

Production Of Dentin Defects by Reciproc File System as Compared to Protaper Rotary File Systems During Endodontic Treatment in Permanent Teeth: A Systematic Review and Meta-Analysis

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Abstract—Background

Nickel-titanium (NiTi) endodontic file systems have significantly improved the efficiency and predictability of root canal treatment. However, mechanical stresses generated during instrumentation may induce dentinal defects such as craze lines, microcracks, and fractures, potentially compromising long-term tooth prognosis. Continuous rotary systems such as ProTaper and reciprocating systems such as Reciproc differ in their kinematics, metallurgy, and stress distribution, which may influence the incidence of dentinal damage.

Aim

To systematically compare the dentin defects produced by ProTaper rotary file systems and Reciproc reciprocating file systems during endodontic treatment in permanent teeth.

Methods

This systematic review and meta-analysis was conducted according to PRISMA 2020 guidelines and registered in PROSPERO (CRD420250648459). Electronic databases including PubMed/MEDLINE, Scopus, Web of Science, Embase, Cochrane Library, Google Scholar, and ProQuest were searched for studies published from 2000 onwards. In vitro, ex vivo, and in vivo studies comparing ProTaper (Universal, Gold, Next) and Reciproc (Reciproc, Reciproc Blue) systems in permanent teeth

were included. Data extraction and study selection were performed independently by two reviewers. Risk of bias was assessed using the QUIN tool.

Results

A total of 21 in vitro studies were included. ProTaper systems demonstrated a higher incidence of dentinal defects in most studies, particularly in the apical third of roots, with crack incidence ranging from 20–60%. Reciproc systems, especially Reciproc Blue, showed fewer defects, with crack incidence ranging from 5–30%. In 13 studies, ProTaper systems produced significantly more dentinal defects than Reciproc systems ($p < 0.05$). Micro-CT studies further revealed that some postoperative cracks were pre-existing before instrumentation. Overall, the reciprocating systems exhibited lower stress on radicular dentin and were associated with reduced dentinal damage compared to rotary systems.

I. INTRODUCTION

The primary objective of endodontic treatment is to effectively clean, shape, and seal the root canal system in order to protect teeth impacted by pulpal disorders.^[1,2] Because of their versatility and capacity to handle intricate canal anatomy, advancements in

nickel-titanium (NiTi) equipment have increased the effectiveness and safety of these treatments.^[3] These tools, however, have the potential to produce mechanical stresses that jeopardize dentinal integrity and result in flaws such fractures and microcracks.^[4,5] NiTi files are categorized into rotary (continuous motion) and reciprocating (bidirectional motion) systems due to their super elasticity and shape memory. While reciprocating systems like Reciproc and Wave One employ a single-file strategy to lessen torsional stress, rotary systems like ProTaper use consecutive files for gradual canal contouring.^[6,7] Despite their benefits, dentinal damage has been linked to both systems and it is still up for dispute how they compare.^[7]

From minor craze lines to severe vertical root fractures (VRFs), dentin abnormalities can cause tooth loss. Anatomical elements including dentin thickness and root curvature, motion kinematics, and instrument design can all contribute to these defects.^[8] Reciprocating systems may produce localized stress through frequent direction changes while rotary systems may provide higher stress because of continuous motion.^[9,10]

Anatomical differences enhance the risk of microcracks, especially in molars with thin dentinal walls or curved canals. Pre-existing structural defects may increase this risk substantially. Clinically, severe fractures frequently require extraction while even small defects can allow bacterial infiltration and impair treatment outcomes.^[11-13]

This systematic review aims to compare dentin defect incidence between ProTaper rotary and Reciproc reciprocating systems, evaluating their impact on dentinal integrity and long-term prognosis in permanent teeth to guide optimal endodontic practice.

II. METHODOLOGY

This systematic review and meta-analysis followed PRISMA 2020 guidelines and the PICOS framework, with protocol registration in PROSPERO (CRD420250648459). The primary aim was to compare dentin defect incidence between Reciproc and ProTaper systems in permanent teeth, with secondary outcomes including defect types,

assessment methods, anatomical susceptibility, and clinical implications.

Inclusion Criteria:

- Population: Permanent human teeth (extracted, cadaveric, or in vivo) undergoing root canal instrumentation.
- Intervention: Reciprocating NiTi file systems, including: Reciproc and Reciproc Blue
- Comparator: Rotary NiTi file systems, including: ProTaper Universal, ProTaper Gold, ProTaper Next
- Outcomes: Studies reporting on the incidence and/or types of dentin defects (microcracks, craze lines, incomplete/complete fractures).
- Study Design: In vitro studies, ex vivo studies, and in vivo clinical studies comparing both file systems.

Exclusion Criteria:

- Studies involving primary teeth or artificial/simulated canals.
- Studies without a comparative analysis of Reciproc vs ProTaper systems.
- Studies using only hand files or non-specified file systems.
- Reviews, editorials, case reports, letters to the editor, and conference abstracts.
- Articles not published in English.
- Studies without full-text access.

Search strategy: A comprehensive search strategy from year 2000 till present in English was implemented to identify relevant studies. Electronic Databases such as PubMed/MEDLINE, Scopus, Web of Science, Embase, Cochrane Library, Google Scholar (for grey literature), ProQuest Dissertations and Theses. A combination of Medical Subject Headings (MeSH) and free-text terms were used. Boolean operators (AND, OR) were employed to refine searches. Filters were applied for In vitro, ex vivo, or in vivo experimental/comparative studies.

Study Selection Process: Two authors carried out the study selection process by separately comparing abstracts and titles to the inclusion/exclusion criteria and found relevant studies. After that, the same two authors separately examined all of the full-text studies, that they had been unable to rule out based just on the

abstract and title. The two authors finished comparing their articles, and there were no differences about what should have been included. The third author then double-checked the final selection of articles. It was discovered that the inter-rater agreement was 0.8. A PRISMA flow diagram was created to document the screening and selection process.

Data extraction: A data extraction form was used to extract the data from the final 21 articles. It contains the first author's name, the article's year of publication, country, study design (in vitro/ex vivo/in vivo), Sample size and tooth type, tooth selection criteria and exclusion parameters, type and brand of file system used, Instrumentation protocol (speed, torque, file size), Assessment method for dentin defects (e.g., micro-CT, stereomicroscopy, SEM), Baseline evaluation for pre-existing cracks, Outcome measures and main conclusions of the study.

Risk of bias in in vitro studies was assessed using the QUIN tool across 10 domains, categorizing studies as low (≥ 8), moderate (5–7), or high (< 5) risk.

III. RESULT

A total of 21 in vitro studies were included in this systematic review.^[14-33] The studies were conducted across nine countries, with Turkey ($n = 7$) contributing the highest number, followed by India ($n = 4$), Iran ($n = 3$), and Brazil ($n = 2$). One study each originated from Germany, China, Iraq, Croatia, and Saudi Arabia ($n = 1$ each). All studies were published between 2013 and 2022, representing the current body of evidence on NiTi file systems and dentinal integrity.

All studies followed an in vitro experimental design utilizing extracted human teeth. The sample size ranged from 30 to 180 teeth, with a mean sample size of 86 teeth per study.

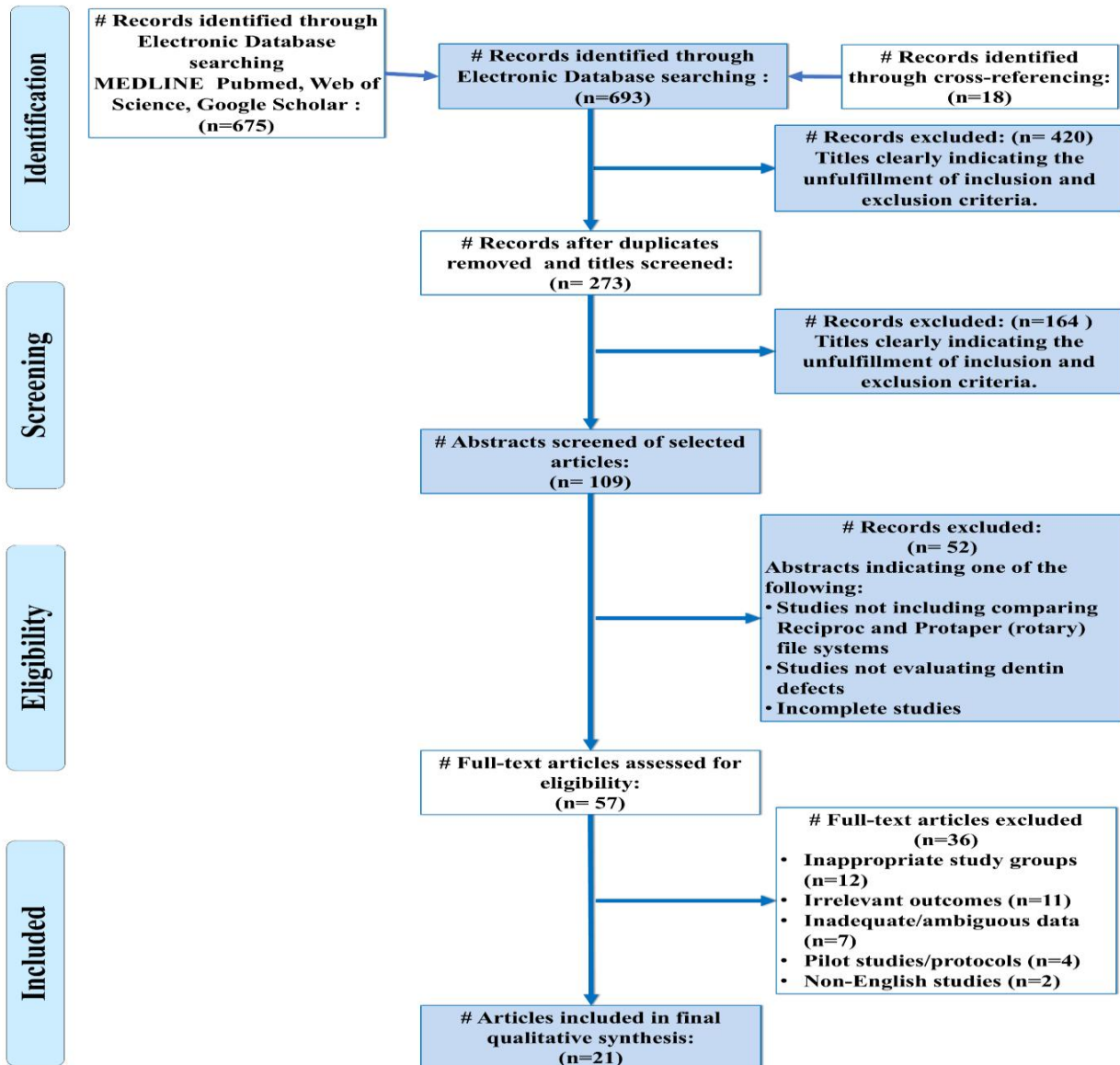
Included studies used mandibular premolars, molars (mainly mesial roots), and incisors with fully developed apices and no prior defects. Assessment methods included stereomicroscopy (sectioning at 3, 6, and 9 mm) and micro-CT for non-destructive 3D evaluation.

ProTaper systems (Universal, Next, Gold) and Reciproc systems (Reciproc, Reciproc Blue) were widely evaluated. All studies reported dentin defects post-instrumentation. ProTaper showed a higher defect incidence in most studies (20–60%), especially in the apical third, with ProTaper Universal being the most aggressive. ProTaper Next and Gold produced fewer defects but still exceeded Reciproc in several studies.

Reciproc systems demonstrated lower defect incidence (5–30%) in most studies, with Reciproc Blue showing the best outcomes. Micro-CT studies often identified many cracks as pre-existing. Defects were most common apically, particularly with ProTaper, while Reciproc showed fewer and more evenly distributed defects. Horizontal cracks and craze lines were most frequent. Statistically, ProTaper caused significantly more defects in most studies ($p < 0.05$), though some showed no significant difference. While all instrumentation can induce dentinal defects, Reciproc systems—especially Reciproc Blue—consistently showed lower incidence and severity compared to ProTaper, particularly in the apical region.

Risk of Bias:

Using the QUIN tool, 4 studies had low risk and 17 moderate risk; none were high risk. Common limitations included lack of sample size calculation, limited use of controls, inadequate randomization, and absence of blinding. Despite this, methodologies and outcome assessments were appropriate, and overall study quality was acceptable.



IV. DISCUSSION

The present systematic review was conducted to comprehensively assess and compare the incidence of dentin defects caused by ProTaper rotary file systems and Reciproc reciprocating file systems during endodontic treatment in permanent teeth. A total of 21 in vitro studies were included, each directly comparing ProTaper (Universal, Gold, or Next) with Reciproc (original or Reciproc Blue), and evaluated using standardized methodology. The findings across these studies provide critical insights into the mechanical behavior of these instrumentation systems, their interaction with radicular dentin, and the implications

of these interactions on root integrity and long-term treatment success.^[14-33]

Majority of the studies in this review revealed that ProTaper systems produce more dentinal defects than Reciproc systems. This was especially evident with ProTaper Universal, whose progressive taper and aggressive cutting action increase stress on canal walls, particularly in the apical third, leading to microcracks and fractures.^[34] Although newer systems like ProTaper Gold and ProTaper Next—featuring heat-treated NiTi alloys and improved flexibility—resulted in fewer defects, they still caused more damage than Reciproc systems in most studies.^[35] Reciproc Blue systems showed lower dentinal damage

due to their single-file reciprocating motion and enhanced flexibility from heat-treated NiTi, which reduce stress on dentin.^[36,37] This is clinically significant as fewer defects may lower the risk of vertical root fractures.^[38] Selecting an instrumentation system that minimizes such structural compromise is therefore paramount in enhancing tooth longevity.

Micro-Computed Tomography (CT) studies provide more accurate assessment of dentin defects by allowing pre- and post-instrumentation evaluation of the same samples and avoiding sectioning artifacts.^[39] Several studies found that many defects existed at baseline, suggesting not all cracks are caused by instrumentation.^[40] This highlights a critical point in endodontic research methodology that distinguishing between iatrogenic and pre-existing defects is essential for accurate evaluation. However, Reciproc systems produce fewer new defects, suggesting they are less aggressive than rotary systems.^[14-33] Anatomy significantly influences dentinal defects: curved, narrow molar roots are more prone due to increased file-dentin contact and stress.^[41] Reciprocating systems exert less cumulative strain, while rotary systems—especially with greater taper and lower flexibility—induce higher stresses.^[42] Clinically, this supports selecting instrumentation based on root morphology, favouring reciprocation in complex cases.^[42]

Control groups (uninstrumented or hand-instrumented) showed minimal or no defects, indicating engine-driven files contribute to crack formation. [24–44] Although hand instrumentation is safer, it is less efficient. Reciprocating systems offer a balance of effective shaping with reduced dentinal damage.^[43] The apical third is most prone to defects—especially with ProTaper—due to narrow canals, thinner dentin, and greater file engagement causing stress concentration.^[14-33] Reciproc systems generate less apical stress, making them less likely to induce defects. Clinically, apical cracks can impair sealing and increase the risk of reinfection or fracture.^[14-33]

In methodology, the review is strengthened by QUIN-based bias assessment. Despite moderate risk (mainly due to lack of blinding and sample size calculation) study quality was acceptable with clear objectives, standardized samples, and appropriate analyses. Most studies showed significantly higher crack incidence with ProTaper systems.^[14-33] The findings of this systematic review strongly support the notion that

Reciproc and Reciproc Blue file systems are safer in terms of dentin preservation compared to ProTaper rotary systems. While all engine-driven instruments inherently carry a risk of inducing microstructural damage to radicular dentin, the evidence consistently demonstrates that reciprocating systems exert less mechanical stress and are therefore associated with fewer and less severe dentinal defects. These findings have significant clinical implications, particularly in cases where long-term tooth preservation is critical. The selection of an appropriate instrumentation technique should therefore not be guided solely by shaping efficiency, but also by its impact on dentin integrity and the structural resilience of the tooth. Future studies should aim to include clinical data, longer follow-up periods, and integrate patient-centered outcomes to further elucidate the real-world significance of these findings.

V. CONCLUSION

Within the limitations of this review, both ProTaper and Reciproc systems can induce dentinal defects however Reciproc—especially Reciproc Blue—consistently shows lower incidence and severity. Design, motion, taper and metallurgy influence stress on dentin, with reciprocating single-file systems being less aggressive than multi-file rotary systems like ProTaper. Clinically, file selection should consider dentin preservation, particularly in thin or curved roots, favoring reciprocation to minimize damage and improve outcomes. Further clinical and micro-CT studies are needed for validation.

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