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INPLASY

Comparative assessment of vertical fracture resistance in endodontically treated roots with different obturating systems and techniques: A systematic review and network meta-analysis of in vitro studies

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ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Formal screening of search results against eligibility criteria.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 08 October 2023 and was last updated on 08 October 2023.

INTRODUCTION

Review question / Objective Pulpitis and periapical inflammation are prevalent conditions affecting the tooth pulp, with root canal therapy being the primary clinical treatment choice. Numerous studies have indicated that endodontically treated teeth are more susceptible to crown or root fractures when compared to teeth with normal vitality. Among these fractures, vertical root fracture (VRF) is not only the most common but also the most severe, often requiring root removal or tooth extraction. Hence, there is an imperative need for VRF prevention in clinical practice. In recent years, numerous endeavors have been made to prevent VRF, with extensive discussions focusing on the impact of various root canal-filling materials and techniques.

Gutta-percha (GP) has long been the preferred root canal filling material due to its notable advantages, including excellent biocompatibility, low cytotoxicity, and thermal plasticity. When combined with the resin-based sealer AH Plus, it forms the gold standard within the current closed systems, extensively utilized for an extended period. Studies have demonstrated that this combination significantly enhances resistance against VRF. However, a drawback is its inability to establish a complete seal along the root canal wall. On the contrary, resin is a polymer-based thermoplastic material enriched with bioactive glass, bismuth chloride, barium sulfate, and opaque fillers. When employed in conjunction with double-curing resin-based root canal sealers like Epiphany or Realseal, it exhibits commendable sealing capabilities and antibacterial properties.
When it comes to filling methods, commonly employed clinical techniques include the lateral

condensation technique (LCT), thermafil obturation technique, and single cone technique (SCT). LCT is widely preferred for its user-friendly operation and minimal need for clinical equipment. However, the thermafil obturation technique excels in achieving effective sealing in three-dimensional spaces. SCT, when combined with bioceramic material sealers like iRoot SP, delivers a straightforward, efficient, and well-sealed clinical outcome. These three filling methods exert a certain pressure on the root canal wall, but the relative impact of their pressure on root canal fracture remains uncertain.

Rationale To the best of our knowledge, no comprehensive systematic reviews and network meta-analyses have been undertaken to thoroughly assess the resistance to VRF among various root canal-filling materials and methods following root canal treatment. Therefore, the current study aims to elucidate these inquiries through the utilization of data derived from in vitro randomized controlled trials.

Condition being studied Comparative assessment of vertical fracture resistance (VRF) in endodontically treated roots with different obturating systems and techniques.

METHODS

Search strategy 1. PubMed:
((((((stress analysis[All fields]) OR (root fracture[All fields])) OR (fracture resistance[All fields])) OR (vertical fracture[All fields])) OR (tooth fracture[All fields])) AND (((((((((root canal obturation[All fields]) OR (treated roots[All fields])) OR (Root canal filling materials[All fields])) OR (obturating material[All fields])) OR (canal filling system[All fields])) OR (root Reinforcement[All fields])) OR (endodontic treatment[All fields])) OR (root obturat*[All fields]))))) AND (English[Language])
2. Embase:
(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root Reinforcement') OR ('endodontic treatment') OR ('root obturat*')) AND (('tooth fracture') OR ('vertical fracture') OR ('fracture resistance') OR ('root fracture') OR ('dental stress analysis')) AND ((English):la) AND [2000-2023]/py
3. ScienceDirect:
#1：(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root Reinforcement') OR ('endodontic treatment')) AND ('tooth fracture')
#2：(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root Reinforcement') OR ('endodontic treatment')) AND ('vertical fracture')
#3：(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root Reinforcement') OR ('endodontic treatment')) AND ('fracture resistance')
#4：(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root Reinforcement') OR ('endodontic treatment')) AND ('root fracture')
#5：(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root Reinforcement') OR ('endodontic treatment')) AND ('dental stress analysis')
1# OR 2# OR 3# OR 4# OR 5#
4. Web of Science:
1#: (((((((AB=(root canal obturation)) OR AB=(treated roots)) OR AB=(Root canal filling materials)) OR AB=(obturating material)) OR AB=(canal filling system[)) OR AB=(root Reinforcement)) OR AB=(endodontic treatment)) OR AB=(root obturat*)
2#: ((((AB=(tooth fracture)) OR AB=(vertical fracture)) OR AB=(fracture resistance)) OR AB=(root fracture)) OR AB=(dental stress analysis)
1# AND 2#
5. Cochrane Library:
(('root canal obturation') OR ('treated roots') OR ('Root canal filling materials') OR ('obturating material') OR ('canal filling system') OR ('root reinforcement') OR ('endodontic treatment') OR ('root obturat*')) AND (('tooth fracture') OR ('vertical fracture') OR ('fracture resistance') OR ('root fracture') OR ('dental stress analysis')) AND (English:la).

Participant or population The specimens were freshly extracted single-rooted human teeth.

Intervention There are many kinds of obturating systems used in the clinic, and six most widely used obturating systems through the preliminary literature survey were selecte (GP/AH-Plus, Resilon/Epiphany, GP/AH-26, GP/MTA-Plus, GP/ZOE, and iRootSP).Different obturating systems need to be combined with different techniques to complete the root canal filling process. Therefore, the following four techniques such as SCT, LCT, VCT and Thermafil, were also incuded in our study.

Comparator Unprepared and unfilled roots (negative control, NC); Prepared and unfilled roots (positive control, PC).

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Study designs to be included In vitro randomized controlled trials.

Eligibility criteria Studies that evaluated the fracture resistance of endodontially treated teeth in vitro and met the following criteria were included: 1) the specimens were freshly extracted single-rooted human teeth with closed apices which should have enough space for obturation after standard root canal preparation; 2) because there were too many obturating systems developed in the past decades and it was difficult to take all of them into consideration, we merely included studies that involved the six most widely used obturating systems through the preliminary literature survey (GP/AH-Plus, Resilon/Epiphany, GP/AH-26, GP/MTA-Plus, GP/ZOE, and iRootSP); 3) at least two comparative endodontial treatments (including positive control and/or negative control) after the exclusion of irrelevant obturating systems; 4) the study design was randomized controlled trial in vitro; 5) the outcome was vertical fracture resistance (VRF) of roots; 6) studies that provided the mean and the standard deviation of VRF, or had sufficient data to calculate them.Ineligible studies were excluded according to the following criteria: 1) non-human source teeth; 2) literature comments, reviews, or conference abstracts; 3) studies that simultaneously assessed the impact of other factors on the resistance to fracture of endodontically treated roots (i.e. radiotherapy); 4) studies in which a single root was obturated using different materials by segments; 5) insufficient data on the fracture resistance of roots; 6) studies were also excluded in case that only the positive control and negative control interventions left after the exclusion of irrelevant obturating systems; 7) studies in which obturating materials and/or sealer were not clearly clarified.

Information sources A systematic literature search was performed to retrieve relevant publications using PubMed, Embase, ScienceDirect, Web of Science, and Cochrane Library databases . The retrieval time range was from January 2000 to September 2023. The subject terms in combination with free terms were used, including “root canal obturation”, “treated roots”, “root canal filling materials”, “obturating material”, “canal filling system”, “root reinforcement”, “endodontic treatment”, “root obturat*”, “tooth fracture”, “vertical fracture”, “fracture resistance”, “root fracture”, and “dental stress analysis”. The language of the publications was restricted to English. Moreover, we also manually screened the reference lists of topic-related reviews and all eligible studies to identify additional studies.

Main outcome(s) The main outcome was the vertical root fracture (VRF) of in endodontically treated roots with different obturating systems and techniques. The standardized mean difference (SMD) and its 95% confidence interval (CI) were taken as effect sizes to compare the VRF of roots treated with different obturating systems or techniques.

Additional outcome(s) None.

Data management We manage our data using Excel and STATA 17.0 software.

Quality assessment / Risk of bias analysis We established a form which included the followig nine items and were either marked as “yes” or “no” depending on the descriptions of individual studies: randomization of teeth, teeth examination before the experiment, standardization of root dimensions, calculation of sample size, endodontic treatment conducted by a single operator, materials used following the protocol provided by the manufacturer, reporting test machine loading rate, blinding of the examiner, and appropriate statistical methods. One item would be scored zero if it was marked as “no”. Otherwise, it would be scored one. The studies were categorized as high, medium, or low risk of bias based on their sum scores: ≤3, 4-5, and ≥6, respectively. Ultimately, the two investigators cross-checked their quality assessing forms. In case of inconsistency, the third investigator was consulted to reach a consensus.

Strategy of data synthesis We used the “network” package in Stata/MP 17.0 software (StataCorp LLC., College Station, TX, USA) to implement the network meta-analysis (NMA) based on the frequency framework using random-effects models. The standardized mean difference (SMD) and its 95% confidence interval (CI) were taken as effect sizes to compare the VRF of roots treated with different obturating systems or techniques. Network diagrams were drawn to illustrate the network relationships of different interventions, in which the size of nodes indicates the number of teeth, and the thickness of lines connecting two nodes indicates the number of studies.

The inconsistency tests were carried out in two steps prior to the conduction of the NMA. Firstly, the global inconsistency was examined using the design-by-treatment interaction model, with the calculation of the Wald $\chi 2$ test. Secondly, the local inconsistency was evaluated using a loop-specific approach which assessed inconsistencies individually for each closed loop of network interventions. The inconsistency factor (IF) was

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calculated by subtracting direct and indirect estimations for each comparison within a specific loop. The 95%CI of IF and P-value for the Z test were calculated as well. Local consistency was satisfied when the lower limit 95%CI of the IF includes 0 or P>0.05. The consistency model would be applied when both global and local consistency assumptions are met.
The results of the NMA were synthesized based on all possible pairwise comparisons, including mixed comparisons and indirect comparisons. The findings were subsequently presented using forest plots. Contribution plots were also drawn. The study ranked the VRF of roots treated with different obturating systems or techniques using surface under the cumulative ranking curve (SUCRA) values, which range from 0 to 1. A higher SUCRA value suggests that there is a higher probability of the intervention having the greatest fracture resistance. Furthermore, the comparison-adjusted funnel plots were drawn to visually evaluate the presence of publication bias or the presence of small-study effects.

Subgroup analysis No subgroup analysis was conducted.

Sensitivity analysis No sensitivity analysis was conducted.

Language restriction The language of the publications was restricted to English.

Country(ies) involved China.

Keywords Vertical fracture resistance; Obturating system; Obturating technique; Endodontically treated roots; Meta-analysis.

Contributions of each author

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