designs on the microhardness in the Edge and Elephant files were non-significant in all the groups ($p>0.05$). The microhardness changes were non-significant after preparation of the three, six and nine canals in both the TAC and CAC groups. Elephant files presented a higher significant microhardness value in all groups.

Conclusions: The access cavity designs and the number of prepared canals had no significant effect on the microhardness of the rotary nickel titanium files.

KEYWORDS: Conservative Access Cavity, Vickers hardness test, microhardness, Controlled memory Files

* Post Graduate Researcher, Endodontics Department, Faculty of Oral and Dental Medicine, Misr International University, Cairo, Egypt
** Associate Professor of Endodontics, Faculty of Oral and Dental Medicine, Misr International University
*** Professor of Endodontics, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt

INTRODUCTION

The initial step in creating an effective access cavity involves removing the pulp chamber roof and widening of the cavity for straight-line access to all canals. This design is known as the traditional access cavity (TAC). TAC offers various advantages including reducing mishaps like canal ledges and zips, facilitating canal negotiation with rotary instruments, decreasing stresses on instruments and lowering the risk of files fractures [1,2]. Tooth fracture is a significant concern after endodontic treatment, which is primarily caused by extensive tooth structure loss from traditional access cavities [3]. To minimize the risk of post-treatment tooth fractures, Clark and Khademi introduced the concept of a conservative access cavity (CAC), focused on preserving pericervical dentin (PCD) [4]. Some studies suggested that the conservative access increases tooth fracture resistance [5-7], while others reported no significant difference between the CAC and the TAC [8-10]. In the realm of endodontics, the hardness of rotary files holds significant clinical implications as it directly affects their cutting efficiency and wear resistance during root canal preparation [11]. Controlled memory (CM) nickel titanium rotary files have very high fracture resistance because they mainly exist in the martensite phase, which makes them highly resistant to cyclic fatigue and have a high surface hardness due to the special thermomechanical surface treatment [12]. The aim of this study was to evaluate the effect of the conservative access cavity on the microhardness of controlled memory Nickel titanium rotary files in comparison to the traditional access cavity. Evaluating that aspect can give a risk assessment regarding files fracture during root canal preparation. The proposed hypothesis in the current study was that the files that were used in the CAC will exhibit greater deterioration in microhardness compared to the TAC.

MATERIALS AND METHODS

Grouping:

Twenty-eight Elephant files sets and twenty-eight Edge files sets were divided each into three groups according to the type of the access cavity: groups A and B comprise 4 Elephant and Edge files sets that were used as control groups, groups C and D comprise 12 Elephant and Edge files sets that were used to prepare conservatively accessed teeth and groups E and F comprise 12 Elephant and Edge files sets that were used to prepare traditionally accessed teeth. Each group was further subdivided into three subgroups based on the number of canals prepared. Four file sets were used to prepare 3 root canals, another 4 file sets for 6 root canals, and the remaining 4 sets for 9 root canals

Teeth collection:

For this study, 144 extracted mandibular first molars with 20-40° mesial root curvatures, according to Schneider's technique (13) were obtained from the Misr International University tooth bank and received approval from the Research Ethical Committee of the Faculty of Dentistry, Misr International University (MIU-IRB-00010118). The selected teeth were numbered from 1-144 and randomly allocated by a randomization list generated by www.random.org [14] so 72 teeth were accessed by traditional access cavity and 72 were accessed by the conservative access cavity. The mesial canals of all the mandibular molars were used for root canals preparation in the present study.

Conservative access cavity preparation:

A tungsten carbide bur has been used to penetrate the roof of the pulp chamber through the central fossa. The cavity was extended as minimally as possible in order to detect the canals orifices and preserve the pericervical dentin and part of the pulp chamber roof [15].

Traditional access cavity preparation:

A tungsten carbide bur has been used to penetrate the roof of the pulp chamber through the central fossa. Endo Z bur was used for complete deroofing of the pulp chamber. A probe was used to make sure that there is no dentine lips or edges present. After detection of the canals orifices the access cavity has been refined to ensure a straight-line access to manual K files and rotary files (1).

Root canals preparation:

Mesial canals have been scouted and negotiated by K-file #15/.02 (Mani, Tokyo, Japan). Working length (WL) has been determined by subtracting 1mm from the length at which the file was visible at the apex. Elephant and EdgeEndo X7 files have been operated using the endodontic rotary motor X-Smart PLUS (Dentsply Sirona, USA) to prepare the mesial canals according to the manufacturer instructions. Elephant 20/.07 served as the orifice opener to prepare the canals up to 2/3 of the WL, Elephant 20/.04, Elephant 25/.04 and finally Elephant 30/.04 to the full WL. EdgeFile SX served as the orifice opener to prepare the canals up to 2/3 of the WL, EdgeFile X7 20/.04, EdgeFile X7 25/.04 and finally EdgeFile X7 30/.04 to the full WL. Patency between each rotary file has been re-established by K-file #15/0.2 and 3ml 5.25% sodium hypochlorite was used as an irrigant between files with a 3ml side-vented needle plastic syringe.

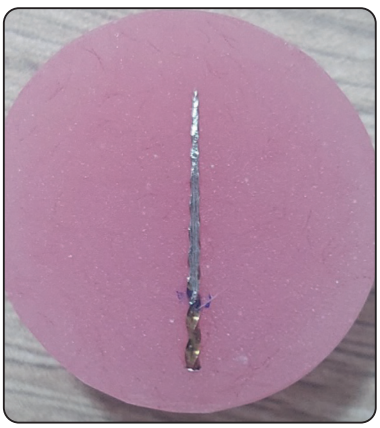

Fig. (1) The sample embedded in acrylic metallographic resin

Evaluation of the files surface microhardness by the Vickers Hardness Test (VHS):

In an attempt to evaluate the same area of each file on multiple examinations, the flat side of each instrument handle was selected as a mark for standardization. The last 12mm part of Elephant 30/.04 and EdgeFile X7 30/.04 files were dissected perpendicular to the long axis with a water-cooled low speed diamond saw. Following this, samples were embedded in acrylic metallographic resin, and were ground parallel to the long axis of the instrument at half radius using sandpapers with granulation sequence 600, 800 and 1200 (Fig 1). Finally, the samples were polished using 0.05 um alumina paste.

Vickers hardness test principles were adopted from Alapati [16]. The area of evaluation was divided into three equal thirds so each third is 4mm. To evaluate the microhardness of each third, three marks have been created in the center of each section, positioned at distances of 2mm, 6mm, and 10mm from the tip of the file. The test involves pressing a pyramid shape diamond indenter into the file's surface under a controlled 300 g load for 10 seconds (Wilson Tukon 1102 microhardness tester, Buehler, USA). After the load is removed, the indentations were observed with a magnifying lens and the two diagonals of the indentations were measured, to the nearest 0.1-µm with a micrometer, and their average is calculated (Fig. 2). The Vickers

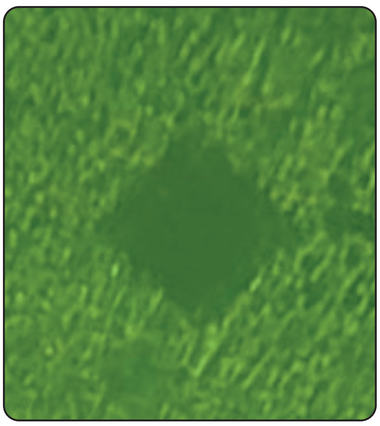

Fig. (2) Vickers hardness test indentation on a sectioned Elephant file under 500x magnification hardness (HV) is calculated using the following formula: HV = 1854.4*L/d2. Where the load L is in gram-force (gf) and the average diagonal d is in µm.

Statistical Analysis:

Numerical data were presented as mean and standard deviation (SD) values. They were explored for normality by checking the data distribution, and using Shapiro-Wilk test. Parametric data (micro-hardness) were analyzed using one-way ANOVA followed by Tukey's post hoc test. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

RESULTS

1- Effect of access cavity design:

Intergroup comparisons, mean and standard deviation values of Vickers hardness test for different access cavity designs were presented in table (1). The CAC groups showed non-significant increase in the microhardness compared to the TAC groups (p>0.05).

2- Effect of number of prepared canals:

The CAC groups showed non-significant increase in the microhardness compared to the TAC groups (p>0.05).

3- Effect of number of prepared canals:

Elephant files showed significant higher microhardness compared to Edge files (p<0.05).

TABLE (1) Intergroup comparisons, mean and standard deviation values of micro-hardness for different number of canals

Distances from the tip	File	Access cavity design	Micro-hardness (mean±SD)				p-value
			New file	3 canals	6 canals	9 canals	
2 mm	Elephant files	Traditional	423.02±1.82	423.58±1.61	423.65±1.50	424.08±1.19	0.375ns
		Conservative	423.02±1.82	423.60±0.87	423.79±1.73	424.59±1.07	0.478ns
	Edge files	Traditional	332.16 ± 1.35	332.34±1.31	333.15±1.21	333.32±1.24	0.258ns
		Conservative	332.16 ± 1.35	332.88±1.33	333.15±1.21	333.89±1.18	0.266ns
6 mm	Elephant files	Traditional	447.72±0.86	447.87±1.17	448.5 ±0.39	448.8 ±0.54	0.314ns
		Conservative	447.72±0.86	448.11±0.73	448.84±0.83	449.24±0.77	0.585ns
	Edge files	Traditional	342.88±0.51	343.30±0.61	344.08±1.19	344.42±0.73	0.214ns
		Conservative	342.88±0.51	344.05±0.94	344.13±1.02	344.45±1.14	0.746ns
10 mm	Elephant files	Traditional	462.47 ± 1.01	463.05±1.07	463.27±1.21	464.03±1.03	0.326ns
		Conservative	462.47 ± 1.01	463.09±1.13	463.6 ±1.18	464.15±1.85	0.742ns
	Edge files	Traditional	351.43±1.09	352.08±1.00	353.41±0.78	354.31±0.78	0.457ns
		Conservative	351.43±1.09	352.85±0.91	353.84±0.77	354.71±0.77	0.627ns

; significant (p ≤ 0.05) ns; non-significant (p>0.05)

DISCUSSION

The conventional method known as the traditional access cavity (TAC) entails the complete removal of the pulp chamber roof. This approach aims to establish a direct and unobstructed path to access all canal orifices (1). The major drawback of TAC is extensive loss of tooth structure which might lead to tooth fracture (3). Recently, the concept of minimal invasive dentistry and the conservative access cavity (CAC) has gained prominence. This approach focuses on preserving the structural integrity of the teeth by retaining a portion of the peri-cervical dentin (PCD) (4). Some Authors claimed that the CAC will increase the fracture resistance of the endodontic treated teeth[5-7]. Controlled memory files were selected for this study. Controlled memory was the alloy of choice because it exhibits high hardness and high cyclic fatigue resistance derived from their unique nano-crystalline martensitic microstructure and special thermomechanical treatments [12]. Edge files were chosen for their global popularity [16] and Elephant files as a representative of Chinese rotary files that gained popularity in the local market as a cost-effective alternative to the American and European brands.

In the realm of endodontics, the hardness of rotary files holds significant clinical implications as it directly affects their cutting efficiency and wear resistance during root canal preparation [11]. The Vickers hardness test is a widely recognized and scientifically validated method for assessing the microhardness of solid materials, including dental rotary files after root canal preparation [17, 18].

The proposed hypothesis in the current study was that the files that were used in the CAC will exhibit greater deterioration in microhardness compared to the TAC. This was not fulfilled because there were no significant differences between all groups. These findings are consistent with Alapati et al and Shen et al who reported a non-significant increase in the hardness of rotary files after preparing multiple root canals [17, 18]. In the contrary to this Ye and Gao found a significant increase in microhardness of rotary instruments at 60% and 90% of their fatigue life during cyclic fatigue resistance test. This can be attributed to the methodology difference [19]. The observed slight increase in hardness values with increasing number of prepared canals can be attributed to the work hardening phenomenon. Work hardening, also known as strain hardening, is a process in which a material becomes stronger and harder as it is subject to plastic deformation[20]. The significantly higher microhardness value of Elephant files compared to Edge files can be attributed to the higher flexibility of Edge files [21,22].

CONCLUSION

Within the limitations of this study:

- The access cavity designs and the number of prepared canals had no significant effect on the microhardness of the rotary nickel titanium files.
- CM-wire instruments can withstand stresses from the conservative access and behave in a similar way to the traditional one.
- Chinese made files are acceptable cost-effective alternative to the more expansive American one.

Future recommendations:

Factors other than the effect of access cavity on rotary files microhardness should be considered when the operator decides which access cavity type will be utilized.

Conflict of Interest and Source of Funding:

Authors deny any conflict of interest. No funding was granted in the current study.

REFERENCES

1. Patel S, Rhodes J. A practical guide to endodontic access cavity preparation in molar teeth. Br. Dent. J. 2007;203:133-140
2. Gutmann J, Fan B. Tooth Morphology, Isolation, and Access. Cohen's Pathways of the Pulp, 11th ed. 2016;145

3. Tang W, Wu Y, Smales R. Identifying and Reducing Risks for Potential Fractures in Endodontically Treated Teeth. J Endod. 2010;36:609-617

4. Clark D, Khademi J. Modern Molar Endodontic Access and Directed Dentin Conservation. Dent Clin N 2010;54: 249–273

5. Krishan R, Paque F, Ossareh A, Kishen A, Dao T, Friedman S. Impacts of Conservative Endodontic Cavity on Root Canal

6. Plotino G, Grande NM, Isufi A, Ioppolo P, Pedulla E, Bedini R, Gambarini G, Testarelli L. Fracture Strength of Endodontically Treated Teeth with Different Access Cavity Designs. J Endod. 2017;43:995-1000

7. Makati, D., Shah, N. C., Brave, D., Rathore, V. P. S., Bhadra, D., & Dedania, M. S. Evaluation of remaining dentin thickness and fracture resistance of conventional and conservative access and biomechanical preparation in molars using cone-beam computed tomography: An in vitro study. Conserv Dent. 2018;21(3):324–327.

8. Rover G, Belladonna FG, Bortoluzzi EA, De-Deus G, Silva EJ, Teixeira CS. Influence of Access Cavity Design on Root Canal Detection, Instrumentation Efficacy, and Fracture Resistance Assessed in Maxillary Molars. J Endod. 2017;43:1657–1662.

9. Sabeti, M., Kazem, M., Dianat, O., Bahrololumi, N., Beglou, A., Rahimipour, K., and Dehnavi, F. Impact of access cavity preparation and root canal taper on the resistance of endodontically treated teeth to fracture: A study on extracted teeth. J Endod. 2018; 44(9): 1402-1406.

10. Augusto CM, Barbosa AFA, Guimarães CC, Lima CO, Ferreira CM, Sassone LM, Silva EJNL. A laboratory study of the impact of ultraconservative access cavities and minimal root canal tapers on the ability to shape canals in extracted mandibular molars and their fracture resistance. Int Endod J. 2020;53(11):1516-1529.

11. Brockhurst PJ, Denholm L. Hardness and Strength of Endodontic Files and Reamers. Int Endod J. 1996;22(2):77-83.

12. Al-Hadlaq SM, Aljarbou FA, AlThumairy RI. Evaluation of cyclic flexural fatigue of M-wire nickel-titanium rotary instruments. J Endod. 2010;36(2):305-7.

13. Schneider S.W. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol. 1971;32(2):271–275.

14. www.random.org

15. Santosh, S. S., Ballal, S., & Natanasabapathy, V. (2021). Influence of Minimally Invasive Access Cavity Designs on the Fracture Resistance of Endodontically Treated Mandibular Molars 103 Subjected to Thermocycling and Dynamic Loading. J Endod. 2021;47(9):1496–1500.

16. https://web.edgeendo.com/testimonials/

17. Alapati SB, Brantley WA, Nusstein JM, Daehn GS, Svec TA, Powers JM, Johnston WM, Guo W. Vickers Hardness Investigation of Work-Hardening in Used NiTi Rotary Instruments. J Endod. 2006;32:1191-1193

18. Shen Y, Coil JM, Zhou H, Zheng Y, Haapasalo M. HyFlex nickel-titanium rotary instruments after clinical use: metallurgical properties. Int Endod J. 2013 Aug;46(8):720-9.

19. Ye J and Gao Y. Metallurgical Characterization of M-Wire Nickel-Titanium Shape Memory Alloy Used for Endodontic Rotary Instruments during Low-cycle Fatigue. J Endod. 2012;38:105-107

20. R.E. Smallman, A.H.W. Ngan. Work Hardening and Annealing. Modern Physical Metallurgy 8th ed. 2014; 11:443-471.

21. Alcalde M, Duarte MAH, Amoroso Silva PA, Souza Calefi PH, Silva E, Duque J, Vivan R. Mechanical Properties of ProTaper Gold, EdgeTaper Platinum, Flex Gold and Pro-T Rotary Systems. Eur Endod J. 2020 Dec;5(3):205-211.

22. Rodrigues CS, Vieira VTL, Antunes HS, De-Deus G, Elias CN, Moreira EJL, Silva EJNL. Call for attention: mechanical characteristics of counterfeit Reciproc instruments. Int Endod J. 2018;51(5):556-563.