



www.bioinformation.net
Volume 22(9)



Research Article

Received September 1, 2026; Revised September 30, 2026; Accepted September 30, 2026, Published September 30, 2026

DOI: 10.6026/973206300225747

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478

2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Declaration on Publication Ethics:

The author's state that they adhere with COPE guidelines on publishing ethics as described elsewhere at <https://publicationethics.org/>. The authors also undertake that they are not associated with any other third party (governmental or non-governmental agencies) linking with any form of unethical issues connecting to this publication. The authors also declare that they are not withholding any information that is misleading to the publisher in regard to this article.

Declaration on official E-mail:

The corresponding author declares that lifetime official e-mail from their institution is not available for all authors

License statement:

This is an Open Access article which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. This is distributed under the terms of the Creative Commons Attribution License

Comments from readers:

Articles published in BIOINFORMATION are open for relevant post publication comments and criticisms, which will be published immediately linking to the original article without open access charges. Comments should be concise, coherent and critical in less than 1000 words.

Disclaimer:

Bioinformation provides a platform for scholarly communication of data and information to create knowledge in the Biological/Biomedical domain after adequate peer/editorial reviews and editing entertaining revisions where required. The views and opinions expressed are those of the author(s) and do not reflect the views or opinions of Bioinformation and (or) its publisher Biomedical Informatics. Biomedical Informatics remains neutral and allows authors to specify their address and affiliation details including territory where required.

Edited by Ruby Singh

E-mail: bioinformationruby@gmail.com

Citation: Saini *et al.* Bioinformation 22(9): 5747-5750 (2026)

Comparative evaluation of dentinal microcracks using different root canal file systems; An *in vitro* Micro-CT study

Pareba Saini, Sumita Giri*, Chetna Arora, Nabanita Sarma, Subhashita Sharma, Prashant Chilgar & Sanjeet Kumar

Department of Conservative Dentistry and Endodontics, Santosh Dental College & Hospitals, Santosh Deemed to be University, Ghaziabad, NCR, Delhi, India; *Corresponding author

Affiliation URL:

www.santosh.ac.in

Author contact:

Pareba Saini - E-mail: parebasaini@gmail.com
Sumita Giri - E-mail: sumitagiri1011@gmail.com
Chetna Arora - E-mail: drchetnaarora1@gmail.com
Nabanita Sarma - E-mail: sarmanabanita007@gmail.com
Subhashita Sharma - E-mail: sharmasubhashita23@gmail.com
Prashant Chilgar - E-mail: prahsantchilgar@gmail.com
Sanjeet Kumar - E-mail: shanusanjeet904@gmail.com

Abstract:

Dentinal microcracks formed during root canal preparation may increase the risk of vertical root fracture. Therefore, it is of interest to compare the microcrack formation after instrumentation with K-files, ProTaper Gold and Self-Adjusting File using micro-CT. Microcracks occurred in 40.0% of specimens, with the highest incidence for K-files (60.0%), followed by ProTaper Gold (50.0%) and Self-Adjusting File (10.0%). The likelihood ratio test showed significant differences among groups ($p = 0.038$) and no complete cracks were observed with the Self-Adjusting File. Thus, data supports self-Adjusting File for dentin preservation and advance minimally invasive endodontic instrumentation.

Keywords: Dentinal microcracks, root canal preparation, protaper gold, self-adjusting file, micro-computed tomography, vertical root fracture, minimally invasive endodontics

Background:

Root canal treatment remains a cornerstone of contemporary endodontic practice, aimed at eliminating pulpal infection and preserving the natural dentition. While advances in nickel-titanium (NiTi) alloy metallurgy and instrument kinematics have substantially improved shaping efficacy and safety, concerns persist regarding the potential of mechanical instrumentation to alter the structural integrity of radicular dentin [1, 2]. Dentinal microcracks are microscopic defects within root dentin that may present as craze lines, incomplete cracks, or complete fractures extending from the canal wall toward the external root surface. These defects can serve as stress concentrators and potential precursors to vertical root fracture (VRF), one of the most unfavourable complications in endodontics, frequently necessitating extraction [3]. The clinical significance of instrumentation-induced microcracks has therefore gained increasing attention in endodontic research. Biomechanical preparation subjects root dentin to torsional, compressive and tensile stresses whose magnitude depends on instrument design, alloy properties, kinematics, taper and canal anatomy [4]. Among contemporary systems, ProTaper Gold (PTG) employs a progressively tapered heat-treated NiTi design and continuous rotary motion, while the Self-Adjusting File (SAF) uses a compressible hollow lattice that adapts to canal morphology and operates with a vibratory motion distinct from conventional rotation [5, 6]. Stainless steel hand K-files represents the traditional manual standard. Comparative evaluation of these three instrumentation strategies under controlled conditions is therefore warranted to support evidence-based instrument selection. The accurate assessment of microcrack formation has been transformed by micro-computed tomography (micro-CT), a non-destructive three-dimensional imaging modality that enables pre- and post-instrumentation comparison on the same specimen, thereby distinguishing newly formed defects from pre-existing ones [7, 8]. Therefore, it is of interest to report the dentinal microcrack formation following preparation with PTG, SAF and K-files using micro-CT, with

baseline-to-post instrumentation assessment to support causal inference within the study framework.

Materials and Methods:

This *in vitro* study was conducted at the Department of Conservative Dentistry and Endodontics, Santosh Dental College & Hospitals, Ghaziabad, following institutional ethical clearance. Thirty extracted human premolars with single straight canals were selected after radiographic screening to exclude pre-existing periapical pathology, calcification, or canal irregularities. Teeth were decoronated at the cemento-enamel junction to standardise root length to 15 mm. All specimens were stored in normal saline until use. Teeth were randomly allocated to three equal groups ($n = 10$ each): Group I -Stainless Steel K-files (manual instrumentation using balanced-force technique to size #40); Group II -ProTaper Gold (PTG; rotary instrumentation using an endomotor per manufacturer protocol, final apical size F2); and Group III -Self-Adjusting File (SAF; adaptive vibratory motion, 1.5 mm file, 5000 rpm, 4 minutes). All groups received irrigation with 2.5% sodium hypochlorite and 17% EDTA using a standardised protocol. Micro-CT scanning was performed before and after instrumentation at identical settings (voxel resolution 14–15 μm) to enable matched baseline-to-post comparison. Cross-sectional images at the coronal, middle and apical thirds were evaluated by two calibrated blinded examiners for the presence, location and type of dentinal defects (no defect, incomplete crack, or complete crack). The presence of microcracks post-instrumentation in specimens confirmed crack-free at baseline was recorded as new microcrack formation. Statistical analysis was performed using SPSS version 26.0. Categorical variables were expressed as frequencies and percentages. Chi-square and likelihood ratio tests were used for intergroup comparisons; Fisher's exact test was applied where expected cell counts were fewer than five. Spearman's rank correlation was used to assess the relationship between instrumentation motion and microcrack formation. A two-tailed p -value < 0.05 was considered statistically significant.

Results:

Pre-instrumentation micro-CT confirmed that all 30 specimens were free of detectable dentinal defects. After instrumentation, microcracks were detected in 12 of 30 samples (40.0%), while 18 of 30 (60.0%) remained defect-free (**Figure 1**). K-files demonstrated the highest incidence of new microcracks (6/10, 60.0%), followed by PTG (5/10, 50.0%) and SAF (1/10, 10.0%) (**Table 1**). Pearson Chi-square analysis yielded a borderline result ($\chi^2 = 5.833$, $df = 2$, $p = 0.054$); however, the likelihood ratio was statistically significant (LR = 6.556, $df = 2$, $p = 0.038$). Among the 12 specimens with microcracks, incomplete cracks accounted for 7 (58.3%) and complete cracks for 5 (41.7%). The SAF group

Table 1: Post-instrumentation dentinal microcrack incidence by file system (n = 30)

File System	New Microcracks n (%)	No Microcrack n (%)	p-value
K-files (n = 10)	6 (60.0)	4 (40.0)	
ProTaper Gold (n = 10)	5 (50.0)	5 (50.0)	
SAF (n = 10)	1 (10.0)	9 (90.0)	
Total (n = 30)	12 (40.0)	18 (60.0)	0.038*†

* $p < 0.05$; †Likelihood ratio test (LR = 6.556, $df = 2$); Pearson $\chi^2 = 5.833$, $df = 2$, $p = 0.054$.

Table 2: Type of dentinal defects by file system (n = 30)

Defect Type	K-files n	PTG n	SAF n	Total n
No defect	4	5	9	18
Incomplete crack	3	3	1	7
Complete crack	3	2	0	5
Total	10	10	10	30

$\chi^2 = 6.276$, $df = 4$, $p = 0.179$ (Pearson Chi-square); PTG: ProTaper Gold; SAF: Self-Adjusting File.

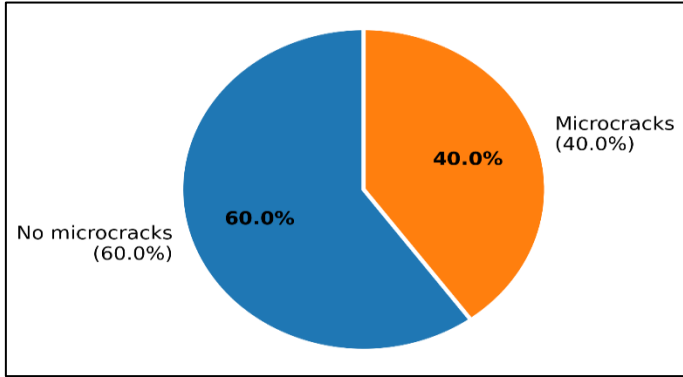


Figure 1: Percentage (%) of dentinal microcrack status after instrumentation

Discussion:

The principal finding of this *in vitro* micro-CT study was that the choice of instrumentation system significantly influenced dentinal microcrack incidence, with SAF showing the lowest rate (10.0%) compared with K-files (60.0%) and PTG (50.0%). The likelihood ratio test confirmed a statistically significant intergroup difference ($p = 0.038$), consistent with evidence that instrument design, alloy properties and motion kinematics are important determinants of dentinal stress distribution [9]. The favourable profile of the SAF is mechanistically plausible. Its compressible hollow NiTi lattice adapts continuously to canal morphology during vibratory motion, potentially distributing stress more uniformly and avoiding localised stress peaks

showed no complete cracks; PTG demonstrated 2 complete and 3 incomplete cracks; K-files showed 3 complete and 3 incomplete cracks (**Table 2**). No statistically significant association was found between file system and defect type ($\chi^2 = 6.276$, $df = 4$, $p = 0.179$). Microcrack distribution across root thirds showed no significant association with file system ($\chi^2 = 6.833$, $df = 6$, $p = 0.337$). Material-based grouping (NiTi vs stainless steel) showed 30.0% vs 60.0% incidence without statistical significance ($\chi^2 = 2.500$, $p = 0.114$). Spearman’s correlation between instrumentation motion and microcrack formation was weak and non-significant ($r = 0.333$, $p = 0.072$) (**Table 3**).

Table 3: Summary of key statistical findings

Parameter	Test	Test Value	p-value
File system vs new microcrack formation	LR test	LR = 6.556, $df = 2$	0.038*
File system vs microcrack type	Chi-square	$\chi^2 = 6.276$, $df = 4$	0.179
Instrument material vs new microcracks	Chi-square	$\chi^2 = 2.500$, $df = 1$	0.114
Apical vs non-apical distribution	Chi-square	$\chi^2 = 2.400$, $df = 2$	0.301
Motion vs microcrack formation	Spearman rho	$r = 0.333$	0.072

*Statistically significant ($p < 0.05$); LR: Likelihood Ratio.

associated with rigid tapered files [10]. This aligns with earlier sectioning-based work and more recent micro-CT studies confirming lower crack rates with SAF compared with rotary NiTi systems [11]. The higher microcrack incidence with K-files (60.0%) is notable given the assumption that manual instrumentation is gentler than engine-driven systems. Stainless steel is substantially stiffer than NiTi and lateral filing forces may transmit considerable tensile and compressive stresses to canal walls. The uniform distribution of K-file-associated microcracks across all root thirds is consistent with stress transmission along the full working length during balanced-force instrumentation [12]. PTG demonstrated an intermediate profile (50.0%), with predominance of middle and apical third involvement. Although heat treatment of the PTG alloy improves cyclic fatigue resistance relative to conventional NiTi, it does not eliminate stress-mediated dentinal damage under the present conditions. These findings are consistent with micro-CT studies reporting system-dependent regional microcrack patterns [13, 14]. The absence of complete cracks in the SAF group supports the interpretation that adaptive instrumentation may better preserve structural dentin integrity. Complete cracks are more likely to propagate under functional loading and contribute to VRF than incomplete defects [15]. Neither instrumentation motion nor instrument material reached statistical significance as independent predictors, reinforcing that microcrack outcomes are multifactorial [16, 17].

Conclusion:

All the three tested systems were associated with dentinal microcrack formation. Self-Adjusting Files showed the lowest

incidence (10.0%), with no complete cracks, whereas Stainless Steel K-files exhibited the highest incidence (60.0%). Microcrack incidence differed significantly among systems ($p = 0.038$), highlighting the importance of instrument selection for dentinal preservation.

Source of Funding: No external funding was received for this study.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability:

The datasets generated during the current study are available from the corresponding author on reasonable request.

References:

- [1] Miguéns-Vila R *et al.* *Journal of Endodontics*. 2021 **47**:309. [PMID: 33096193]
- [2] Shantiaee Y *et al.* *Dental and Medical Problems*. 2021 **58**:515. [PMID: 34994116]
- [3] Barbosa AFA *et al.* *Journal of Endodontics*. 2022 **48**:1146. [PMID: 35697303]
- [4] Aggarwal A *et al.* *Journal of Endodontics*. 2021 **47**:1314. [PMID: 34023360]
- [5] Katanec T *et al.* *Iranian Endodontic Journal*. 2020 **15**:6. [PMID: 36704321]
- [6] Arumugam S *et al.* *Australian Endodontic Journal*. 2021 **47**:520. [PMID: 33956372]
- [7] De-Deus G *et al.* *International Endodontic Journal*. 2019 **52**:857. [PMID: 30549297]
- [8] Alkahtany SM & Al-Madi EM. *International Journal of Dentistry*. 2020 **2020**:4030194. [PMID: 32322272]
- [9] de Lima CO *et al.* *Int Endod J*. 2025 **58**:357. [PMID: 39630529]
- [10] Deopujari J *et al.* *Journal of Contemporary Dental Practice*. 2022 **23**:74. [PMID: 35656661]
- [11] Faus-Matoses V *et al.* *Int J Environ Res Public Health*. 2022 **19**:718. [PMID: 35055540]
- [12] Tejaswi S *et al.* *Nigerian Journal of Clinical Practice*. 2022 **25**:524. [PMID: 35439914]
- [13] Zarean P *et al.* *Materials*. 2022 **15**:3002. [PMID: 35591336]
- [14] Ahmad M *et al.* *Cureus*. 2026 **18**:e115977. [DOI: 10.7759/cureus.115977]
- [15] Mustafa M *et al.* *Journal of Pharmacy and Bioallied Sciences*. 2024 **16**:S3796. [PMID: 39927048]
- [16] Soltaninejad F *et al.* *BMC Oral Health*. 2025 **25**:529. [PMID: 40217241]
- [17] Alovisei M *et al.* *J Endod*. 2025 **51**:1477. [PMID: 40609828]

Caveat Emptor is applicable among the literate community where required and possible. The publisher, its journal, editors and the internal/external reviewers take adequate steps to check, evaluate, correct, edit, revise and improve content where possible and required.