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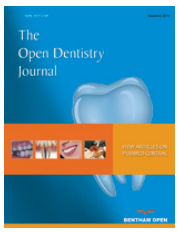

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REVIEW ARTICLE

Vertical Tooth Root Fracture Detection through Cone-beam Computed Tomography: An Umbrella Review Protocol Testing Four Hypotheses

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Abstract:

Detecting vertical root fractures represents an immense challenge for oral health professionals. One of the main tools used to detect this type of biological complication is the periapical radiograph. However, conventional radiography consists of two-dimensional imaging that is limited by the superimposition of bony structures that complicate the detection of root fractures. The alternative, a Cone-Beam Computed Tomography (CBCT) scan, cannot be prescribed in every case since radiation should be kept to a minimum as stipulated by the "As Low As Reasonably Achievable" (ALARA) principle. Therefore, to justify the use of a CBCT scan to detect a vertical tooth root fracture, the clinician must prove that it has significant benefits over traditional imaging. Since few systematic reviews have compared CBCT technology to traditional radiography for the diagnosis of vertical root fractures, it is of utmost importance in clinical practice, especially in endodontology and clinical dental medicine, where the available reviews are examined to generate a clinical recommendation. The four hypotheses of this protocol are that **(1)** CBCT is superior to traditional radiography for detecting vertical root fractures of vital teeth; **(2)** CBCT is superior to traditional radiography for detecting longitudinal root fractures of vital teeth with radiopaque restorations; **(3)** CBCT is superior to traditional radiography for detecting vertical root fractures of root-filled teeth without a radiopaque post that may cause artifacts; and **(4)** CBCT is superior to traditional radiography for detecting vertical root fractures of root-filled teeth with a radiopaque post regardless of its longitude. To test these hypotheses, all the current secondary resources related to the aim of this meta-review are evaluated. If there is sufficient evidence to support clinical decisions, then the appropriate recommendations will be formulated.

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1. INTRODUCTION

The definition of a vertical tooth root fracture is a longitudinally oriented fracture limited to the tooth root, extending from the pulp canal to the periodontium [1]. This type of fracture may involve the entire root length or only a portion of it. Fuss *et al.* [2] analyzed extracted root-filled teeth; those with a suspected root fracture represented a prevalence of up to 20%. In other words, detecting vertical root fractures is a considerable challenge for dental clinicians.

Conventional radiography consists of two-dimensional imaging that is limited by the superimposition of bony structures that complicate the detection of root fractures. One reason for this limitation is that the radiographic beam orientation and the plane of the fracture should be parallel [3, 4]. Another reason that leads to overlooking root fractures is that there may be a geometric distortion of the anatomic structures [5, 6]. As a result of these limitations, periapical radiographs may only detect one in three vertical root fractures [7]. Cone-Beam Computed Tomography (CBCT) consists of three-dimensional (3D) imaging and has been used in dental medicine with high accuracy and sensitivity [8 - 10]. In endodontology, CBCT modality is used more often; however, image artifacts related to root-filling and restorative materials may impede proper root fracture detection [11, 12].

There is no previously published umbrella review similar to the proposed review to appraise these imaging methods. A further purpose of this project is to facilitate diagnoses in dental medicine by educating policymakers, researchers, and clinicians [13] about vertical root fracture detection through CBCT. A preliminary search of the literature showed that there are a few published systematic reviews that study the determ-

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ination of possible vertical root fractures with CBCT. Moreover, there is a need to explore the disagreements between these analyses and produce appropriate clinical recommendations. Therefore, an over view of reviews is a valid study design [13, 14]. This review will provide the opportunity to contrast review findings when their objectives overlap, such as the differences assessed in the methods, the included studies, the assessed outcomes, and other factors associated with outcome differences. Complementary data from diverse reviews are compiled into a single source and essential disparities across reviews focusing on similar outcomes are identified.

An umbrella review (*i.e*., overview of reviews, or systematic review of systematic reviews) [15 - 18] enables the comparison of the aims, methods, and conclusions of the available systematic reviews related to this topic to develop a deeper understanding of the existing data regarding the diagnostic values of CBCT versus conventional imaging to detect vertical tooth root fractures.

2. STUDY METHODS

The present protocol describes the methodology for conducting the planned umbrella review. The methods were selected based on chapter 22 of the Cochrane Handbook, which discusses the methods for summarizing the reviews, [19] as well as the recommendations by Smith *et al*. [20]. Since the purpose of the present study is to compare the findings regarding the measures of surgical outcomes across reviews, Alfredo Jadad's framework for the assessment of conflicting reviews is also used [14, 21]. Furthermore, this review protocol is registered in the PROSPERO database (CRD42018067792), and has been prepared based on the PRISMA-P statement [22 - 24]. All the discrepancies between the protocol and the methodology applied in the review are reported as supplementary information in the analysis.

2.1. Research Questions

The focused review questions are answered by an overview of the review designs which are as follows: Is CBCT superior to traditional radiography for detecting vertical root fractures of vital teeth? Is CBCT superior to traditional radiography for detecting vertical root fractures of vital teeth with metallic restorations? Is CBCT superior to traditional radiography for detecting vertical root fractures of root-filled teeth without a metal post? Is CBCT superior to traditional radiography for detecting vertical root fractures of root-filled teeth with a metal post?

2.2. Inclusion Criteria

Selection criteria was prepared in terms of the population, intervention, comparison, outcome, settings, and study design (PICOSS) framework.

2.2.1. Population

Systematic reviews included patients with permanent human dentition with vertical fractured roots (unfilled and root-filled).

2.2.2. Intervention/Comparator

The intervention necessary for a study to be eligible for this over view of reviews was the use of CBCT as a diagnostic tool, where the comparator was any conventional two-dimensional radiograph (digital or film).

2.2.3. Outcomes

The established *a priori* eligibility criteria included sensitivity, specificity, positive predictive value, and negative predictive value of the detection of vertical root fractures.

2.2.4. Settings

No specific setting was included in this study.

2.2.5. Study Design

The present study is an overview of the available reviews, and the eligible study designs were limited to those reviews that used a systematic review design. Studies were considered as systematic reviews if they contained a systematic strategy description of at least one electronic literature database, specified a review question, and synthesized the information using a quantitative or qualitative approach. The studies not meeting these criteria were excluded from the overview.

2.3. Search Strategy

An advanced literature search was performed in MEDLINE *via* OVID (Table **1**), EMBASE *via* OVID, Cochrane Library, and Database of Abstracts of Reviews of Effects (DARE) until April 2019, without language or time restriction. An additional hand-search was carried out in the leading international journals in the field of dentistry, oral and maxillofacial radiology, and endodontology: *British Dental Journal, Clinical Oral Investigations, European Journal of Oral Sciences, Implant Dentistry, Journal of Endodontics*, and International Endodontic Journal, and Inter-national Endodontic Journal. Issues published from January 2016 to April 2019. The reference lists of the identified sys-tematic reviews were also checked for possible additional studies. At least three sources for grey literature were screened. The eligible studies were exported to an EndNote library where duplicates were removed prior to the parallel screening of abstracts and full articles.

Table 1. Advanced search history sorted by search number descending to be used in Medline *via* OVID search engine†.

Sr. No.	Searches
1	(longitudinal or vertical).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
2	root.mp.
3	exp "TOOTH ROOT"/
4	fracture*.mp.
5	*Tooth Fractures/
6	1 and (2 or 3) and 4
7	1 and 5

(Table 1) contd.....

Sr. No.	Searches
8	6 or 7
9	exp Cone-Beam Computed Tomography/
10	cbct.mp.
11	volume*.mp.
12	cone-beam.mp.
13	x-ray*.mp.
14	*X-Rays/
15	13 or 14
16	tomograph*.mp.
17	*TOMOGRAPHY/
18	16 or 17
19	scan.mp.
20	CAT.mp.
21	CT.mp.
22	comput*.mp.
23	11 or 12 or 15
24	18 or 19
25	20 or 21 or 22
26	23 and 24
27	23 and 25
28	24 and 25
29	26 or 27 or 28
30	(ability or accuracy or accurateness or capability or certainty or competence or competency or efficacy or efficiency or exactitude or exactness or performance or preciseness or sureness or truthfulness or veracity).mp.
31	exp DIAGNOSIS/
32	diagnos*.mp.
33	31 or 32
34	(analysis or assessment or appraisal or appraisement or detection or evaluation or examination or identification or interpretation).mp.
35	33 or 34
36	30 and 35
37	exp Meta-analysis as topic/
38	exp Meta-Analysis/
39	meta-analy*.mp.
40	metaanaly*.mp.
41	(integrative research or research integration).mp.
42	exp "REVIEW"/
43	systematic review*.mp.
44	overview*.mp.
45	(meta-review* or meta-overview* or meta-synthes* or technology assessment* or HTA or HTAs).mp.
46	exp Technology assessment, biomedical/
47	37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46
48	8 and 29 and 36
49	8 and 29 and 36 and 47

† Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions(R), from 1946 to date of search.

2.4. Study Selection

Two reviewers independently examined all the records identified from the database searches after going through their titles and abstracts. All the records considered as potentially eligible were fully screened. Any disagreement was settled through the consultation of a third reviewing author. A similar process was used to screen full texts. No piloting or calibration exercise was used. Following the PRISMA Statement recommendation, [25, 26] a flow diagram is presented to describe the study selection process [27]. The screening management was performed using EndNote software.

2.5. Data Collection

Each of the included studies examined the characteristics of the patients, teeth, and radiographic devices, as well as the imaging parameters used, the number of included primary studies, dates of literature searches, and eligibility criteria. Further synthesis of findings summarizing/contrasting these features concerning the primary studies that each review assessed may be considered.

Data extraction was performed by one reviewer and was confirmed by the second reviewer, with the involvement of a third reviewer to establish consensus whenever disagreements may be encountered. Microsoft Excel software was used to extract the data electronically from each review. Missing data was requested from the analysis in question or primary study authors [28].

2.6. Assessment of Methodological Quality

Methodological quality/risk of bias for the included studies was completed using the "risk of bias in systematic reviews" (ROBIS) tool [29]. The assessment of the rigor and reporting of included reviews was aided by displaying the ROBIS results in tables and graphs.

2.7. Data Summary

As mentioned above, the Cochrane Handbook chapter "Overviews of Reviews" was followed to summarize the findings [19]. It includes the use of traditional tables with characteristics and findings in addition to graphics. Also, the framework for discordant reviews by Alfredo Jadad was used to assess discrepancies among reviews [21].

A report of review methods was presented concerning the eligibility criteria, literature search details, meta-analytic statistics (if used), and rigor of review methods. The data reported by different reviews was assessed to identify similarities. For example, the date ranges of the studies considered in each review and the number of primary studies and teeth evaluated among reviews were compared. Additionally, there was a potential to generate a citation matrix, which could clearly display the similarities across reviews. Finally, a comparison of review findings and conclusions is presented.

2.8. Reporting of Review Findings

The meta-review is drafted as a manuscript for publication in a peer-reviewed journal in endodontics/endodontology and oral and maxillofacial radiology. The PRISMA statement was taken into consideration for proper and transparent reporting of this review [25 - 27]. Additionally, a PRISMA checklist was included as supplementary material to document completeness of reporting.

3. DISCUSSION

Vertical root fractures are common in the field of dental medicine [2]. To date, detecting these fractures with precision represents a considerable challenge for dental clinicians. In most cases, the diagnosis requires a combination of radiologic signs and clinical symptoms. Conventional radiography may help to detect about one-third of vertical root fractures [2, 30]. CBCT modality is known to be more accurate than conventional modality; however, image artifacts from restorative materials may limit root fracture detection. While there is literature supporting each radiographic modality over the other, there is also literature showing no differences between the methods [1, 3 - 6, 11]. Therefore, assessing the estimates of the diagnostic accuracy measures of both the modalities will help in the development of a clinical recommendation for dental practitioners.

Furthermore, an effort to identify the remaining gaps in the existing body of literature must be undertaken. There is a clear need to analyze the findings of several reviews available regarding CBCT versus conventional imagining in vertical root fracture identification and to fully comprehend the existing data, as well as to identify different areas and find a solution that may lead to a solid clinical recommendation.

There are an inherent number of challenges that the meta-review may encounter [13]. For instance, it may try to align different diagnostic values, definitions, and methodological approaches. Although *in vitro* studies on vertical root fractures constitute the majority of such studies, they have limited clinical application. Going forward, *in vivo* studies are better subjects for the such reviews [31].

CONCLUSION

The findings are published with the purpose of suggesting potential research directions and prospective modifications to enhance the imaging diagnosis of vertical tooth root fractures.

STANDARD OF REPORTING

This review protocol is registered in the PROSPERO database (CRD42018067792), and has been prepared based on the PRISMA-P statement.

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

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Declared none.

AUTHORS' CONTRIBUTIONS

KIA finalized the study research questions and the study design, prepared the first draft, reviewed and approved the final version of the study protocol. DM reviewed and approved the final version of the study protocol.

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