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[Intervention Review]

Interventions for the management of external root resorption

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ABSTRACT

Background

External root resorption is a pathological process, which tends to occur following a wide range of mechanical or chemical stimuli such as infection, pressure, trauma or orthodontic tooth movement. Although it is predominantly detected by radiography, in some cases root resorption may be identified by clinical symptoms such as pain, swelling and mobility of the tooth. Treatment alternatives are case-dependent and aim to address the cause of the resorption and aid the regeneration of the resorptive lesion.

Objectives

To evaluate the effectiveness of any interventions that can be used in the management of external root resorption in permanent teeth.

Search methods

The following electronic databases were searched: the Cochrane Oral Health Group Trials Register (to 14 October 2015), the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library*, 2015, Issue 9), MEDLINE via OVID (1946 to 14 October 2015) and EMBASE via OVID (1980 to 14 October 2015). We searched the US National Institutes of Health Trials Register (<http://clinicaltrials.gov>) and the WHO Clinical Trials Registry Platform for ongoing trials. No restrictions were placed on the language or date of publication when searching the electronic databases.

Selection criteria

We included randomised controlled trials of permanent teeth with any type of external root resorption, which has been confirmed by clinical and radiological examination, comparing one type of intervention (root canal medications and canal filling, splinting or extraction of teeth or the surgical removal of any relevant pathology) with another, or with placebo or no treatment.

Data collection and analysis

Two review authors screened search records independently. Full papers were obtained for potentially relevant trials. If data had been extracted, the statistical guidelines set out in the Cochrane Handbook would have been followed.

Main results

No randomised controlled trials that met the inclusion criteria were identified. However, we identified one ongoing study that is potentially relevant to this review and will be assessed when it is published.

Authors' conclusions

We were unable to identify any reports of randomised controlled trials regarding the efficacy of different interventions for the management of external root resorption. In view of the lack of reliable evidence on this topic, clinicians must decide on the most appropriate means of managing this condition according to their clinical experience with regard to patient-related factors. There is a need for well designed and conducted clinical trials on this topic, which conform to the CONSORT statement (www.consort-statement.org/).

PLAIN LANGUAGE SUMMARY

Interventions for the management of external root resorption

Review question

This review has been conducted to assess different interventions for managing the reabsorption of the tooth root.

Background

External root resorption is when the body's own immune system dissolves the tooth root structure. It can occur following tooth infection, orthodontic treatments or in the presence of unerupted teeth in the jaw. Although this condition does not usually produce symptoms, external root resorption may result in movement of the tooth and, if not diagnosed and treated at an early stage, might eventually result in the tooth falling out. Despite this condition being quite common, treatment is generally on a case-by-case basis and there is a lack of evidence regarding the best treatments.

Study characteristics

Authors from the Cochrane Oral Health Group carried out this review of existing studies, and the evidence is current up to 14 October 2015. There were no studies found that met the inclusion criteria for this review.

Key results and quality of the evidence

This review revealed that there is no evidence for the effectiveness of available treatments and there is therefore a need for further research to help clinicians and patients to make informed choices about treatment options.

BACKGROUND

Resorption of the root of a permanent tooth is a pathological process that can occur inside the tooth (internal resorption), or on the outer surface of the tooth (external root resorption) and can ultimately lead to loosening of the tooth and its early loss. External root resorption (ERR) occurs when the cementoblastic layer or other tooth tissue on the root surface are either damaged or removed ([Leach 2001](#)).

Classification

There is some uncertainty over the most appropriate way of classifying ERR and several methods have been proposed and used. The classical approach divides ERR into three subgroups: surface resorption; inflammatory resorption and replacement (ankylosis) resorption but this classification was based on root resorption following traumatic injuries ([Andreassen 1985](#)). Classification of ERR by its clinical and histological appearance, i.e. external surface resorption, external inflammatory root resorption, replacement resorption and ankylosis has also been recommended ([Ne 1999](#)).

A further classification, which is based on factors that may act as a stimulus for resorption, has been shown to be useful in helping clinicians to diagnose and treat ERR. It classifies root resorption due to: pulpal (tooth nerve) or periodontal (gum) infection; orthodontic tooth movement; impacted tooth or tumour pressure and as result of tooth ankylosis ([Fuss 2003](#)). Moreover, a recent review has proposed a new category of tooth resorption entitled hyperplastic invasive cervical resorption, which is said to have either an internal or external origin, and the potential predisposing factors to this condition include trauma, orthodontic treatment and intracoronary bleaching. There are also some rare tooth resorptions of unknown cause that do not fit into any of the above categories and they are usually labelled 'idiopathic' ([Heithersay 2007](#)).

Diagnosis

Whichever classification is used, early diagnosis is a critical factor in the management of ERR because the sooner treatment is initiated, the less severe the long-term consequences of resorption ([Da Silveira 2007](#)). Diagnosis should be based on a combination of radiographic and clinical examination. Intraoral radiographs of the lesion usually show an uneven root surface outline, and radiographs obtained at different angles may be useful to determine which surface is affected ([Bergmans 2002](#)). Vitality testing may also be helpful in detecting the type of ERR ([Fuss 2003](#); [Nance 2000](#)).

Recent studies have indicated that computerised tomography may be a useful diagnostic tool, particularly in detecting small and less accessible root resorption, due to its higher sensitivity and specificity ([Da Silveira 2007](#)). Diagnosis should also seek to differentiate between ERR and internal root resorption (IRR) ([Carrotte 2004](#)).

Description of the condition

External root resorption tends to occur more frequently in people aged between 21 and 30 years (28.40%) and is more common in females (59.04%) than males ([Opacic 2004](#)). Trauma, previous periodontal surgery, pressure from adjacent unerupted teeth and pathological conditions such as tumours as well as tooth re-implantation have all been implicated as aetiological factors

([Opacic 2004](#); [St George 2006](#)). Orthodontic tooth movement may also play a role in ERR, especially where the forces applied to induce tooth movement are not controlled, and in these situations the resorption usually occurs in the apical third of the root ([Abuabara 2007](#)). Root resorption may also occur as a result of systemic disease and endocrine disorders, i.e. hyperparathyroidism, Paget's disease, calcinosis, Gaucher's disease and Turner's syndrome, as well as after radiation therapy ([Carrotte 2004](#)). However, it is generally accepted that, in the majority of cases, two factors, injury and stimulation, are required to initiate root resorption ([Fuss 2003](#)).

Description of the intervention

Treatment alternatives depend on the type and extent of resorption and may include symptomatic treatment for relief of pain and swelling and the stabilisation of any mobile teeth, if appropriate ([Trope 2000](#)).

If there is pulpal involvement, endodontic therapy together with surgery to remove the granulation tissue and filling of the resorptive defect may be required ([Fuss 2003](#)). Root canal medications and intracanal cements, such as MTA, have also been used in an attempt to arrest the resorptive process and provide an apical seal for the tooth ([Gulsahi 2007](#)).

If the root resorption is extensive and the cervical margin (adjacent to the gum) is involved with the most apical parts of the root, the treatment is usually more complicated, and not infrequently, extraction may be the only option ([Fuss 2003](#); [Gulsahi 2007](#); [Trope 2002](#)).

If it has occurred as a result of pressure from an unerupted tooth or erupting teeth or during orthodontic treatment and there is no sign of infection, removal of the tooth or pressure will usually stop further root resorption ([Heithersay 2007](#)). However, if teeth are severely mobile after completion of orthodontic treatment, splinting may be required.

In case of hyperplastic invasive cervical resorption, due to its invasive nature, total removal or inactivation of the resorptive tissue via chemical approach or surgical modalities is essential ([Heithersay 2007](#)).

As for replacement resorption (ankylosis), the treatment will depend on the stage of tooth development, the severity of trauma and the extent of periodontal ligament necrosis. In younger people, there is a greater chance of early tooth loss followed by ridge resorption, and therefore a need for the clinician to consider timely and appropriate management of the resorptive process. This may involve regenerative treatments, orthodontic space closure, or ultimately extraction of the ankylosed tooth followed by bone augmentation ([Sapir 2008](#)).

Currently there is no consensus on the management of the different forms of external root resorption ([Fuss 2003](#); [Majorana 2003](#)).

OBJECTIVES

The objective of this review is to evaluate the effectiveness of any interventions that can be used in the management of external root resorption in permanent teeth.

METHODS

Criteria for considering studies for this review

Types of studies

Only randomised controlled clinical trials (RCTs) were considered in this review.

Types of participants

Participants with single and multiple permanent teeth with evidence of any type of external root resorption irrespective of its aetiology, and confirmed by clinical and radiological examination.

Types of interventions

Root canal medications and canal filling, splinting or extraction of teeth or the surgical removal of any relevant pathology, in comparison with each other, or placebo or no treatment.

Types of outcome measures

Primary outcomes

- (1) Change in the amount of root resorption visible on radiological examination.
- (2) The number of teeth extracted at any follow-up period.

These additional primary outcomes were considered if studies included patients with acute symptoms:

- (1) Pain/discomfort: patient-assessed using any recognised validated pain scale
- (2) Tooth mobility
- (3) Infection (abscess, inflammation, fistulae).

Secondary outcomes

- (1) Number of visits.
- (2) Any self-assessed quality of life or patient satisfaction outcome evaluated with a validated questionnaire.

Adverse effects

We intended to report on any adverse effects related to any of the interventions or control.

Search methods for identification of studies

For the identification of studies included or considered for this review, we developed detailed search strategies for each database searched. These were based on the search strategy developed for MEDLINE (OVID) but revised appropriately for each database. The search strategy used a combination of controlled vocabulary and free text terms and was linked with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials (RCTs) in MEDLINE: sensitivity maximising version (2008 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of the *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011) (Higgins 2011). Details of the MEDLINE search are provided in [Appendix 1](#). The search of EMBASE was linked to the Cochrane Oral Health Group filter for identifying RCTs.

Electronic searches

We searched the following electronic databases:

- The Cochrane Oral Health Group's Trials Register (to 14 October 2015) (see [Appendix 2](#));
- The Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library*, 2015, Issue 9) (see [Appendix 3](#));
- MEDLINE via OVID (1946 to 14 October 2015) (see [Appendix 1](#));
- EMBASE via OVID (1980 to 14 October 2015) (see [Appendix 4](#)).

No restrictions were placed on the language or date of publication when searching the electronic databases.

Searching other resources

All the references lists of the included studies would have been checked manually to identify any additional studies.

Ongoing trials

We searched the following databases for ongoing trials (see [Appendix 5](#) for information):

- US National Institutes of Health Trials Register (<http://clinicaltrials.gov>) (to 14 October 2015);
- The WHO Clinical Trials Registry Platform (<http://apps.who.int/trialsearch/default.aspx>) (to 14 October 2015).

Handsearching

We handsearched the following journals for this review:

- *Shahid Beheshti Medical University Dental Journal* (1990 to 2009);
- *Journal of Mashad Dental School* (from inception to 2009);
- *Journal of Islamic Dental Association* (from inception to 2009);
- *Journal of Dentistry Shiraz University of Medical Sciences* (from inception to 2009);
- *Iranian Journal of Endodontics* (from inception to 2009).

Data collection and analysis

Selection of studies

Two review authors, Mina Mahdian (MM) and Zbys Fedorowicz (ZF), independently assessed the titles and the abstracts of studies identified in the searches. Full copies of all potentially relevant trials, those appearing to meet the inclusion criteria, or for which there were insufficient data in the title and abstract to make a clear decision, were obtained. The full-text papers were assessed independently and any disagreement on the eligibility of trials was resolved through discussion and consensus, or if necessary through a third party, Mona Nasser (MN). All potentially relevant studies that failed to meet the eligibility criteria were excluded and the reasons for their exclusion noted in the [Characteristics of excluded studies](#) section of this review.

Data extraction and management

Although no studies were included in this review, in the event that future studies are identified and included in updates, the following methods of data extraction and management will apply.

Study details will be collected using a pre-determined form designed for this purpose and entered into the Characteristics of included studies table. Two review authors (MN and ZF) will independently extract the relevant data. Any disagreements will be resolved by consulting with a third author (Zohreh Ahangari (ZA)).

The following trial details will be extracted.

(1) Trial methods:

- (a) method of allocation
- (b) masking of participants and outcome assessors
- (c) exclusion of participants after randomisation and proportion of losses at follow-up.

(2) Participants:

- (a) demographic characteristics including symptoms of external root resorption
- (b) source of recruitment
- (c) country of origin
- (d) sample size
- (e) age
- (f) sex
- (g) inclusion and exclusion criteria as described in the 'Criteria for considering studies for this review' section of this protocol.

(3) Intervention:

- (a) type of intervention
- (b) duration and length of time in follow-up.

(4) Control:

- (a) type of control or placebo or no treatment
- (b) duration and length of time in follow-up in the control group.

(5) Outcomes:

- (a) primary and secondary outcomes as described in the outcome measures section of this review.

Any sources of funding reported in the included trials will be noted. This information will be used to help assess heterogeneity and the external validity of the trials.

Assessment of risk of bias in included studies

Although we did not identify any relevant randomised controlled trials, we plan to apply the following methods for assessing risk of bias if further studies are identified in future updates.

Two review authors (MN and ZA) will grade the selected trials using a simple contingency form following the domain-based evaluation described in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). The evaluations will be compared and any disagreements between the review authors discussed and resolved.

The following domains will be assessed as low, high or unclear risk of bias:

1. sequence generation;
2. allocation concealment;
3. blinding (of participants, personnel and outcome assessors);
4. incomplete outcome data;
5. selective outcome reporting;
6. other sources of bias.

These assessments will be reported for each individual study in a 'Risk of bias' table.

After assessment the included studies will be grouped accordingly.

(A) Low risk of bias (plausible bias unlikely to seriously alter the results): if all criteria were met.

(B) Unclear risk of bias (plausible bias that raises some doubt about the results): if all criteria were at least partly met or are unclear.

(C) High risk of bias (plausible bias that seriously weakens confidence in the results): if one or more criteria were not met as described in Section 8.7 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

Measures of treatment effect

The data would have been analysed by MN and ZF using Review Manager (RevMan) 5 and reported as outlined in Chapter 9 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

In general, for continuous data, we would have calculated the mean difference and 95% confidence intervals. Risk ratios and their 95% confidence intervals would have been calculated for all dichotomous data.

Assessment of heterogeneity

We planned to assess clinical heterogeneity by examining the characteristics of the studies: the similarity between the types of participants, the interventions and the outcomes as specified in the criteria for included studies. Statistical heterogeneity would have been assessed using a Chi² test and the I² statistic where I² values over 50% indicate moderate to high heterogeneity (Higgins 2003).

Assessment of reporting biases

Whilst recognising its limitations, if a sufficient number of randomised controlled trials had identified, we would have assessed publication bias using a funnel plot (Egger 1997).

Data synthesis

We planned to pool the results of clinically and statistically homogeneous trials to provide estimates of the effects of the interventions. If the studies had similar interventions received by similar participants, the fixed-effect model would have been used. In the case of substantial heterogeneity between the studies, we intended to use the random-effects model provided there were more than three studies in the meta-analysis.

In the event that there were insufficient clinically homogeneous trials for any specific intervention or insufficient study data that can be pooled, a narrative synthesis would have been presented.

Subgroup analysis and investigation of heterogeneity

If sufficient data were available, we had intended to conduct the following subgroup analyses: participant age group and severity of external root resorption.

Sensitivity analysis

If a sufficient number of trials had been included in this review, we planned to conduct sensitivity analyses to assess the robustness of our review results by repeating the analysis with the following adjustments: exclusion of studies with unclear or inadequate allocation concealment, unclear or inadequate blinding of outcomes assessment and completeness of follow-up.

RESULTS

Description of studies

Results of the search

Our search strategy identified 70 titles and abstracts of studies, which were independently assessed for relevance by two of the review authors (Mina Mahdian (MM) and Zbys Fedorowicz (ZF)) and all were subsequently excluded from further analysis.

We also ran a free-text search on Google Scholar for any further potentially eligible trials, which resulted in the identification of eight publications (seven clinical trials (Acar 1999; El-Bialy 2004; Gibson 2008; Owman-Moll 1995; Owman-Moll 1996; Owman-Moll 1998; Schjott 2005) and one review article (Heithersay 2007)) and one ongoing study (NCT00423956). Full-text copies of these studies were obtained from the Internet, and the Cochrane Collaboration Oral Health Group (CCOHG) and were then subjected to further assessment. We also checked the bibliographical references of these papers for any relevant studies and found another review article (Killiany 2002), which provided another study (Levander 1994) for which we sought the full-text copy and considered for further evaluations. Handsearching of the five Iranian dental journals did not retrieve any eligible studies. We also contacted experts on this subject directly or via the CCOHG's Managing Editor for any possible studies and failed to retrieve any further unpublished or ongoing relevant trials.

Included studies

We did not find any studies suitable for inclusion.

Excluded studies

The Schjott 2005 trial was excluded as it assessed the regenerative effect of Emdogain on avulsed teeth. We also excluded the Gibson 2008 study as it compared the quality of canal obturation radiographically via two methods of calcium hydroxide dressing.

Of the remaining reports, all of which assessed different treatment options for root resorption induced by orthodontic treatment, one study (Owman-Moll 1995) failed to provide an explicit report of the efficacy of the intervention in terms of the incidence and severity of root resorption, and was excluded.

Another study (Owman-Moll 1996) compared the effect of two orthodontic forces (50 cN and 200 cN) on tooth movement and severity of root resorption. This evaluation was carried out on sound teeth without any evidence of initial root resorption and therefore this study was subsequently excluded. The Acar 1999 trial, which assessed the effect of continuous and discontinuous orthodontic force application on the incidence and severity of root resorption, was also conducted on sound teeth and although the treatment allocation was randomised, it did not fulfil all the inclusion criteria and was excluded.

In a further trial (Owman-Moll 1998), 16 patients with initial orthodontically induced root resorption were divided into two groups and subjected to either two to six or three to seven weeks of retention period. This study was designed to assess the reparative pattern of root resorption regarding type and location and since it did not provide any relevant outcomes, it was excluded.

The El-Bialy 2004 and Levander 1994 trials were also excluded. Details on these along with the rest of the excluded studies are provided in the [Characteristics of excluded studies](#) table.

Ongoing studies

We also found an ongoing study (NCT00423956), which will be followed and reported if relevant.

Risk of bias in included studies

No trials were included.

Effects of interventions

None of the studies fulfilled our inclusion criteria and therefore no data analysis was conducted.

DISCUSSION

External root resorption may seriously compromise the longevity of a tooth to such an extent that it may result in its early loss. It is, therefore, important that diagnosis and treatment occur at an early stage. Many studies have been conducted to assess different treatment alternatives for this pathological process, however our comprehensive search did not reveal any reports of eligible randomised controlled trials (RCTs). We identified one non-randomised clinical trial that assessed the healing effect of low-intensity pulsed ultrasound (LIPUS) on orthodontically induced root resorption (OIRR) in human premolars. This application was based on the anti-inflammatory effect and osteogenic stimulatory effect of the ultrasonic waves (El-Bialy 2004). There is an ongoing randomised controlled trial (retrieved from <http://clinicaltrials.gov/>) that is currently recruiting patients. This randomised controlled trial builds on a previous study (El-Bialy 2004) and aims to evaluate the effect of different treatment protocols of LIPUS on the healing process of orthodontically induced tooth-root resorption due to torque (complex) type of tooth movement. The review authors are following this study and awaiting its completion to consider for further assessment (NCT00423956).

A previous non-Cochrane systematic review was conducted to assess the possible aetiological factors and introduced an aetiology-related classification of external root resorption (ERR) (Segal 2004). We also identified several narrative reviews, which suggested various treatment options depending on the aetiology and type of root resorption. However, this systematic review illustrates that there is no reliable source of evidence regarding the most appropriate means of treating this pathological phenomenon. Treatment selection is basically case-dependent and very much related to the clinician's experience or an expert's opinion. The absence of relevant RCTs on this issue might be because various types of ERR respond to different treatment options and in many cases are asymptomatic so incidence may easily be underestimated. Moreover, our diagnostic tools do not fulfil the accuracy required for the diagnosis since they provide two dimensional images.

AUTHORS' CONCLUSIONS

Implications for practice

There is little evidence relevant to this review question, only case report studies and some empirical trials. In the absence of any

evidence from randomised controlled trials, clinicians should base their decisions on clinical experience in conjunction with patients' preferences where appropriate.

Implications for research

Although there would appear to be a need for robust clinical trials to evaluate the efficacy of interventions for the management of external root resorption, future randomised controlled trials might focus more closely on specific treatment options for specific categories of external root resorption and include comparisons of different treatment alternatives or no treatment in each group accordingly. Any further trials that are conducted should be robust,

well designed and reported according to the CONSORT statement (www.consort-statement.org/).

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Trope M. Luxation injuries and external root resorption - etiology, treatment, and prognosis. *Journal of the California Dental Association* 2000;**28**(11):860-6.

Trope 2002

Trope M. Root resorption due to dental trauma. *Endodontic Topics* 2002;**1**:79-100.

CHARACTERISTICS OF STUDIES

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Acar 1999	This study was carried out on sound teeth, i.e. without initial root resorption.
El-Bialy 2004	Non-randomised, histological outcomes reported.
Gibson 2008	This study compared two methods of calcium hydroxide dressing in traumatised teeth and assessed the quality (i.e. density and length) of canal obturation radiographically; hence it failed to report the proper outcomes considered for the review.
Levander 1994	Insufficient data and unclear methodology.
Owman-Moll 1995	Irrelevant outcomes reported.
Owman-Moll 1996	This study was carried out on sound teeth, i.e. without initial root resorption.
Owman-Moll 1998	Irrelevant outcomes reported.
Schjott 2005	This study investigated the efficacy of Emdogain on avulsed teeth.

Characteristics of ongoing studies [ordered by study ID]

NCT00423956

Trial name or title	Repair of orthodontically induced tooth root resorption by ultrasound.
Methods	Controlled orthodontic force would be initially applied to induce orthodontically induced root resorption (OIRR) in first premolars. Ultrasound will be employed randomly for 20 minutes for a period of 4 weeks.
Participants	Patients between 12-28 years of age with sound premolars the roots of which were fully formed.
Interventions	Application of low-intensity pulsed ultrasound (LIPUS) 20 minutes every day for 4 weeks.
Outcomes	Evaluation of the effect of LIPUS on OIRR and studying the effect of LIPUS on alveolar bone remodeling plus assessing any pain or discomfort during the treatment period.
Starting date	January 2007.
Contact information	University of Alberta, Graduate Orthodontic Program, Edmonton, Alberta, Canada, T6G 2N8, tel-bialy@ualberta.ca
Notes	http://clinicaltrials.gov/ct2/show/NCT00423956?term=root+resorption&rank=1 Participants still being recruited at time of publication (Oct 2015).

APPENDICES

Appendix 1. MEDLINE via OVID search strategy

1. exp Endodontics/
2. ("systemic disease\$" or (endocrine adj5 disorder*)).mp.
3. (hyperthyroidism or "padget\$ disease" or calcinosis or "gaucher\$ disease" or "Turner\$ syndrome" or "radiation therapy").mp.
4. ((tooth adj5 root\$) and (injur\$ or fracture\$ or trauma\$ or ankylo\$)).mp
5. "Tooth Root"/
6. ((pulp\$ and infect\$) or ((tooth adj5 nerve) and infect\$) or periodont\$ or orthodont\$ or "tooth movement" or ((unerupted or impact\$ or erupt\$) and (tooth or teeth or molar\$ or premolar\$))).mp.
7. ((tumour or tumor) and pressure\$).mp.
8. (2 or 3 or 7) and tooth.mp. and root\$.mp. and resorpt\$.mp.
9. (1 or 4 or 5 or 6) and resorpt\$.mp.
10. (8 or 9) and external\$.mp.
11. exp Tooth Resorption/
12. 11 and external\$.mp.
13. 10 or 12
14. (((root adj5 resorpt\$) and external\$) or ("EARR" or "ERR") and tooth)).mp.
15. 13 or 14

The above subject search was linked to the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomized trials in MEDLINE: sensitivity maximising version (2008 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of *The Cochrane Handbook for Systematic Reviews of Interventions*, Version 5.1.0 [updated March 2011] (Higgins 2011).

1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. exp animals/ not humans.sh.

11. 9 not 10

Appendix 2. The Cochrane Oral Health Group's Trials Register search strategy

From April 2014, searches of the Cochrane Oral Health Group Trials Register were undertaken for this review using the Cochrane Register of Studies and the search strategy below:

1. endodontic*
2. ("systemic disease*" or (endocrine AND disorder*))
3. (hyperthyroidism or "Paget* disease" or calcinosis or "Gaucher* disease" or "Turner* syndrome" or "radiation therapy")
4. ((tooth AND root*) and (injur* or fracture* or trauma* or ankylo*))
5. ((pulp* and infect*) or ((tooth and nerve) and infect) or periodont* or orthodont* or "tooth movement" or ((unerupted or impact* or erupt*) and (tooth or teeth or molar* or premolar*)))
6. ((tumour or tumor) and pressur*)
7. (#2 or #3 or #6)
8. tooth and root and resorp*
9. #7 and #8
10. #1 or #4 or #5
11. ((#9 or #10) and external*)
12. (root and resorp* and external*)
13. ((EARR or ERR) and tooth)
14. #11 or #12 or #13

Previous searches of the Cochrane Oral Health Group Trials Register were undertaken using the Procite software and the search strategy below:

(((((endodont* or (root AND (fracture* or injur* or trauma* or ankylo*)) or (pulp* AND infect*) or ("tooth nerve" AND infect*) or periodont* or orthodont* or "tooth movement" or ((unerupted or impact* or erupt*) AND (tooth or teeth or molar* or premolar*))) AND resorp*) OR ((("systemic disease*" or "endocrine disorder*" or hyperthyroidism or "paget* disease" or calcinosis or "gaucher* disease" or "Turner syndrome" or "radiation therapy" or ((tumor or tumor) AND pressure*)) AND (tooth AND root* AND resorp*))) AND external*) OR ("EARR" or "ERR") AND tooth))

Appendix 3. The Cochrane Central Register of Controlled Trials (CENTRAL) search strategy

1. Exp ENDODONTICS
2. "systemic disease*" or (endocrine NEAR disorder*)
3. hyperthyroidism or "paget* disease" or calcinosis or "gaucher* disease" or "Turner syndrome" or "radiation therapy"
4. ((tooth NEAR root*) AND (injur* or fracture* or trauma* or ankylo*))
5. Exp TOOTH ROOT
6. ((pulp* AND infect*) or ((tooth NEAR nerve) AND infect*) or periodont* or orthodont* or "tooth movement" or ((unerupted or impact* or erupt*) AND (tooth or teeth or molar* or premolar*)))
7. ((tumour or tumor) AND pressure*)
8. ((#2 or #3 or #7) AND tooth AND root* AND resorp*)
9. ((#1 or #4 or #5 or #6) AND resorp*)
10. ((#8 or #9) AND external*)
11. Exp TOOTH RESORPTION
12. #11 AND external*
13. #10 or #12
14. ((root NEAR resorp*) AND external*) or (("EARR" or "ERR") AND tooth))
15. #13 or #14

Appendix 4. EMBASE via OVID search strategy

1. exp Endodontics/
2. ("systemic disease\$" or (endocrine adj5 disorder\$)).mp.
3. (hyperthyroidism or "padget\$ disease" or calcinosis or "gaucher\$ disease" or "Turner\$ syndrome" or "radiation therapy").mp.
4. ((tooth adj5 root\$) and (injur\$ or fracture\$ or trauma\$ or ankylo\$)).mp.
5. "Tooth Root"/
6. ((pulp\$ and infect\$) or ((tooth adj5 nerve) and infect\$) or periodont\$ or orthodont\$ or "tooth movement" or ((unerupted or impact\$ or erupt\$) and (tooth or teeth or molar\$ or premolar\$))).mp
7. ((tumour or tumor) and pressure\$).mp.
8. (2 or 3 or 7) and tooth.mp. and root\$.mp. and resorp\$.mp.

9. (1 or 4 or 5 or 6) and resorpt\$.mp.
10. (8 or 9) and external\$.mp.
11. "tooth resorption".mp.
12. 11 and external\$.mp.
13. 10 or 12
14. (((root adj5 resorpt\$) and external\$) or (("EARR" or "ERR") and tooth)).mp.
15. 13 or 14

The above subject search was linked to the Cochrane Oral Health Group filter for identifying RCTs in EMBASE via OVID:

1. random\$.ti,ab.
2. factorial\$.ti,ab.
3. (crossover\$ or cross over\$ or cross-over\$).ti,ab.
4. placebo\$.ti,ab.
5. (doubl\$ adj blind\$).ti,ab.
6. (singl\$ adj blind\$).ti,ab.
7. assign\$.ti,ab.
8. allocat\$.ti,ab.
9. volunteer\$.ti,ab.
10. CROSSOVER PROCEDURE.sh.
11. DOUBLE-BLIND PROCEDURE.sh.
12. RANDOMIZED CONTROLLED TRIAL.sh.
13. SINGLE BLIND PROCEDURE.sh.
14. or/1-13
15. (exp animal/ or animal.hw. or nonhuman/) not (exp human/ or human cell/ or (human or humans).ti.)
16. 14 NOT 15

Appendix 5. The US National Institutes of Health Trials Register (ClinicalTrials.gov) and the WHO International Clinical Trials Registry Platform search strategy

external root resorption

WHAT'S NEW

Date	Event	Description
26 January 2016	Amended	Minor edit (hyperlink).

HISTORY

Protocol first published: Issue 4, 2009

Review first published: Issue 6, 2010

Date	Event	Description
14 January 2016	Review declared as stable	This is an empty review containing no trials, and will not be updated until a substantial body of evidence on the topic becomes available.
19 November 2015	New citation required but conclusions have not changed	Review has been updated but no studies have been found for inclusion.
14 October 2015	New search has been performed	New search. No studies for inclusion.
16 June 2010	Amended	Acknowledgements section edited.

CONTRIBUTIONS OF AUTHORS

Mona Nasser (MN), Zohreh Ahangari (ZA) and Mina Mahdian (MM) were responsible for designing and co-ordinating the review. MM and Zbys Fedorowicz (ZF) were responsible for screening of the search results, and the retrieved papers against inclusion criteria. MM and Melissa Marchesan (MAM) were responsible for organising the retrieval of papers and writing to authors of papers for additional information.

MM, ZA, MAM, MN and ZF were responsible for writing the review.

ZA conceived the idea for the review and will be the guarantor for the review.

DECLARATIONS OF INTEREST

There are no financial conflicts of interest and the review authors declare that they do not have any associations with any parties who may have vested interests in the results of this review.

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INDEX TERMS

Medical Subject Headings (MeSH)

*Dentition, Permanent; Root Resorption [*therapy]

MeSH check words

Humans