Stomatologija. Baltic Dental and Maxillofacial Journal, 22: 67-74, 2020

Influence of temporary filling material on dental cracks and fractures during endodontic treatment: A systematic review

Aušra Mickevičienė[1,2], Greta Lodienė[2], Tadas Venskutonis[2]

SUMMARY

Introduction. A significant loss of dental structures during endodontic treatment increases the probability of tooth cracks, fractures or even tooth loss. The objective of this systematic review was to assess the influence of temporary filling material on dental cracks and fractures during endodontic treatment.

Materials and methods. The literature was digitally searched for *in vivo* and *in vitro* studies using Pubmed, ScienceDirect and Wiley Online Library databases. A total of 38 potentially relevant records were identified in the literature search after duplicates were removed. After screening, full-text analysis of selected studies was done. Two reviewers independently selected the studies, extracted the data which was structured and summarized.

Results. Five publications met the selection criteria. Ten temporary filling materials were evaluated in this review. The analysis demonstrated that non-eugenol chemically hardening temporary filling materials significantly increase filling and dental fractures and have the lowest fracture and tooth fracture resistance. Glass ionomer cements (GIC) presented the higher hermetic, tightness and fracture resistance features.

Conclusions. A temporary filling material during endodontic treatment may influence dental cracks and fractures. Highest impact for dental cracks and fractures has ready-to-use, eugenol-free temporary filling materials, whereas the least impact has GIC.

Key words: coronal seal, cracks, endodontics, temporary filling, tooth fractures.

INTRODUCTION

An adequate coronal seal between treatment sessions should be provided to ensure the successful outcome of a root canal treatment. It has to prevent contamination of the root canal system by saliva, food, fluids, microorganisms and other materials from the oral cavity (1–3). Temporary materials are exposed to masticatory forces, temperature changes and humidity in the oral cavity. Various physico-chemical and biological factors can cause changes in the temporary filling: wear, infractions, cracks, fractures, dimensional changes, fluid absorption. These factors could affect hermetic sealing and strength of the material and properties, which are important for saving tooth structures from cracks and fractures between appointments (4–6).

Most teeth undergoing endodontic treatment have been already structurally weakened by caries or have lost one or both marginal ridges and are further weakened by endodontic procedures. The loss of one marginal ridge decreases tooth rigidity by 46%, while a mesial-occlusal-distal (MOD) preparation, where both marginal ridges are removed, results in a dramatic loss of 63% relative cuspal rigidity (7). Fracturing of endodontically treated teeth and, in consequence, the risk of tooth loss is considerably higher than that of teeth with vital pulps. Tooth hard tissue loss due to caries, dental procedures, the use of various irrigators and dehydration leads to significant tooth biomechanical changes, resulting in a high incidence of fractures (8). Adverse effects due to root canal treatment, preparation and additional masticatory forces are major concerns regarding teeth fractures (7). A number of other parameters such as age, plaque, the number of adjacent teeth,

[1]Department of Preventive Medicine, Lithuanian University of Health Sciences, Kaunas, Lithuania
[2]Department of Dental and Oral Pathology, Lithuanian University of Health Sciences, Kaunas, Lithuania

Address correspondence to Aušra Mickevičienė, Department of Preventive Medicine, Academy of Medicine, Lithuanian University of Health Sciences, Tilžės g. 18-307, Kaunas, LT-47181, Lithuania.
Email: ausra.mickeviciene@lsmuni.lt

occlusal contacts, tooth position in dental arch, apical status and collagen degradation affect the fracture resistance of endodontically treated teeth as well (9). Ideally, the temporary restorative material for coronal sealing should be a physical and biological barrier with adequate microleakage and antibacterial properties, as well as properties such as abrasion resistance and dimensional stability, to reinforce the remaining structure to prevent the tooth from cracking and fracturing (7, 10, 11). Most crown or root fractures can be avoided by adequately protecting the tooth during root canal treatment procedures (12).

There is a lack of studies evaluating the effect of temporary filling materials during root canal treatment on the occurrence of cracks or fractures within the tooth. This systematic review aimed to compare different temporary filling materials' influence on cracks and fractures of endodontically treated teeth.

MATERIALS AND METHODS

This systematic review was carried out according to the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions (13), following the 4-phase flow diagram of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (14). This report is based on the PRISMA statement. The focus question, "Does the temporary filling material have influence on dental cracks and fractures during endodontic treatment?," was proposed by following the PICO principle: Patients – *in vivo* or *in vitro* studies with specimens (extracted human teeth) undergoing endodontic treatment; Intervention – teeth with temporary coronal filling; Comparison – healthy teeth, prepared teeth ready for placement of temporary filling or teeth with it; Outcomes – evaluation of tooth infractions, cracks or fractures. The systematic review protocol registration number on PROSPERO is CRD42018093710.

Due to the multiplicity of terminologies and various categorizations in different studies, the term "tooth cracks" was used in this work and includes all teeth defects that are discussed in the review by Mamoun J. and colleagues, starting with microcracking of the tooth structure, tooth infraction, non-structural craze line, "cracked tooth syndrome," incomplete fracture in different directions (vertical, horizontal, oblique) or anatomical structures; the term "tooth fracture" was used to define the complete fracture, which includes the splitting of the tooth in different directions and anatomical structures and whose line divides the tooth into separate parts (15).

Study selection and search strategy

Medline via PubMed, ScienceDirect and Wiley Online Library databases were searched for the studies published in English.

The articles were selected according to the following inclusion criteria:

1. *In vitro* or *in vivo* studies that compared the influence of different temporary filling materials on dental cracks or fractures and that mimicked real-life processes in the mouth: humidity, temperature changes, mechanical crush, compression, bending, stretching movements or forces.
2. Studies that reported at least 1 comparison of 2 different teeth groups (with temporary filling vs. without, with 2 different temporary fillings, with temporary filling vs. healthy teeth).
3. Studies that used extracted, undamaged permanent human teeth with fully developed roots and closed apices, with standard endodontic cavity preparation so that the pulp chamber was completely accessible and with chemo-mechanical preparation and filling of these teeth root canal systems.
4. Studies that evaluated tooth tissue and temporary filling for cracks or fracture lines by using optical devices with magnification.

The exclusion criteria comprised articles that evaluated other properties of temporary filling materials (microleakage, antibacterial properties, sealing, expansion, etc.) and studies with less than five specimens per group.

Due to lack of data, a date limit was not set with the start period and screening process, which was completed on 27 March, 2018. The references of all eligible articles were also searched for all related or similar articles. An additional hand search was performed and based on the reference lists in the selected articles. A wide search strategy was used to avoid missing information: ("temporary filling" OR "temporary restoration" OR "temporary restorative material" OR "temporary cement" OR "coronal sealing" OR "coronal seal") AND ("tooth fractures" OR "cracks" OR "fracture resistance" OR "cracked tooth" OR "fractures"). In the absence of full-article versions in the aforementioned databases, authors were contacted personally by e-mail or through the professional researcher network ResearchGate with a request for a full-text publication. Literature search results were de-duplicated by using Zotero for Windows software (RRCHNM, Arlington, VA, USA). Two independent reviewers (A. M. and T. V.) initially screened the titles of all identified studies. If the title indicated possible inclusion, the abstract was carefully appraised, and the articles considered eligible for the review, or in case of doubt, were selected for full-text reading. The complete articles of the remaining abstracts were critically appraised following specific inclusion and exclusion criteria. Discrepancies were resolved by discussion with a third reviewer G. L.

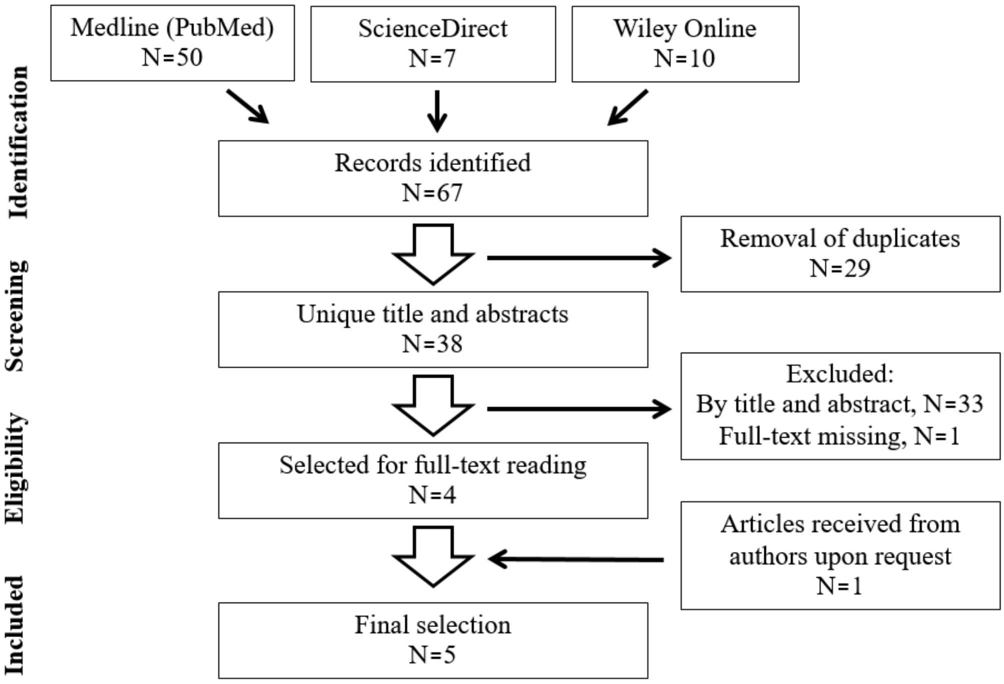

Figure. Flow diagram of the study according to the PRISMA statement

Table 1. Characteristics of included studies

Characteristics	**n (%) 426 (100.0)**	**Reference/-s**
Tooth type		
Molars (maxilla, mandible)	296 (69.48)	1, 3, 11
Premolars (maxilla)	130 (30.52)	7, 17
Tooth cavity preparation		
Mesial-occlusal (MO)	90 (21.12)	17
Mesial-occlusal-distal (MOD)	204 (47.89)	3, 7, 11
Occlusal-distal (OD)	132 (30.99)	1
Study duration		
7 days	90 (21.13)	17
14 days	264 (61.98)	1, 11
20 days	32 (7.5)	3
40 days	40 (9.39)	7
Instruments used for dental canals system preparation		
Hand	40 (9.39)	7
Rotary	386 (90.61)	1, 3, 11, 17
Irrigants used for chemo-mechanical root canals preparation		
2.5% NaOCl	130 (30.52)	7, 17
3.0% NaOCl	264 (61.97)	1, 11
No data	32 (7.51)	3
Root canal obturation materials		
Gutta-percha	162 (38.03)	3, 7, 17
Calcium hydroxide	264 (61.97)	1, 11
Storage conditions		
Storage in humidity, 37ºC	296 (69.48)	1, 3, 11
Storage in humidity, 37ºC and compression static loading	130 (30.52)	7, 17
The proportion of temporary filling in all studies		
ZOE base materials (ZOE, Zonalin, IRM)	122 (28.64)	3, 17
Ready to use, eugenol-free (*Coltosol*, *Coltosol®F*, *Cimpat N*, *Bioplic*)	426 (100.00)	1, 3, 7, 11, 17
GIC (*Vidrion R*, *Fuji II LC*)	130 (30.52)	7, 17
Composites (*Clearfill™ Core*)	264 (61.97)	1, 11

n – number of specimens; % – percents; ºC – Celsius temperature scale. NaOCl – sodium hypochlorite; ZOE – zinc oxide eugenol; GIC – glass ionomer cement.

Data collection and analysis

A standardized outline was used for data extraction that was based on the characteristics of the studies and groups tested. The following items have been registered: sample size (number of comparison groups; number of the teeth and their group in the study), method of analysis (type of study, duration, type of tested materials, cavity configuration, intervention and measurement parameters), results (percentage, statistically significant differences) and conclusions. Considerable heterogeneity was present in the selected studies regarding the research design, methods, outcome variables and data variability. Because meta-analysis was considered inappropriate, the characteristics of studies were summarized descriptively.

Quality assessment of included studies

In vitro studies form a pivotal role in dental research by contributing to a substantial evidence base. Thereby, these studies form the major proportion of research that is carried out and published in dentistry. For example, the fracture resistance of natural tooth following endodontic treatment or the compressive strength of composite resins cannot be studied clinically. The reporting standards of these studies are not uniform, thus resulting in lacunae in evidence reported. Krithikadatta J. with colleagues created standardized guidelines for improving quality and transparency in reporting *in vitro* studies in experimental dental research – Checklist for Reporting In-vitro Studies (CRIS) (16). In the publication, the authors declared that existing lacunae among *in vitro* studies that need to be addressed to promote quality and transparency of evidence could include the reporting of sample size calculation, meaningful difference between groups, sample preparation and handling, allocation sequence, randomization and blinding and statistical analysis. In our research, additional data of the included studies were collected: financial support and the patients' written informed consent for using their extracted teeth for research.

REVIEW

Number of included studies

The flowchart of the systematic review is shown in Figure. A total of 67 studies were obtained during the search process. The screening of titles and abstracts initially resulted in 4 articles, and 1 additional article was received from authors upon request (17). In total, 5 studies were included in this review and processed for data extraction (1, 3, 7, 11, 17) (Figure).

Characteristics of articles

All articles involved in this review were experimental *in vitro* laboratory studies. Main characteristics of the studies are summarized and presented in Table 1. Full details of the included studies, sorted by year ascending, are shown in Table 2.

The duration of experiments in the majority of the studies was 7-14 days (n=354; 83.11%). Most frequently, maxillary molars teeth and MOD cavity preparation design were used (n=296; 69.48% and n=204; 47.89%, respectively). Generally, root canals were prepared using rotary instruments (n=386; 90.61%), irrigated with sodium hypochlorite solution (n=394; 92.49%), and calcium hydroxide was used as intracanal medication (n=264; 61.97%). All specimens were stored in 37^{o}C temperature and humidity: in water (n=32; 7.51%) (3), in 100% humidity (n=40; 9.39%) (7), in water-soaked foam material (n=132; 30.98%) (11), in sterile Ringer's solution (n=132; 30.98%) (1) and in normal saline (n=90; 21.14%) (n=90; 21.14%) (17). In two studies, additional compression static loading was used (n=130; 30.52%) (Table 1).

Materials used in the included studies:

1. Zinc oxide eugenol-base materials: Zinc oxide eugenol (ZOE), Skanderborg Pharmacy, Skanderborg, Denmark (3); *Zonalin*, Kemdent, Wiltshire, UK (17); *IRM*, Dentsply Caulk, Germany (17).
2. Ready to use, eugenol-free materials: *Coltosol*, *Coltene*, Whaledent, USA (17); *Coltosol®F*, *Coltene* Whaledent, USA (1, 3, 11); *Cimpat N*, Septodont, Saint Maur des Fosses, France (7); *Bioplic*, Biodinamica Ltda, Ibipora, Brazil (7).
3. Glass ionomer cements (GIC): *Vidrion R*, SS White, Petropolis, Brazil (7); *Fuji II LC*, RMGI, GC America, Inc. (17).
4. Composite: *Clearfill™ Core*, Kuraray Europe GmbH, Frankfurt/Main, Germany (1, 11).

Ready to use, eugenol-free temporary filling materials (*Coltosol*, *Coltosol®F*, *Cimpat N*, *Bioplic*) were evaluated in all included studies. They were compared with each other (*Cimpat N* vs. *Bioplic* (7)), with zinc oxide eugenol-based materials (*Coltosol®F* vs ZOE (3) , *Coltosol* vs. *Zonalin* and vs. *IRM* (17)), with composite (*Coltosol®F* vs. *Clearfill™ Core* (1,11)) and with GIC (*Cimpat N* and *Bioplic* vs. *Vidrion R* (7), *Coltosol* vs. *Fuji II LC* (17)). The majority of the studies evaluated materials as *Coltosol* or *Coltosol®F* (n=386; 90.6%) (1, 3, 11, 17).

In all studies, teeth cracks and fracture lines were evaluated using optical devices with magnification. Teeth with cracks that might have been caused by excessive force during extraction, storage, occlusal forces or restorative procedures were excluded from the biggest part of the studies and replaced with new ones (n=354; 83.1%) (1, 11, 17) (Table 2).

Quality Assessment of Included Studies

Evaluating the quality of the included studies, we observed that the majority of the studies met all CRIS requirements. Full details of the quality of the included studies are shown in Table 3.

All the studies declared statistical analysis of the results. The only article written by Bello Y. and his coauthors stated that their research data were normally distributed according to the normality test

(Kolmogorov-Smirnov, p>0.05) and why the appropriate statistical methods were used (7). In three surveys carried out by Tennert C. and Milani A. with colleagues, it was declared that there was consultation with statisticians on the application of appropriate statistical methods, which increases the value of these publications (1, 11, 17). Although none of those studies accurately quantified the sample and why a certain number of teeth was selected, there may appear a risk of distortion of the research results (18). The quality of Laustsen M.H.'s and coauthors' publication is not very high in CRIS because of a lack of information on study blindness, randomization and why appropriate statistical methods were used; small sample size groups reduce the value of this publication (19).

DISCUSSION

To the extent of the authors' knowledge, this registered systematic review is the first to present a comparison of the influence of temporary filling materials on dental cracks and fractures during endodontic treatment.

Table 2. Articles included in the systematic review and overall findings

No.	Author, year, place, reference	Sample size (number of groups), study duration	Tooth type, cavity form	Material	Method	Conclusion	CRIS quality requirements
1.	Laustsen M.H. *et al.*, 2005, Denmark, Sweden (3)	32 (2), 20 days	Molars (U, L) MOD	*Coltosol®F*, ZOE	Humidity, 37ºC	Hygroscopic expansion of *Coltosol®F* in a cavity may lead to cusp deflection, infraction development and fracture.	-
2.	Bello Y. *et al.*, 2014, Brazil, United States, Singapore (7)	40 (4), 40 days	Premolars, (U) MOD	*Cimpat N*, *Bioplic*, *Vidrion R*	Humidity, 37ºC, Compression static loading	Glass ionomer cement *Vidrion R* presented the higher fracture resistance.	+
3.	Tennert C. *et al.*, 2015, Germany (11)	132 (4), 14 days	Molars (U, L) MOD	*Coltosol®F*, *Coltosol®F* 2 mm + *Clearfill™ Core, Clearfill™ Core*	Humidity, 37ºC	*Coltosol®F* when used alone as a restorative material, led to tooth fractures in Class II cavities in teeth undergoing root canal treatment.	+
4.	Tennert C. *et al.*, 2016, Germany (1)	132 (4), 14 days	Molars (U, L) OD	Coltosol®F, Coltosol®F 2 mm + *Clearfill™ Core, Clearfill™ Core*	Humidity, 37ºC	*Coltosol®F* when used alone as a restorative material led to tooth fractures in two-surface Class II cavities in teeth undergoing root canal treatment.	+
5.	Milani A. *et al.*, 2016, Iran (17)	90 (6), 7 days	Premolars, (U) MO	*IRM, Coltosol, Zonalin, Fuji II LC*	Humidity, 37ºC, Compression static loading	Resin-modified glass ionomer could be the first choice for short-term temporary restoration of endodontically treated teeth.	+

U – upper jaw; L – lower jaw; MO – mesial-occlusal; MOD – mesial-occlusal-distal; OD – occlusal-distal; ºC – Celsius temperature scale; "+" – meet all CRIS requirements; "-" – don't meet all CRIS requirements.

Table 3. Quality of included studies, following CRIS requirements

No.	Author, year, reference	Sample size calculation	Meaningful difference between groups	Sample preparation and handling	Allocation sequence, randomization and blinding	Statistical analysis
1.	Laustsen M.H. *et al.*, 2005 (3)*	+/-	+	+	-	+/-
2.	Bello Y. *et al.*, 2014 (7)*	+/-	+	+	+	+
3.	Tennert C. *et al.*, 2015 (11)**	+/-	+	+	+	+
4.	Tennert C. *et al.*, 2016 (1)**	+/-	+	+	+	+
5.	Milani A. *et al.*, 2016 (17)	+/-	+	+	+	+

* – financial support and acknowledgement are not specified. ** – patients gave their written informed consent for using the extracted teeth for research. "+" – data available; "-" – data are not available; "+/-" – data partially annotated.

Despite considerable heterogenicity in the selected studies regarding the research design and methods, all studies represented that a temporary filling material used for coronal sealing during endodontic treatment may cause tooth cracks and fractures. Therefore, the choice of temporary restorative material should be done with great care until tooth will be restored finally. *Coltosol®F* has been chosen often as temporary filling material because of its easy handling and removal properties. In the Laustsen *et al.* study, ZOE was chosen as control material because of modest dimensional changes during setting and water absorption (3). The fracture frequency of teeth filled with *Coltosol®F* and ZOE differed significantly. It was concluded that hygroscopic expansion of *Coltosol®F* in a cavity may lead to cusp deflection, infraction development and fracture, and masticatory forces could strengthen this effect *in vivo*. These results have been confirmed by Laustsen et al's study *in vivo*, in which tooth fractures occurred in root-filled teeth with occlusal *Coltosol®F* fillings (3), as well as in Srivastava et al's *in vitro* study, in which fracture occurred in *Coltosol*-subjected groups due to the expansion of material in cuspal regions (10). It should be noted that the use of ready-to-use, eugenol-free temporary filling materials (*Coltosol*, *Coltosol®F*, *Cimpat N*, *Bioplic*) has been investigated in all studies included in this review. These materials had significantly higher incidence on filling or tooth cracks and fractures due to the absorption of moisture (1, 3, 11), the lowest fracture (*Bioplic*) and flexural strength (non-eugenol cement, *Cimpat N*) (7) and the lowest fracture resistance, compared to GIC (*Fuji II LC*) or intact teeth (17).

Previous studies have investigated the effect of expansion of a filling material to the tooth, and it was found that filling material and tooth fractures occurred at different times (1, 3, 11). One study made by Tennert *et al.* declared that after 24 h, a high prevalence of fractures (64%) within the filling material was observed in the *Coltosol®F* group. After 5 days, no further cracks could be observed. At the end of the observation time, 85% teeth had cracks within the *Coltosol®F* group. The first tooth fractures were observed after 4 days. At the end of the experiment (14 days), 39% of teeth had tooth fractures. It was concluded that tooth fractures occurred up to 4 days after the placement of the temporary filling (11). Another study, made by Tennert *et al.,* also found that fractures occurred at different time intervals. After 24 h, all restorations in the *Coltosol®F* group showed cracks of the filling material, and after 14 days, a total of 76% teeth had fractures. The majority of fractures (70%) were observed within the first 5 days after placement of the filling, with a peak on day 3 of the observation period (1). In the Laustsen *et al.* study, it was found that in teeth filled with *Coltosol®F*, the number of infractions increased through the entire test period (20 days), concluding that *Coltosol®F* material is not recommended for temporary filling in root-filled teeth except for a few days (3).

The previous studies indicate that the most commonly fractured teeth *in vivo* were the mandibular molars and maxillary premolars (15, 20). Mamoun *et al.* declared that maxillary premolars, which often have steep inclines on nonfunctional cusps that result in torque forces during mastication, are more likely to crack than mandibular premolars, which experience mostly compression forces due to opposing teeth occluding into the mandibular premolar buccal cusps (15). A literature review by Lubisich *et al.* found that most of the studies reporting on the incidence and prevalence of incomplete tooth fractures agreed that cracked teeth were significantly associated with intracoronal restorations and were most prevalent in mandibular molars (21). This aspect gives added value to our study because all specimens in our study were molars or upper premolars.

Tooth cracks have been shown to be the third largest cause of tooth loss after dental caries and periodontal disease (22). The probability of tooth fracture increases when the cavity appears. It can also be affected by the cavity's shape, size and dimensions and occlusal masticatory forces. In fact, premolar fracture strength decreases up to 55% when teeth with MOD preparation undergo root canal treatment (7). In several studies included in our review, half of specimens were prepared with MOD cavities (3, 7, 11), and this could have had an effect on the final results of our study as Tennert *et al.* showed that MOD cavities significantly weaken cuspal rigidity by 63% (13). The methodology of the study did not followed the manufacturer's instructions for the use of *Coltosol®F*, where it is stated that the material should not be placed on multiple areas nor extended under the gingiva (13).

Root-filled teeth are more prone to tooth loss than teeth with vital pulps. To increase the prognosis and outcome of endodontic therapy, root canal-treated teeth should be restored with final restoration as soon as possible. According to Srivastava *et al.,* one of the most important factors in predicting the prognosis and outcome of endodontic therapy is the type and quality of crown restoration (10). Atreya S. *et al.* and Laustsen M.H. *et al.* denoted that occlusion factors, time periods between visits, thickness and placement methods of temporary filling material had a significant impact on dental cracks (3, 23). Additional factors such as preparation of an access cavity, root canal instrumentation, irrigation, medical dressings, additional medial or distal cavities, thickness of the cavity walls, collagen degradation caused by $Ca(OH)_2$, removal of filling materials, etc. may weaken the stiffness of the tooth or the dental hard tissues (1, 3). Zarow *et al.* found that teeth were more prone to tooth loss than teeth with vital pulps due to individual factors such as gender, occlusion, parafunctions, antagonist occlusal surface, oral hygiene or saliva flow, which also can influence the tooth prognosis of restored teeth (8). Kishen *et al.* also confirmed that there are many iatrogenic and non-iatrogenic factors that could affect cracking or fracturing of endodontically treated teeth (24). All the studies were performed *in vitro*, so the additional risk and individual factors *in vivo* can increase that possibility (3, 11).

There is no evidence-based material or guidelines for temporary filling during endodontic treatment. Most authors suggested GIC (7), *Fuji II LC* (17), and *Clearfill[TM]Core* (1, 11). According to Baba *et al.,* zinc oxide eugenol or calcium sulfate-based temporary restorations protect the root canal system from reinfection for a short period of time, while glass-ionomer or resin-modified glass-ionomer protect for a longer period of time (25). Studies have shown that materials such as GIC (7) or composite (11) bond to the tooth structure and have the potential to increase fracture resistance upon compressive stress. GIC presented the higher fracture resistance compared to ready-to-use, eugenol-free temporary filling materials (*Cimpat N, Bioplic*), and this should be considered when selecting a temporary material to restore highly weakened teeth subjected to direct occlusal loads (7).

The limitations of this systematic review are that in all included studies, only one or two risk factors were analyzed, which could influence dental cracks and fractures due to temporary filling during endodontic treatment; although, there are much more aforementioned factors that can influence tooth cracks and fractures. In several included studies, no load was applied to the specimens (1, 3, 11). In the case that masticatory load would be applied to the restored teeth, the incidence of fractures within the filling material and fractures of the tooth might increase (11). The sum of exposure risk factors *in vivo*, discussed earlier, may increase the risk of teeth cracks and fractures.

The results and differences between studies might depend on the different methodologies of the studies, and their clinical relevance is limited. To date, no standard methodology test design has been introduced. *In vitro* test design would be useful to imitate more conditions that are exposed in the oral cavity. A study on natural teeth must take into account the unique specificity of every tooth that can compromise the reproducibility of the results (pressure applied on more or less important volumes of dental tissues and filling material). Although the present results are based on *in vitro* studies, they provide evidence that may prepare the background for clinical studies and/or protocols. Laboratory studies are generally considered of low clinical relevance, but it is clear that their results are useful in the preclinical evaluation of new materials and to guide protocols for several clinical approaches, especially considering the absence of evidence from well-designed clinical trials in dentistry and particularly in endodontics (26).

CONCLUSION

Within the limitations of this systematic review, a temporary filling material during endodontic treatment may influence dental cracks and fractures. Highest impact for dental cracks and fractures has ready-to-use, eugenol-free temporary filling materials, whereas the least impact has GIC. This should be considered when selecting a temporary material to restore teeth undergoing root canal treatment.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

The authors state no conflicts of interest.

REFERENCES

1. Tennert C, Fischer GF, Vach K, Woelber JP, Hellwig E, Polydorou O. A temporary filling material during endodontic treatment may cause tooth fractures in two-surface class II cavities in vitro. Clin Oral Investig. 2016 Apr;20(3):615–20.
2. Savadkouhi ST, Bakhtiar H, Ardestani SE. In vitro and ex vivo microbial leakage assessment in endodontics: A literature review. J Int Soc Prev Community Dent. 2016;6(6):509–16.
3. Laustsen MH, Munksgaard EC, Reit C, Bjørndal L. A temporary filling material may cause cusp deflection, infractions and fractures in endodontically treated teeth.

Int Endod J. 2005 Sep 1;38(9):653–7.
4. Okayama S, Suzuki Y, Shimpo H, Ohkubo C. Fixation of magnet assembly to denture base using alternative resins. Dent Mater J. 2015;34(3):364–70.
5. Prabhakar AR, Shantha Rani N, V Naik S. Comparative Evaluation of Sealing Ability, Water Absorption, and Solubility of Three Temporary Restorative Materials: An in vitro Study. Int J Clin Pediatr Dent. 2017 Jun;10(2):136–41.
6. Chao-Tsang L, Lin, Jia-Horng. Mechanical Property Evaluation of Fiber-Reinforced and Fabric-Reinforced Zinc Oxide-Eugenol Temporary Filling Materials. Journal of Engineered Fabrics & Fibers (JEFF) . 2014, Vol. 9 Issue 2, p165-170. 6p.
7. Bello YD, Barbizam JV, Rosa V. Structural reinforcement and sealing ability of temporary fillings in premolar with class II mod cavities. J Contemp Dent Pract. 2014 Jan 1;15(1):66–70.
8. Zarow M, Ramírez-Sebastià A, Paolone G, de Ribot Porta J, Mora J, Espona J, et al. A new classification system for the restoration of root filled teeth. Int Endod J. 2018 Mar 1;51(3):318–34.
9. Naumann M, Metzdorf G, Fokkinga W, Watzke R, Sterzenbach G, Bayne S, et al. Influence of test parameters on in vitro fracture resistance of post-endodontic restorations: a structured review. J Oral Rehabil. 2009 Apr;36(4):299–312.
10. Srivastava PK, Nagpal A, Setya G, Kumar S, Chaudhary A, Dhanker K. Assessment of Coronal Leakage of Temporary Restorations in Root Canal-treated Teeth: An in vitro Study. J Contemp Dent Pract. 2017 Feb 1;18(2):126–30.
11. Tennert C, Eismann M, Goetz F, Woelber JP, Hellwig E, Polydorou O. A temporary filling material used for coronal sealing during endodontic treatment may cause tooth fractures in large Class II cavities in vitro. Int Endod J. 2015 Jan;48(1):84–8.
12. Carrotte P. Endodontics: Part 3 Treatment of endodontic emergencies. Br Dent J. 2004 Sep;197(6):299–305.
13. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions [Internet]. The Cochrane Collaboration, 2011. [cited 2018 Feb 9]. (Version 5.1.0). Available from: http://training.cochrane.org/resource/data-collection-forms-intervention-reviews
14. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009 Jul 21;6(7):e1000097.
15. Mamoun JS, Napoletano D. Cracked tooth diagnosis and treatment: An alternative paradigm. Eur J Dent. 2015;9(2):293–303.
16. Krithikadatta J, Gopikrishna V, Datta M. CRIS Guidelines (Checklist for Reporting In-vitro Studies): A concept note on the need for standardized guidelines for improving quality and transparency in reporting in-vitro studies in experimental dental research. J Conserv Dent JCD. 2014;17(4):301–4.
17. Milani AS, Froughreyhani M, Mohammadi H, Tabegh FG, Pournaghiazar F. The effect of temporary restorative materials on fracture resistance of endodontically treated teeth. Gen Dent. 2016 Feb;64(1):e1-4.
18. Suresh K, Chandrashekara S. Sample size estimation and power analysis for clinical research studies. J Hum Reprod Sci. 2012;5(1):7–13.
19. Faber J, Fonseca LM. How sample size influences research outcomes. Dent Press J Orthod. 2014;19(4):27–9.
20. Roh B-D, Lee Y-E. Analysis of 154 cases of teeth with cracks. Dent Traumatol Off Publ Int Assoc Dent Traumatol. 2006 Jun;22(3):118–23.
21. Lubisich EB, Hilton TJ, FERRACANE J. Cracked Teeth: A Review of the Literature. J Esthet Restor Dent Off Publ Am Acad Esthet Dent Al [Internet]. 2010 Jun [cited 2019 Feb 8];22(3). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3870147/
22. Xie N, Wang P, Wu C, Song W, Wang W, Liu Z. Impact of cusp inclinations on dental fractures in cracked tooth syndrome model and relevant risk evaluation. Exp Ther Med. 2017 Dec 1;14(6):6027–33.
23. Atreya S, Patel B. Temporary and Interim Restorations in Endodontics. In: Endodontic Treatment, Retreatment, and Surgery [Internet]. Springer, Cham; 2016 [cited 2018 Feb 21]. p. 27–41. Available from: https://link.springer.com/chapter/10.1007/978-3-319-19476-9_2
24. Kishen A. Biomechanics of fractures in endodontically treated teeth. Endod Top. 2015 Nov 1;33(1):3–13.
25. Baba NZ, White SN, Bogen G. Restoration of Endodontically Treated Teeth. In: Endodontic Prognosis [Internet]. Springer, Cham; 2017 [cited 2018 Feb 9]. p. 161–92. Available from: https://link.springer.com/chapter/10.1007/978-3-319-42412-5_10
26. Silva Almeida LH, Moraes RR, Morgental RD, Pappen FG. Are Premixed Calcium Silicate-based Endodontic Sealers Comparable to Conventional Materials? A Systematic Review of In Vitro Studies. J Endod. 2017 Apr;43(4):527–35.

Received: 20 01 2020
Accepted for publishing: 25 09 2020