

**INTERVENCIONES PARA EL MANEJO DE LA RESORCION RADICULAR EXTERNA EN DIENTES
PERMANENTES: UNA REVISIÓN SISTEMÁTICA (ACTUALIZACION)**

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GUÍA DE CONTENIDO

Resumen

Abstract

Artículo

	Pág.
Introducción	1
2. Marco teórico	2
3. Planteamiento del problema	5
4. Justificación	6
5. Objetivos	7
5.1 Objetivo general	7
5.2 Objetivos específicos	7
6. Metodología del Proyecto	8
6.1. Tipo de estudio	8
6.2. Métodos y técnicas para la recolección de la información	8
6.2.1. Criterios de selección de la muestra	9
6.2.2. Criterios de inclusión	9
6.2.3. Criterios de exclusión	9
6.2.4. Selección por palabras claves por temática	10
6.2.5. Estructuración de estrategia de búsqueda por temática	12
6.2.6. Resultados de aplicación de estrategia de búsqueda por temática en base de datos	13
6.2.7. Preselección de artículos por temática	15
7. Consideraciones éticas.	25
8.. Resultados	26
9. Discusión	28
10. Conclusiones	32
11. Referencias bibliográficas	33
12. Anexos	38

RESUMEN

Intervenciones para el manejo de la resorción radicular externa en dientes permanentes: una revisión sistemática

Objetivo: El objetivo de esta revisión sistemática fue observar la efectividad de las diferentes intervenciones para el tratamiento de la detención de la resorción radicular externa en dientes permanentes. **Materiales y métodos:** Se realizó la búsqueda en el Registro de Ensayos del Grupo de Salud Oral de Cochrane (CENTRAL), MEDLINE y EMBASE utilizando la misma estrategia de búsqueda, incluyendo artículos de febrero de 2019 sin restricción de lenguaje. Los estudios fueron considerados elegibles para la inclusión si ellos presentaban pacientes con dientes permanentes que tuvieran reabsorción radicular externa de tipo inflamatorio, de superficie, por reemplazo, anquilosis, presión u ortodoncia que hayan sido intervenidos con la colocación de medicamento intraconducto, férulas, extracción o remoción quirúrgica y un tiempo de seguimiento de mínimo 3 meses. **Resultados:** De los 33 artículos potencialmente elegibles, 18 estudios (54.5%) dieron un manejo endodóntico a la reabsorción radicular externa, la medicación intraconducto fue utilizada como protocolo en (57.5%) de los casos. El MTA fue el material más utilizado en 21 estudios (63.6%) para sellar este tipo de defecto, promover la cicatrización y la regeneración de los tejidos. El ionómero de vidrio y la resina de fotocurado también fueron utilizadas, pero en una menor proporción (1.32%) para el selle de estos defectos. **Conclusión:** En conclusión, se encontró que el tratamiento endodóntico en combinación con un medicamento intraconducto para eliminar la infección y detener la resorción radicular junto con un material de selle como el MTA que además promueve la regeneración tisular y cicatrización según los resultados obtenidos son las opciones más adecuadas para el tratamiento de la reabsorción radicular externa.

Palabras clave (Mesh verificado): hidróxido de calcio, blanqueamiento dental, diente impactado, resorción radicular, trauma

ABSTRACT

Interventions for the Management of External Root Resorption: A Focused Systematic Review

Objective: the aim of this systematic review was to observe the effectiveness of the different interventions to treat and stop external root resorption in permanent teeth. **Materials and methods:** a search was made in Cochrane Controlled Register of Trials (CENTRAL), MEDLINE and EMBASE using the same search strategy in all the databases. It included articles from February 2019 without language restriction. The studies were considered eligible for inclusion if they presented patients in permanent dentition with external inflammatory root resorption, surface resorption, replacement resorption, ankylosis resorption, resorption due to pressure or orthodontics, treated with intracanal medication, splints, extraction or surgical extraction and follow-up time of at least 3 months. **Results:** 18 (54.5%) of the 33 potentially eligible articles performed root canal as treatment for external root resorption. Intracanal medication was used in 57.5% of the cases. MTA was the preferred material in 21 studies (63.6%) to seal this type of defect and promote healing and tissue regeneration. Glass ionomer and light-cured composite were also used to seal these defects but in less proportion (1.32%). **Conclusion:** according to the results obtained in this study, the endodontic treatment in combination with an intracanal medication for the elimination of the infection and to stop the root resorption, together with a sealing material such as MTA that promotes tissue regeneration and healing, is the most suitable option to treat external root resorption.

Keywords (Mesh verified): calcium hydroxide, dental bleaching, impacted tooth, orthodontic treatment, radicular resorption, root, trauma.

ARTICULO CIENTIFICO

Interventions for the Management of External Root Resorption: A Focused Systematic Review

Abstract

Purpose: To evaluate the effectiveness of different interventions implemented for the management of external root resorption in permanent teeth. **Materials and Methods:** A search of the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE and EMBASE was performed. The search was conducted following the same strategy in all three databases, and included articles through February 2019 without language restriction. Articles were eligible for the study if they included patients with a permanent dentition having external root resorption, such as invasive inflammatory, superficial, and substitutional/replacement that may be due to trauma, pressure, or orthodontic treatment and that had been treated with an intracanal medication, splints, extraction or surgical removal with a minimum follow-up period of 3 months. **Results:** 18 (54.5%) out of the 33 potential articles rendered endodontic intervention to external root resorptive defects. Intracanal medication was used in 57.5% of cases, while 21 studies (63.6%) reported the use of Mineral Trioxide Aggregate (MTA) to seal this type of defect, promote healing with scar formation or tissue regeneration. Glass ionomer and light-curing resin were also used, but less frequently (1.32%). **Conclusion:** Root canal treatment combined with intracanal medication to eradicate infection and to halt all types of external radicular resorption, in conjunction with a sealing material such as MTA, were the most reliable options for the management of external radicular resorption.

Key words: calcium hydroxide, dental bleaching, impacted tooth, orthodontic treatment, radicular resorption, root, trauma.

Introduction

Radicular resorption (RR) on permanent teeth is a pathologic process that may affect either the internal or external surface of a tooth. In the first case, the condition is known as internal radicular resorption (IRR) and in the second situation it is known as external radicular resorption (ERR). Based on the type and extent of the resorption a poor prognosis is rendered, which often times leads to tooth loss. (Ahangari *et al.*, 2010).

ERR arises when a disruption in the equilibrium between osteoblastic and osteoclastic activity occurs, which in turn halts the body's capacity to maintain the adequate physiological state of the root, thus resulting in dentin, cementum, and bone resorption. (Sogure *et al.*, 2010) Furthermore, the presence of endotoxins and inflammatory mediators that may be present in the gingival sulcus act as chemo attractants for osteoclasts that damage the cementum; and if and inflamed, necrotic pulp is present, may enhance the resorption of the adjacent dentin once the cementum has been penetrated, creating an overwhelming acidic environment that intensifies the resorptive process. (Kim *et al.* 2011).

Several classification systems for RR have been proposed, most of which are based on its clinical and histologic characteristics. According to a system proposed in 2010, RR could be classified as superficial, inflammatory, and substitutional, also known as ankylosis. Some studies (Trope, 2008; Kanaset *et al.*, 2011) have proposed another type of RR, i.e., hyperplastic invasive cervical resorption (HICR), which has an external origin. Predisposing factors for HICR include history of root canal treatment (RCT) and trauma. (Patel *et al.*, 2018) Moreover, there are singular cases of RR of unknown etiology that do not fit into any of the aforementioned categories and they are referred to as idiopathic resorption. (Ahangari *et al.*, 2010).

The most common causes of ERR are dentoalveolar trauma (due to tooth replantation) and orthodontic treatment, especially when applied forces are poorly or not-well controlled. (Jacobs *et al.*, 2014) Clinically, ERR could be associated with periodontal inflammation and periodontal pockets, although it is generally asymptomatic. (Andersson, 2012) Currently, there is a lack of consensus regarding the management of the many types of RR. (Abbott, 2016) The purpose of this paper, therefore, is to perform a systematic review (SR) of the literature in order to determine the most effective method to manage teeth affected by ERR. The following focused

question was addressed: “Which are the most effective treatment options for the management of ERR?”

Materials and Methods

This SR was designed according to the guidelines established by PRISMA, the Cochrane Handbook of Systematic Reviews of Interventions, and Check Review checklist. The protocol is registered at the National Institute for Health Research PROSPERO, International Prospective Register of Systematic Reviews (<http://www.crd.york.ac.uk/PROSPERO>, registration number CRD42015019796).

Type of Studies and Participants (Inclusion Criteria)

Observational studies (i.e., cross sectionals, cases and controls, cohort studies case series and case reports) were considered. Studies were eligible if they complied with the following: a) patients with a diagnose of ERR; b) permanent teeth; c) inflammatory, superficial, substitution, pressure or orthodontic ERR; d) interventions for its treatment such as intracanal medications, splints, extraction or surgical removal; and e) a minimum follow-up period of 3 months.

Exclusion Criteria

Studies including ERR associated with systemic conditions, such as Pagets Disease, Papillon-Lefèvre Syndrome, as well as patients presenting teeth with a previous diagnose of IRR/ERR were excluded.

Outcome Measures

The number and/or percentage of teeth in which the method of treatment for ERR was effective.

Search Strategy

An electronic search of the English literature was performed. The Cochrane Oral Health Group Trials Register, MEDLINE, and EMBASE were searched. Terms, key words, and other terms free from the Medical Subject Heading (MeSH) were employed. Boolean operators OR, AND were used. Databases were searched up to and including February, 2019. The full search strategy was established for each database to be searched based on the search strategy developed for the MEDLINE search (via PubMed): ([. "systemic disease*" OR (endocrine NEAR disorder*)] OR [hyperthyroidism OR "paget* disease" OR calcinosis OR "gaucher* disease" OR "Turner syndrome" OR "radiation therapy"] OR [tooth NEAR root*) AND (injury* OR fracture* OR trauma* OR ankylosis*) OR [Exp TOOTH ROOT] OR [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*)) OR [(tumour OR tumor) AND pressure*)] OR ((#2 OR #3 OR #7) AND tooth AND root* AND resorpt*) OR [.(#1 OR #4 OR #5 OR #6) AND resorpt*)] OR [(#8 OR #9) AND external*) OR [Exp TOOTH RESORPTION] OR [#11 AND external*)] OR [.#10 OR #12]] OR [((root NEAR resorpt*) AND external*) OR (("EARR" OR "ERR") AND tooth)] OR [#13 or #14]].

Unpublished data and manual search

The reference lists of the potential studies were examined manually in order to identify more papers that could be used for the review.

Assessment of the Validity and Data Extraction

Initially, 2 reviewers (LXLS, FPU) independently examined the titles, abstracts, and entire articles. The reviewers were not blinded to the authors, their affiliations, and the publishing site reports. The full report was obtained for all studies that apparently met the inclusion criteria or at times had insufficient information on the title, and key words in order to make an unbiased decision. All 2 reviewers assessed the retrieved studies independently. Disagreements between them were solved through discussion with a fifth reviewer (MCC).

When important information was missing, the authors of the specific article(s) were contacted to obtain further details. The studies that met the inclusion criteria were subjected to data evaluation and validation. Subsequently, the information was extracted and saved using evaluation templates specifically designed for data extraction: i) citation, publication status, and publication year; ii) participants characteristics; iii) types of interventions; and iv) treatment outcomes.

Data Synthesis

Retrieved data was pooled into an evidence table and a descriptive summary was created to determine the quantity of data and study variations in terms of characteristics and results.

Results

Description of Studies and Search Results

The flowchart (Fig. 1) describes the article selection process. Initially, the search strategy identified 27,277 publications (excluding duplicates). After assessing the titles and abstracts of each paper, 27,207 articles were excluded. The remaining 70 were examined and excluded if they did not meet the inclusion criteria. Finally, a total of 33 articles were included for the review.

Included Studies

Thirty-three publications, of which 26 were case reports and 7 case series, were analyzed. Table 5 describes the most important features of such studies.

Methodological Characteristics of Included Studies

Due to the nature of the included studies (case reports/case series) and their inherent methodological deficiencies, no formal quality evaluation was performed (all of them were considered as either “high risk of bias” or as “low methodology quality”). They contained information about the number of patients, gender, age, and number of teeth affected by ERR (whether or not presented history of orthodontic treatment, intracoronal bleaching, trauma,

history of infection or if it was idiopathic in nature). These studies described the measurement instruments i.e., clinical exam, radiographic images, CBCT, sensitivity tests, palpation, and percussion. Likewise, they reported follow-up periods ranging from 3 (Mittal, 2013) to 180 months. (Reston *et al.*, 2017) The mean follow-up period was 32 months.

Individual Results and Combined Estimates of Studies

The analysis of the selected studies showed that 18 (54.5%) out of the 33 cases were treated by means of root canal treatment (RCTx). In 4 cases (33.3%), treatment for ERR was revascularization: 11 (12.1%) cases did not report any endodontic intervention, only 1 (0.33%) study did not report success. 18 (54.5%) cases had conventional RCTx in which 8 (44.4%) reported the use of intracanal medication with calcium hydroxide: 1 (5.5%) with antibiotic paste, and 1 (5.5%) with ledermix paste. In 14 (77.7%) cases, NaOCl irrigation solution in conjunction with EDTA in 6 (33.3%) of cases was used. Chlorohexidine was used in 2 (11.1%) of the reported cases, trichloroacetic acid was used in 3 (16.6%) of cases in which a direct seal of the defect and conventional RCTx were performed.

In 4 (12.1%) of the case reports ERR was managed with revascularization using NaOCl for irrigation in 4 (100%) of the cases, and EDTA 3 (75%) in conjunction with the NaOCl, intracanal medication with calcium hydroxide in 2 (50%) and antibiotic paste in 2 (50%), finalizing each treatment with a coronal seal using MTA.

Regarding the management of ERR by means using other endodontic interventions, several alternatives were proposed in 11 case reports (33.3%); filling the entire canal system with MTA in 3 (27.2%) cases; apical microsurgery in 1 case; intentional tooth replantation; orthodontic traction; additional direct sealing of the defect with MTA in 2 (18.1%) cases; glass ionomer resin, and glass fiber post in one of the cases as definite ionomer and resin restoration. Three (27.7%) cases used NaOCl as irrigation solution and 1 (9%) with EDTA. Five studies (45.4%) reported the use of intracanal medication with calcium hydroxide, and cement Calcium Enriched Mixture or CEM (9%) as retro-obturation material for intentional replantation.

Discussion

Most studies provide evidence for the endodontic management of ERR. MTA is the material most commonly used (63.6%) to seal the defect created by the resorption process and to promote healing and regeneration of tissues since it shows a higher success rate. On the other hand, the use of intracanal medication (57.5%) in conjunction with conventional RCTx (54.5%) was common in over half the cases, while revascularization (12.1%) was an alternative treatment in immature apices for the management of resorption. Glass ionomer and light-curing resin were also used for sealing cervical resorption. (Table 1).

Quality of the Evidence

All cases included in this SR were case reports and case series (which could lead to significant methodological weakness) and their inclusion in a systematic review could result in inaccurate data in light of the proposed research question. (Chambrone *et al.*, 2009; Chambrone *et al.*, 2010; Needleman *et al* 2012) The exclusion of studies due to limited methodology can avoid bias. However, and in cases such as the present SR, when adequate sources of evidence are not available, all levels of evidence should be included. A detailed evaluation of the current evidence shows that individual studies do not provide sufficient information because of race, location, behavior, and severity of the injury. The methods used to assess the status of resorption were adequate, since all the included studies gave a correct diagnosis by using clinical and radiographic parameters, such as sensitivity tests, probing, percussion, palpation, and radiographic images from different angulations. Nevertheless, data from the included studies were diverse, since they are based on different inclusion/exclusion criteria (Table 1).

All included papers reported the results of patients treated with MTA, CEM, biodentine, and glass ionomer/resin. These interventions required the original data of each patient to perform an adequate analysis of the study and in this way establish a valid success/failure rate. The failure/success of treatment for ERR should be determined by a good clinical and radiographic evaluation, such as the depth of the pocket, the presence of bleeding, suppuration, mobility, and the absence of symptoms after a suitable follow-up period. (Needleman *et al* 2012).

Limitations and Potential Biases in the Review Process

This SR is an upgrade of a Cochrane review that had as inclusion criteria randomized clinical trials. (Ahangari *et al.*, 2010) Due to the studied subject, our investigation included case reports and case series in order to determine the adequate treatment for ERR. Due to ethical considerations, we are unable to include other types of studies (since this pathosis has a low incidence, it is impossible to wait for a minimum number of patients to be treated and followed by interventional or observational studies). As a consequence, we reviewed case reports regarding treatment options for ERR in an effort to establish guidelines for the treatment of this condition. Moreover, it should be noted that no formal “Quality Assessment” of the included studies was performed. The decision of not performing that has to do with the nature of these papers (i.e. case reports or small case series including a limited number of participants), which pose an increased risk of bias. Despite not being able to reduce or alter the effect of treatment *per se*, these issues may be considered as the main limitation of the present SR, and must be considered when interpreting the present findings. In many respects this SR, due to an increase in the potential for bias and a high level of clinical heterogeneity, may be better identified as a structured critical analysis. (Solow, 2019).

Agreements and Disagreements with Other Studies or Reviews

In this review, the number of studies that were successful and those that failed was noted. Only 1 out of the 33 studied cases was a failure. In this study, management of ERR was by means of glass ionomer over the defect and posterior root canal treatment, but the severity and extent of the resorption was not assessed. The authors of this case indicated that when extensive loss of tooth structure is present, any given treatment could end up in failure. Undoubtedly, this would be an important factor to consider when making a decision regarding ERR management. (Discacciati *et al.*, 2016).

The papers analyzed for this SR indicated a management protocol for ERR, which includes RCTx in conjunction with the placement of a medication inside the root canal in order to control the infection and to halt the process alongside with a suitable sealing material such as MTA, which at the same time promotes healing; such is the treatment that has yielded the best success rates for this condition. Nevertheless, the use of MTA is not recommended for anterior teeth because its use might compromise the aesthetics due to the potential for staining. (Mozynska *et al.*, 2017). In these cases it would be beneficial to use glass ionomer and/or resin. RCTx is essential in the management of ERR because the root canal system is replete of microorganisms that, if left untreated, could aggravate the condition and prevent regeneration of the surrounding tissues. Most of the studies included in this SR managed ERR by means of RCTx. Reports have linked hypoxia to ECR initiation and propagation. It has been hypothesized that hypoxia within an ECR lesion can occur because of local alterations of the microcirculation at the involved area because of the gradient distribution of hypoxia within the ECR lesion, which might also indicate that different factors can play different roles in root canals. (Mavridou *et al.*, 2019). Case reports have been used in dental research to describe unusual diagnosis/conditions and their alternative/potential treatment approaches as “pilot information” prior to the development /design of proper clinical trials involving the same subject. Implementing such therapies or findings into clinical practice is questionable and caution must be exercised. Such data, however, is of interest when clinical and radiographic results must be assessed in particular conditions that cannot be easily found in both private and academic settings. Therefore, a strong evaluation of the therapies could not be achieved and, what is more, definitive answers might not be found.

Conclusions

Within the limitations of the present SR, depending on the specific clinical situation, conventional RCTx and regenerative treatments, such as revascularization in cases of immature apices in combination with intracanal medication and a sealing material were used as treatment methods in cases where the access was possible through the root canal. Other alternatives were proposed due to the limited access to the canal or the defect, such as orthodontic extrusion, surgical approach, intentional replantation, apical microsurgery in combination with a bioactive sealing material, which seems to promote tissue regeneration and healing.

1. Introducción

Este trabajo fue realizado para realizar una actualización y dar continuidad a la indagación sobre el manejo de la reabsorción radicular externa, ya que se han planteado diferentes opciones terapéuticas de acuerdo a su clasificación, hasta ahora no existe un tratamiento definitivo para la resorción, en intentos para controlar la reabsorción se ha sugerido el uso de agentes terapéuticos como son la pasta de ledermix usada como medicamento intraconducto, otros materiales como el hidróxido de calcio pueden ser usados para la estimulación de la formación de tejido duro sobre la superficie radicular afectada.(Ambu et al.,2017)

La superficie radicular ha sido tratada con materiales como el Emdogain en un intento por detener la resorción, sin presentar grandes ventajas frente a otros materiales; Pierce, demostró histológicamente que el ledermix erradica experimentalmente la resorción radicular inflamatoria inducida (Aggarwal *et al.*, 2010).

La solución balanceada de Hank es recomendada como medio de almacenamiento para dientes avulsionados, al igual que el propoleo, la leche de soya y la formula de leche para bebés son sugeridas para el almacenaje de dientes avulsionados por encima de 8 h. Para la detención de la resorción cervical esencialmente el tratamiento involucra la remoción del tejido resorativo y restaurar el defecto, el tratamiento endodóntico dependerá de la profundidad de la lesión (Ambu *et al.*,2017).

En la actualidad, existe una infinidad de tratamientos terapéuticos en un intento de impedir o detener el avance de la temida reabsorción radicular externa en dentición permanente, algunos de ellos usados sistemáticamente, y algunos quedan por ser explorados. Por eso la intención es aportar con la revisión a un soporte sistemático, basados en literatura actualizada.(Ambu *etal.*,2017).

2. Marco teórico

La resorción radicular en la dentición permanente es un proceso patológico que puede ocurrir tanto en el interior del diente (resorción interna) o en la superficie externa del diente (resorción radicular externa). La resorción radicular externa se presenta cuando no se produce un equilibrio entre la activación osteoblástica y osteoclástica que mantienen el estado fisiológico de la raíz del diente resultando en la destrucción de dentina, cemento y hueso. El daño a la capa de cemento radicular debido a la presencia de endotoxinas y mediadores inflamatorios que actúan como quimios atrayentes para osteoclastos puede reabsorber la dentina adyacente a esta zona produciendo un medio ácido que favorece este proceso patológico. (Kimet *et al.*, 2011). Se ha propuesto una clasificación en tres subgrupos: resorción de superficie; reabsorción inflamatoria y reabsorción por sustitución (anquilosis); esta clasificación se basó en su apariencia clínica e histológica posterior a lesiones traumáticas. (Ahangari., *et al* 2010). Diferentes estudios han propuesto una categoría de resorción radicular llamada resorción hiperplásica cervical invasiva, la cual ha demostrado ser de origen interno o externo y los factores potenciales predisponentes de esta condición incluyen trauma, tratamiento ortodóntico y aclaramiento intracoronal. También hay algunas reabsorciones dentales raras y de origen desconocido que no encajan en ninguna de las categorías nombradas, estas son llamadas usualmente como idiopáticas. (Ahangari., *et al* 2010; Ambu *et al.*, 2017).

La reabsorción radicular externa tiende a ocurrir con mayor frecuencia en los pacientes entre 21 y 30 años de edad (28,40%) y es más común en mujeres (59,04%) que en hombres (Ahangari., *et al* 2010). Este proceso patológico puede tener diferentes causas como infección pulpar o periodontal; dientes impactados, por presión de un tumor, como resultado de la anquilosis dental, traumas siendo la avulsión la más propensa a generar este tipo de patología debido a la reimplantación, otra de las causas son movimientos ortodónticos, especialmente cuando las fuerzas aplicadas para inducir el movimiento de los dientes no están controlados y en estas situaciones la resorción por lo general ocurre en el tercio apical de la raíz. (Jacobs *et al.*, 2014). El diagnóstico debe basarse en una combinación de exámenes radiográficos y clínicos. Las radiografías intraorales de la lesión suelen mostrar una superficie irregular de la raíz. Las

radiografías obtenidas en diferentes angulaciones pueden ser útiles para determinar la superficie que se encuentra afectada. La tomografía computarizada se ha considerado como la herramienta más precisa para detectar la reabsorción radicular. (Machado et al., 2017; Tzanetakis et al., 2017)

Clínicamente, la reabsorción radicular externa podría estar asociada con inflamación periodontal y formación de bolsa periodontal; aunque esta condición es generalmente asintomática y no es tan fácil su diagnóstico, la reabsorción radicular externa puede resultar en la movilidad dental y, si no es diagnosticado y tratado en una fase temprana, con el tiempo puede resultar en la pérdida dental.

Las alternativas de tratamiento dependerán del tipo y el alcance de la reabsorción y puede incluir un tratamiento para el alivio de la sintomatología, inflamación y la ferulización de los dientes con movilidad si es necesario. Si hay afección en el tejido pulpar, la terapia endodóntica, o la cirugía apical para eliminar el tejido de granulación junto con una obturación del defecto de la reabsorción será recomendada. Los medicamentos intraconducto y cementos selladores tales como el MTA, han sido utilizados para tratar de detener el proceso de reabsorción y proporcionar un selle apical en el diente. (Ahangari et al., 2010). Si se ha producido como resultado de la presión de un diente no erupcionado o por la erupción de dientes o durante el tratamiento de ortodoncia y no hay signos de infección, la remoción del diente o de la presión generalmente detendrá la reabsorción radicular.

Las opciones de tratamiento incluyen la extirpación pulpar y la colocación de un medicamento intraconducto antiresortivo como el hidróxido de calcio, corticoides, clobetasol, pasta triantibiótica para intentar detener la resorción radicular. Cuando la pulpa de los dientes inmaduros avulsionados se necrosa, las opciones de tratamiento son limitadas y el pronóstico es reservado debido a la dificultad de instrumentación, paredes dentinales delgadas dejando el diente débil y propenso a la fractura. (Kheirieh et al., 2014) Muchos estudios han demostrado in vivo que es posible desinfectar dientes permanentes inmaduros y permitir la cicatrización de la reabsorción radicular inflamatoria usando combinaciones de pastas antibióticas. Finalmente, una excelente restauración y selle son importantes para el éxito del tratamiento. Materiales

tales como amalgama, resina compuesta, ionómero de vidrio, y MTA se han utilizado para este propósito. (Fernández et al., 2011)

Actualmente no existe un consenso sobre el manejo de las diferentes formas de reabsorción radicular es por esto que el propósito de esta revisión sistemática es conocer cuáles son las opciones de tratamiento más efectivas para tratar dientes que presenten una resorción radicular externa.

Esta revisión sistemática es una actualización de otra revisión de Cochrane library que tuvo como criterios de inclusión experimentos clínicos aleatorizados (Ahangari *et al.*, 2010). Debido al tema y patología tratada nuestra revisión sistemática ha sido basada con un diseño de reportes de caso para determinar el tratamiento adecuado para la resorción radicular externa. Este tema no nos permite incluir en nuestra revisión estudios diferentes, debido a que desde un enfoque ético esto no es posible, además esta patología es de baja incidencia y es imposible obtener estudios observacionales, por la cual esta revisión está basada en reportes de caso y series de casos. Nuestra revisión tiene un diseño mucho más acorde para determinar el tratamiento adecuado para la reabsorción radicular externa.

El objetivo de esta revisión sistemática fue el análisis de reportes de casos sobre las opciones de tratamiento para la reabsorción radicular externa, con el fin de delinear las principales características sobre la cual es la mejor forma de tratar esta patología y las dificultades para su manejo dando una respuesta a la pregunta de la revisión: ¿Cuáles son las alternativas de tratamiento más eficaces para el manejo de dientes afectados por la ERR?

3. Planteamiento del problema

Después de una lesión dental como la avulsión y las luxaciones dentales, el ligamento periodontal es lesionado involucrando tejido orgánico e inorgánico, resultando en una superficie afectada que es quimiotáctica a las células resortivas, la combinación de la presencia de osteoblastos vitales adyacentes, la eventual exposición de los túbulos dentinales, el contenido pulpar ya sea isquémico, estéril, necrótico e infectado conducen a una resorción radicular externa en el sitio de la lesión. (Patel et al.,2018).

Una estimulación adicional de larga duración, como la irritación mecánica del tejido, presión incrementada de este, la infección dentro del conducto radicular y finalmente la combinación con ciertas enfermedades sistémicas, desencadenan en una reabsorción radicular. (Kheirieh et al., 2014). La resorción radicular externa hace parte de la clasificación de las reabsorciones ocasionadas por diferentes injurias como lo son: el trauma, la ortodoncia, fenómenos de presión, infección, entre otros. Esta patología puede incluso ocasionar la pérdida dental.

El diagnóstico de la reabsorción radicular es bastante complejo se determina por manifestaciones clínicas como cambio de color, dolor o a veces inflamación, pero la mayoría de las veces el proceso es silencioso, haciéndolo cada vez más complicado, otro medio de diagnóstico es la radiografía y cuando se descubre muchas veces es tarde, la tomografía computarizada de Haz cónico ayuda en el análisis de las lesiones resortivas. (Fernández et al., 2011) Las primeras exámenes clínicos y radiográficos de los pacientes traumatizados son cruciales para determinar el diagnóstico inicial, severidad de la injuria, plan de tratamiento y crear un record para el seguimiento.

Para su detención han sido considerados diferentes tratamientos, como lo son medicamentos intraconductos, tratamiento de conducto, abordajes quirúrgicos en un intento para mantener el diente o detener la pérdida dental pero incluso se plantea la exodoncia como tratamiento. Sin embargo, estos tratamientos no dependen de una justificación dada por un protocolo sino por un manejo dado por el clínico. No existe un tratamiento estándar para el manejo de la reabsorción radicular externa en la dentición permanente. (Ahangari et al., 2010)

4. Justificación

Los tratamientos encaminados a detener o tratar la resorción radicular externa, presentan una gran variabilidad, no existe un protocolo claro para su manejo, muchas veces se establecen como simples intentos basados en una decisión propia del clínico, justificado en sus propias experiencias que un tratamiento regido por protocolos científicos.

Sin embargo, la fundamentación científica basada en la literatura se sustenta en el manejo generalizado de reabsorciones no solo dentales, que proveen una serie de manejos terapéuticos encaminados a su detención, y la accesibilidad incrementada a estos recursos bibliográficos obtenidos de la tecnología, permite validar estos contenidos.

Para la comunidad científica los soportes en las revisiones sistemáticas permiten un apoyo en la toma de decisiones y un soporte en el manejo clínico de las entidades patológicas. Para un manejo específico y certero de la reabsorción radicular externa el clínico debe conocer las diferentes opciones de tratamiento, su repercusión y probabilidades de éxito para establecer o escoger la información suficiente para optimizar los recursos. Este estudio permitirá a través de una revisión concienzuda de la literatura del manejo de la resorción radicular externa, que tiene como claro objetivo su manejo en la detención de esta. (Lo Giudice *et al.*, 2016).

5. Objetivos

5.1 Objetivo general

Evaluar la efectividad de diferentes intervenciones que se pueden utilizar para el tratamiento de la resorción radicular externa en dientes permanentes.

5.2 Objetivos específicos

- Actualizar la revisión sistemática realizada hasta el año 2019
- Dar a conocer los tratamientos realizados para el manejo de la resorción radicular externa, esto incluye uso de medicamentos, abordajes quirúrgicos y distintos materiales para el sellado de la misma.
- Conocer el potencial que presentan diferentes materiales utilizados según lo encontrado en los artículos de la revisión.

6. Metodología del proyecto

Esta revisión fue estructurada de acuerdo con las guías de PRISMA, el Manual Cochrane de Revisiones Sistemáticas de Intervenciones, la lista de verificación, así como su protocolo se ha registrado en el Instituto Nacional de Investigación en Salud PROSPERO, Registro prospectivo Internacional de Revisiones Sistemáticas (<http://www.crd.york.ac.uk/> Próspero, número de registro CRD42015019796).

6.1 Tipo de estudio

Revisión sistemática para la evaluación de diferentes métodos para la detención de la reabsorción radicular externa. Se incluyeron en la revisión, estudios observacionales (Estudio retrospectivo, corte transversal, casos y controles) e intervencionales (Reportes de caso y series de caso).

6.2 Métodos y técnicas para la recolección de información

Tres autores revisores independientes realizarán una búsqueda utilizando las bases de datos electrónicas: MedLine, ScienceDirect, Biomed, Embase, Proquest y EBSCO. No se realizará búsqueda manual ni de literatura gris. La búsqueda se realizará combinando los siguientes términos MeSH root resorption AND Case-control studies AND Cohort studies AND Case reports AND Calcium hydroxide AND follow-Up studies AND Longitudinal studies AND Retrospective studies AND Glucocorticoids AND Ledermix AND Clobetasol AND Orthodontics AND Tooth Bleaching AND Trauma AND Injuries AND Glucocorticoids AND Tooth impacted AND Cyst AND Splint.

6.2.1 Criterios de selección de la muestra

6.2.2 Criterios de inclusión

Los estudios fueron considerados elegibles para su inclusión si involucraban específicamente lo siguiente: a) pacientes con diagnóstico de reabsorción radicular externa b) dientes permanentes

c) Reabsorción radicular externa de tipo inflamatorio, de superficie, por reemplazo, anquilosis, presión u ortodoncia d) intervenciones para el tratamiento de la reabsorción como medicamento intraconducto, férulas, extracción o remoción quirúrgica e) tiempo de seguimiento de mínimo 3 meses.

6.2.3 Criterios de exclusión

Estudios que incluían reabsorción radicular externa asociada a enfermedades sistémicas (Enfermedad de Paget, Síndrome de papillon y lefevre), pacientes con diagnóstico de reabsorción interna y externa.

6.2.4 Selección palabras clave por temática

Se establecerán palabras claves para cada temática para poder elaborar estrategias de búsqueda, las cuales se diligenciaron en la tabla número 1.

TABLA 1.- SELECCIÓN DE PALABRAS CLAVES POR TEMÁTICA DE REVISIÓN		
Temática	Resorción radicular externa	
Variable	Palabras claves	
Resorción radicular externa	Palabra clave	Resorption
	Términos [MeSH] ingles	Toothresorption
		Rootresorption
	Términos [DeSC] español/ inglés/ portugués	Boneresorption/ Resorción Ósea/ReabsorçãoÓssea
	Sinónimos / Términos relacionados	Bone Loss
		Osteoclastic Bone Loss
Endodoncia	Palabra clave	Root
	Términos [MeSH] ingles	Root canal therapy
		Root canal preparation
		Root canal irrigants
		Root canal obturation
	Términos [DeSC] español/ inglés/ portugués	Root canal fillingmaterials
		Tratamiento del Conducto Radicular/ Root Canal Therapy/ Tratamento do Canal Radicular

TABLA 1.- SELECCIÓN DE PALABRAS CLAVES POR TEMÁTICA DE REVISIÓN		
Temática	Resorción radicular externa	
Variable	Palabras claves	
	Sinónimos / Términos relacionados	Tratamiento del Conducto Radicular/ Root Canal Therapy/ Tratamento do Canal Radicular

Para agilizar la identificación de los estudios incluidos o potencialmente elegibles para la inclusión en esta revisión sistemática, la Cochrane Oral Grupo de Salud Trials Register (CENTRAL), MEDLINE y EMBASE hasta incluyendo marzo de 2019 en idioma inglés. Términos, palabras clave, y otros términos libres del encabezamiento Medical Subject (MeSH) se utilizaron para la búsqueda, y se utilizaron los operadores booleanos (OR, AND) combinación de búsquedas. La estrategia de búsqueda completa fue establecida para cada base de datos que se deben buscar con base a la estrategia de búsqueda desarrollado para la búsqueda en MEDLINE (vía PubMed): ([. "systemic disease*" or (endocrine NEAR disorder*)] o [hyperthyroidism or "paget* disease" or calcinosis or "gaucher* disease" or 11 "Turner syndrome" or "radiation therapy"] o [tooth NEAR root*) AND (injury* or fracture* or trauma* or ankylosis*) o [Exp TOOTH ROOT] o [pulp* AND infect*) or ((tooth NEAR nerve) AND infect*) or periodont* or orthodontic* or "tooth movement" or ((unerupted or impact* or erupt*) AND (tooth or teeth or molar* or premolar*)) 0 [(tumour or tumor) AND pressure*)] o .((#9 or #11 or #32) AND tooth AND root* AND resorpt*) 0 [.(#2 or #14 or #25 or #31) AND resorpt*)] o [(#34 or #38) AND external*) o [Exp TOOTH RESORPTION] o [#44 AND external*)] o [. #40 or #50)] o [((root NEAR resorpt*) AND external*) or (("EARR" or "ERR") AND tooth)] o [#57 or #58]]

6.2.5 Estructuración de estrategia de búsqueda por temática

Tabla 2. ESTRATEGIA DE BUSQUEDA	
Temática	Resorción radicular
#1	'endodontics'/exp OR 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 (injury* OR fracture* OR trauma* OR ankylosis*)]
#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 resorpt*)
#9	[((#1 OR #4 OR #5 OR #6) AND resorpt*)]
#10	([#8 OR #9) AND external*) OR [Exp TOOTH RESORPTION] OR [#11 AND external*)]
#11	[#11 AND external*)]
#12	[.#10 OR #12)]
#13	[((root NEAR resorpt*) AND external*) OR ((“EARR” OR “ERR”) AND tooth)] OR [#13 or #14)]

6.2.6 Resultados de aplicación de estrategia de búsqueda por temática en base de datos (Pubmed-Embase)

Tabla 3. Resultados aplicación de Estrategia de búsqueda por Temática PUBMED Sort by: BEST MATCH Fecha: Febrero /2019			
Temática	Resorción radicular externa		
Búsqueda	Algoritmos	Cantidad de artículos encontrados	Cantidad seleccionada por Título/ abstract
#1	'endodontics'/exp OR endodontics	228	1
#2	([. "systemic disease*" OR (endocrine NEAR disorder*)])	331	0
#3	[hyperthyroidism OR "paget* disease" OR calcinosis OR "gaucher* disease" OR "Turner syndrome" OR "radiation therapy"]	256	0
#4	[tooth NEAR root*] AND (injury* OR fracture* OR trauma* OR ankylosis*)	365	0
#5	[Exp TOOTH ROOT]	450	0
#6	[pulp* AND infect*) OR ((tooth NEAR nerve) AND infect*) OR periodont* OR orthodontic* OR "tooth movement" OR ((unerupted OR impact* OR erupt*) AND (tooth OR teeth OR molar* OR premolar*))]	228	0
#7	[(tumour OR tumor) AND pressure*]	336	0
#8	((#2 OR #3 OR #7) AND tooth AND root* AND resorpt*)	118	0
#9	[((#1 OR #4 OR #5 OR #6) AND resorpt*)]	223	0
#10	[(#8 OR #9) AND external*) OR [Exp TOOTH RESORPTION] OR [#11 AND external*)]	332	17
#11	[#11 AND external*)]	112	0
#12	[.#10 OR #12)]	225	0
#13	[((root NEAR resorpt*) AND external*) OR (("EARR" OR "ERR") AND tooth)] OR [#13 or #14)]	368	6

Tabla 3. Resultados aplicación de Estrategia de búsqueda por Temática EMBASE Sort by: BEST MATCH Fecha: Febrero /2019			
Temática	Resorción radicular externa		
Búsqueda	Algoritmos	Cantidad de artículos encontrados	Cantidad seleccionada por Titulo/ abstract
#1	'endodontics'/exp OR endodontics	228	0
#2	([. "systemic disease*" OR (endocrine NEAR disorder*)])	300	0
#3	[hyperthyroidism OR "paget* disease" OR calcinosis OR "gaucher* disease" OR "Turner syndrome" OR "radiation therapy"]	225	0
#4	[tooth NEAR root*] AND (injury* OR fracture* OR trauma* OR ankylosis*)	335	0
#5	[Exp TOOTH ROOT]	125	0
#6	[pulp* AND infect*) OR ((tooth NEAR nerve) AND infect*) OR periodont* OR orthodontic* OR "tooth movement" OR ((unerupted OR impact* OR erupt*) AND (tooth OR teeth OR molar* OR premolar*))]	112	0
#7	[(tumor OR tumor) AND pressure*)]	200	0
#8	((#2 OR #3 OR #7) AND tooth AND root* AND resorpt*)	352	7
#9	[((#1 OR #4 OR #5 OR #6) AND resorpt*)]	226	0
#10	([#8 OR #9) AND external*) OR [Exp TOOTH RESORPTION] OR [#11 AND external*)]	400	0
#11	[#11 AND external*)]	325	0
#12	[.#10 OR #12)]	258	0
#13	[(((root NEAR resorpt*) AND external*) OR ("EARR" OR "ERR") AND tooth)] OR [#13 or #14)]	500	0

6.2.7 Preselección de artículos por temática

Los artículos encontrados y preseleccionados por título o abstract se registraron en la siguiente tabla

TABLA 4. PRESELECCIÓN DE ARTÍCULOS POR TEMÁTICA	
TEMATICA	Resorción radicular externa
BASE DE DATOS	PUBMED
ALGORITMO FINAL	(((root NEAR resorpt*) AND external*) OR ((“EARR” OR “ERR”) AND tooth)) OR [#13 or #14]]
artículos preseleccionados Referencia -estilo Vancouver y abstract	
Aggarwal V, Singla M. Management of inflammatory root resorption using MTA obturation a four-year follow-up. Br Dent J. 2010; 208:287-9. A case report of severe external inflammatory root resorption is presented. The patient reported with a complaint of increased tooth mobility after avulsion and replantation. The case was treated with full root canal obturation with mineral trioxide aggregate. A 48 month follow up review showed arrest of root resorption with satisfactory clinical results. This article discusses the etiology of inflammatory root resorption and the use of the latest root canal obturation materials in improving healing outcomes.	
Araújo RA, Silveira CF, Cunha RS, et al. Single-session use of mineral trioxide aggregate as an apical barrier in a case of external root resorption. J Oral Sci. 2010; 52:325-8. Abstract: External root resorption may occur as a consequence of trauma, orthodontic treatment, bacterial infection or incomplete sealing of the root canal system (bacterial re-infection), and lead to crater formation on the resorbed apex. This would deform the root apex surface, and cause loss of apical constriction. Depending on the extent of the resorptive process, different treatment regimens have been proposed. A 34-year-old male patient presented with an intra-radicular retainer and an inadequate filling on tooth #21, as well as a radiographic image suggesting periapical bone rarefaction. After root canal retreatment, the defect was accessed coronally. The resorption area was chemomechanically debrided and since the apical end was very wide, a calcium sulphate matrix was made. Mineral trioxide aggregate (MTA) was used to fill the resorptive defect, and the coronal access was temporarily sealed. After 24 h, the quality of the apical seal was evaluated with the aid of an operating microscope, and then the root canal system was filled. A 12-month follow-up radiograph showed adequate repair of the resorption. Clinically, the tooth was asymptomatic. We concluded that MTA can be successfully used to avoid overextension of the filling material when treating a tooth with external resorption.	
Cunha RS, Abe FC, Araujo RA, Fregnani ER, Bueno CE. Treatment of inflammatory external root resorption resulting from dental avulsion and pulp necrosis: clinical case report. Gen Dent. 2011; 59:101-4. The aim of this case report was to present a treatment for severe inflammatory external root resorption. The condition developed due to the patient's neglect to seek adequate treatment following replantation of an avulsed maxillary left central incisor. Following diagnosis, treatment consisted of conventional endodontic therapy with calcium hydroxide dressings and definitive filling of the root canal after the resorption was controlled radiographically. A 24-month follow-up showed that the resorption process had stabilized and the patient was free of symptoms. Successful tooth replantation requires following the indicated therapy effectively. Nevertheless, when an inflammatory external root resorption occurs, adequate endodontic treatment to remove the necrotic content and bacteria is required, as is the use of calcium hydroxide dressings.	
Fernandez R, Rincon JG. Surgical endodontic management of an invasive cervical resorption class 4 with mineral trioxide aggregate: a 6-year follow-up. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112:8-22.	

Invasive cervical resorption is a type of external resorption rarely seen as an adverse effect after a guided tissue regeneration procedure for a periodontal condition. This case report summarizes the surgical endodontic management of an invasive cervical resorption class 4 (Heithersay) with mineral trioxide aggregate, in a mandibular incisor of a 67-year-old man. A 6-year clinical follow-up with radiovisiography and cone-beam computerized tomography revealed complete healing. A surgical endodontic management could promote healing and survival of a tooth with advanced root resorption due to a periodontal condition.	
Gandi P, Disha S. Treatment of maxillary central incisor with external root resorption using mineral trioxide aggregate: 18 months follow-up. BMJ Case Rep. 2013;10:1-3. Summary External cervical resorption is the loss of dental hard tissue as a result of odontoclastic action; it usually begins on the cervical region of the root surface of the teeth. This case report demonstrates an external cervical resorption in a maxillary central incisor of a 24-year-old male patient. After surgical intervention and root canal treatment, the resorption was subsequently sealed with mineral trioxide aggregate. The 18 months follow-up demonstrates no pathological changes on clinical and radiographic examination. This case report presents a treatment strategy that might improve the healing outcomes for patients with external cervical resorption.	
Harris BT, Caicedo R, Lin WS, Morton D. Treatment of a maxillary central incisor with class III invasive cervical resorption and compromised ferrule: a clinical report. J Prosthet Dent. 2014; 111:356-61 This clinical report presents the treatment of a maxillary central incisor with class III invasive cervical resorption and a compromised ferrule. Nonsurgical endodontic therapy combined with periodontal surgery was provided for debridement. Direct light-polymerizing resin-modified glass ionomer cement and a zirconia crown were used to repair the defect. Symptomatic endodontic complication was diagnosed with localized cone beam computed tomography at 6-month follow-up, and periapical microsurgery was rendered. The patient was followed-up for 30 months after treatment and had no further complications	
ALGORITMO FINAL	([#8 OR #9) AND external*] OR [Exp TOOTH RESORPTION] OR [#11 AND external*])
artículos preseleccionados Referencia -estilo Vancouver y abstract	
Ikhar A, Thakur N, Patel A, Bhede R, Patil P, Gupta S. Management of external invasive cervical resorption tooth with mineral trioxide aggregate: a case report. Case Rep Med. 2013;2013:139801. Invasive cervical resorption is entirely uncommon entities and the etiology is poorly understood. A 19-year-old patient presented with fractured upper left central incisor and sinus tract opening on the distobuccal aspect in cervical region. Radiographic examination shows irregular radiolucency over the coronal one-third and it extended externally towards the external invasive resorption. After sectional obturation, the defect was accessed surgically. The resorption area was chemomechanically debrided using irrigant solution. Fibre post placement using flowable composite resin and Mineral Trioxide Aggregate (MTA) was used to fill the resorptive defect, and the coronal access was temporarily sealed. Composite restoration was subsequently replaced with ceramic crown after 4 years. Radiographs at 1 and 4 years showed adequate repair of the resorption and endodontic success. Clinically and radiographically the tooth was asymptomatic, and no periodontal pocket was found after a 4-year followup.	
Kheirieh S, Fazlyab M, Torabzadeh H, Eghbal MJ. Extraoral retrograde root canal filling of an orthodontic-induced external root resorption using CEM cement. Iran J Endod. 2014;9:149-52. Abstract Case Report Inflammatory external root resorption (IERR) after orthodontic treatments is an unusual complication. This case report describes a non-vital maxillary premolar with symptomatic extensive IERR (with a crown/root ratio of 1:1) after receiving orthodontic treatment. The first appointment included drainage, chemo-mechanical preparation of the canal and intra-canal medication with calcium hydroxide (CH) along with prescription of analgesic/antibiotic. The subsequent one-week follow-up revealed the persistence of symptoms and formation of a sinus tract. Finally, extraoral endodontic treatment was planned; the tooth was atraumatically extracted and retrograde root canal filling with calcium enriched mixture (CEM) cement was placed followed by tooth replantation. Clinical signs/symptoms subsided during 7 days postoperatively. The sinus tract also resolved after one week. Six-month and one-year follow-ups revealed complete healing and a fully functional asymptomatic tooth. This case study showed favorable outcomes in a refractory periapical lesion associated with orthodontically induced extensive IERR. The chemical as well as biological properties of CEM	

cement may be a suitable endodontic biomaterial for these cases.
Lux HC, Goetz F, Hellwig E. Case report: endodontic and surgical treatment of an upper central incisor with external root resorption and radicular cyst following a traumatic tooth avulsion. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110:61-7. In the age group between 6 and 12 years, trauma to the upper incisors happens frequently. In the case of avulsion, a replantation is the state-of-the-art treatment; however, it may lead to several complications, particularly if suitable posttraumatic management is not carried out. External cervical resorptions as well as apical granuloma and cysts due to microbial contamination of the root canal are common complications. In the presented trauma case, a conservative approach was chosen to treat a large cystic lesion combined with cervical and apical resorptions. After initial placement of Ledermix and calcium hydroxide into the root canal, a marsupialization with the temporary insertion of an obturator was performed. The gradual reduction led to a fast recovery of the bony defect and a root canal filling was placed. The 2-year follow-up showed an improved condition. All adjacent teeth remained vital during the course of the treatment.
Mittal N. Clinical management of severe external root resorption: a case report. Case Rep Dent. 2013;31-34 Abstract Brief Background The article demonstrates external root resorption arrests the formation of an apical barrier by conventional endodontic therapy combined with calcium hydroxide dressing and a mineral trioxide aggregate (MTA) apical plug. Materials and Methods Conventional root canal treatment combined with calcium hydroxide dressing is the first choice of treatment. MTA powder was mixed with distilled water and packed into 10 mm of the apical end as an apical plug. After the MTA had set, the residual canal space was filled with gutta-percha and zinc oxide eugenol. The access cavity was prepared and restored with composite resin. Discussion The purpose of calcium hydroxide dressing was disinfection and creation of a physicochemical barrier. The calcium hydroxide dressing can also help control infection and maintain the root canal of high PH value an environment suitable for hard tissue formation and MTA setting. Summary and Conclusions The use of MTA in cases of external root resorption plays a very important role in restoration.
Saeed A, Ali N, Amir S. Management of inflammatory external root resorption by using Calcium Enriched Mixture cement: A case report. J Endod. 2011;37:411- 413. Abstract Introduction: Inflammatory external root resorption is one of the major complications after replantation of avulsed teeth. Here we report a case of inflammatory external root resorption in a maxillary left central incisor in an 11-year old male patient that was managed and treated by using calcium enriched mixture (CEM) cement. Methods: The patient's chief complaint was mobility of avulsed and replanted maxillary left central incisor and pain in chewing on left central and lateral incisors. Radiographic examination showed progressive inflammatory external root resorption of the left central incisor with an inadequately obturated root canal treatment. Both teeth were immature and had periapical radiolucencies. Both teeth were irrigated copiously with 2.5% NaOCl and obturated with CEM cement. However, the central incisor was treated with calcium hydroxide 6 weeks before CEM cement obturation. Results: The clinical and radiographic examinations at 3-, 6-, 12-, 24-, and 40-month follow-up showed that treated teeth were functional with normal mobility, the progression of the inflammatory external root resorption ceased, the resorptive lacunae were filled with newly formed bone, and periapical radiolucencies healed. Conclusions: Considering the biological properties of CEM cement, especially its alkalinity and sustained calcium hydroxide release, using this novel cement for treatment of inflammatory external root resorption and obturation of immature necrotic teeth might be an applicable choice.
Vinothkumar TS, Tamilselvi R, Kandaswamy D. Reverse sandwich restoration for the management of invasive cervical resorption: a case report. J Endod. 2011; 37:706-10. Abstract Introduction: Invasive cervical resorption (ICR) may occur as a consequence of trauma, orthodontic treatment, intracoronary bleaching, and surgical procedures and may lead to the progressive and destructive loss of tooth

structure. The restoration of these resorptivedefects is a challenging task because no single restorativematerial possesses good sealing ability, reinforcementof remaining tooth structure, and biocompatibilitysimultaneously. Methods: This case presented withinvasive cervical resorption class 2 (Heithersay) and apicalinflammatory resorption caused by trauma in tooth #9.The surgical management of ICR was performed, and, finally, the roots were externally reinforced by filling theresorptive defect with a combination of composite andresin-modified glass ionomer cement, proposed asreverse sandwich restoration (RSR). Results: This novelRSR was well tolerated by the periodontal tissues. Afollow-up x-ray showed no pathological changes andno recurrence of resorption. Conclusions: This casereport presents a treatment strategy for root reinforcementthat might improve the healing outcomes forpatients with invasive cervical resorption.

Ya-Ching C, Lin HG, Lee YL. Repairing invasive cervical root resorption by glass ionomer cement combined with mineral trioxide aggregate. J Dent Sci. 2012; 7:395-399.

Abstract

Cervical invasive root resorption is a type of external inflammatory root resorptionthat is relatively uncommon and aggressive, and leads to loss of tooth structure. A diagnosis ofcervical invasive root resorption depends on careful routine clinical and radiographic examinations.This report describes the diagnosis and successful treatment of a 41-year-old malepatient with invasive cervical root resorption at tooth #21. The distinctive feature was a largeresorptive defect at the cervicopalatal aspect of the maxillary central incisor involving theroot-canal space. A radiographic examination revealed a large periradicular lesion and severeperiodontal damage around this tooth. The defect was surgically repaired using resinreinforcedglass ionomer cement (GIC) and mineral trioxide aggregate (MTA) to restore thecoronal half and apical half of the resorption cavity, respectively. Thereafter, conventionalroot-canal treatment was performed. The 11-month recall revealed good healing of both theperiodontal and periradicular conditions and no obvious clinical symptoms. This case providesa new treatment modality to repair defects of cervical invasive root resorption and promotethe healing of periodontal defects.

Yilmaz HG, Kalender A, Cengiz E. Use of Mineral Trioxide Aggregate in the treatment of invasive cervical resorption. A case report. J Endod. 2010;36:160-163

Abstract

Introduction: Guided tissue regeneration (GTR) isa successful treatment procedure of periodontal reconstructivesurgery. Adverse effects can be observed afterGTR procedure, but external root resorption is rarely reportedat clinical studies. Invasive cervical resorption isa clinical term used to describe a relatively uncommon,insidious, and often aggressive form of external rootresorption. Methods: The present case demonstratesan invasive cervical resorption that is a potential latecomplication of GTR in a maxillary canine of a 59-year-old male patient. After the surgical interventionand root canal treatment, the resorption was subsequentlysealed with mineral trioxide aggregate.Results: The 1-year follow-up demonstrates no pathologicchanges on clinical and radiographic examination.Conclusions: This case report presents a treatmentstrategy that might improve the healing outcomes forpatients with invasive cervical resorption.

Huang Z, Chen LL, Wang CY, Dai L, Cheng B, Sun J, et al. Three-year follow-up results for non-surgical root canal therapy of idiopathic external root resorption on a maxillary canine with MTA: a case report. Int J ClinExpPathol. 2014; 7:3338-46.

Abstract:

External root resorption (ERR) is an uncommon and intractable disease. Treatment alternatives are case-dependant and aim for the repair of the resorptive lesion and long-term retention of the tooth. A forty-year-old Asian female was diagnosed with idiopathic ERR on tooth #11 (the left maxillary canine) by CBCT. Non-surgical root canal therapy was completed with the aid of an operating microscope. The apical third of the root canal was filled with warm gutta-percha and the resorption defect was filled with mineral trioxide aggregate (MTA). The periapical radiographs were taken immediately after operation, one-month follow-up, six-month follow-up and three-year follow-up, respectively. Clinically, the canine was asymptomatic, and no evidence of any further resorption was found. The six-month follow-up radiograph showed initial healing of the bony lesion, while the three-year follow-up radiograph manifested almost complete healing. MTA can be a superior material to be successfully used in the non-surgical treatment of ERR. CBCT is very useful for evaluating the true nature and severity of absorption lesions in root resorption. It is the first complete case report from China about non-surgical treatment of severe ERR along with a relatively long term follow-up.

Lo Giudice G, Matarese G, Lizio A, Lo Giudice R, Tumedei M, Zizzari VL, et al. Invasive cervical resorption: A case series with 3-year follow-up. Int J Periodontics Restorative Dent. 2016;36:103-9

Abstract

Invasive cervical resorption (ICR) lesion is an aggressive form of tooth destruction that usually begins immediately below the epithelial attachment. It has been described as a purely inflammatory reaction that can be started by microorganism infection, or an aseptic resorptive process that can be secondarily infected. The potential etiologic and predisposing factors for ICR are orthodontic treatment, traumatic injuries, bleaching, periodontal therapy, and idiopathic factors. This case series with a 3-year follow-up shows that Class 2 ICR lesions have a good prognosis in 100% of cases. Class 3 ICR lesions should be considered at risk. However, in the authors' experience, the treatment of Class 3 ICR lesions is compatible with tooth maintenance.

Machado R, Tomazinho LF, Magagnin R, Leal Silva EJ, Vansan LP. Management of progressive apical root resorption 13 years after dental trauma and primary endodontic treatment. Gen Dent. 2016; 64:74-6.

Abstract

Many studies have focused on the search for a restorative material with good sealing properties and biocompatibility for treatment of teeth with open apices and necrotic pulps, which can result from periradicular disease and root resorption. Mineral trioxide aggregate (MTA) has exhibited promising clinical results in retrograde fillings and pulpotomies as well as for treatment of root perforations, root resorptions, incomplete root formations, and pulpal necrosis. This case report describes the management of a progressive apical root resorption in a previously traumatized tooth that had been endodontically treated. Five years of clinical and radiographic follow-up demonstrated the clinical efficacy of MTA in limiting the inflammatory resorptive process and promoting apexification and regeneration of periradicular tissue.

Chaniotis A. The use of a single-step regenerative approach for the treatment of a replanted mandibular central incisor with severe resorption. IntEndod J. 2016; 49:802-12.

Abstract

AIM: To report the clinical and radiographic treatment outcome of an immature replanted mandibular incisor with severe inflammatory external root resorption following a single-step regenerative approach. **SUMMARY:** A 7-year-old female patient was referred 1 week following an extrusion injury to her mandibular central incisor (tooth 31). There was a history of a 6 months previous avulsion injury to the same tooth, which had been replanted after 20 min of extra-oral time. On clinical examination, all teeth were asymptomatic and there was an arch wire splint placed on the mandibular incisors. Radiographic examination revealed severe inflammatory external root resorption of tooth 31. A diagnosis of necrotic pulp and asymptomatic apical periodontitis was made. Under local anaesthesia and rubber dam isolation, an access cavity was prepared. The canal was irrigated using 6% NaOCl solution delivered through the EndoVac negative pressure irrigation system (EndoVac, Axis/SybronEndo, Coppel, TX, USA). A 17% EDTA solution was used for 5 min followed by a final rinse of sterile water. The periapical tissues were probed using a K-file, and bleeding was induced. A blood clot was allowed to form filling the entire canal. A thick plug of MTA was placed in direct contact with the blood clot. The tooth was restored with composite resin. All procedures were performed in a single visit. The splint was removed 2 weeks later. Recall examination after 24 months revealed healthy soft tissues with normal periodontal probing and mobility. The 24 months radiographic evaluation revealed healing of the severe inflammatory external root resorption and continuous root development/dentine wall thickening of the apical third. No signs of ankylosis or significant discoloration was present.

Ionta FQ, de Oliveira GC, de Alencar CR, Goncalves PS, Alcalde MP, Minotti PG, et al. Conservative management of external root resorption after tooth reimplantation: a 3-year follow-up. Gen Dent. 2016; 64:42-6.

Abstract

The aim of this case report is to describe the treatment of a 9-year-old patient who suffered external root resorption of the permanent maxillary left lateral incisor following reimplantation of the avulsed left central and lateral incisors. Sixteen days after reimplantation and splinting of the incisors in a hospital emergency department, the patient was brought to the pediatric department of a dental school for

further treatment. Root canal access was created in the maxillary left lateral and central incisors, and calcium hydroxide paste was used as intracanal dressing. At the 5-month follow-up, a radiograph revealed extensive external root resorption, a communicating root canal, and a periodontal lesion affecting the left lateral incisor. Management of the root resorption included obturation of the apical third of the canal with guttapercha and the middle third with mineral trioxide aggregate (MTA). At the 3-year recall examination, the patient was asymptomatic, and no mobility or soft tissue alterations were observed clinically. There was no radiographic sign that resorption had progressed. Despite the success of treatment, observation is still required. The use of MTA may be considered an alternative treatment for external root resorption after tooth reimplantation. The technique may allow tooth preservation in children until skeletal growth and development are completed and implant treatment may be considered.

Leneena G, Jeevan M, Prafulla M. Trauma induced external inflammatory root resorption: Case report. J Young Pharm, 2018;10:494-496

Abstract

Inflammatory root resorption is a serious complication of dental trauma, which leads to progressive loss of the root structure. It is challenging for a dental clinician to diagnose and plan the treatment for root resorption. This case report describes the diagnosis and treatment of a previously traumatized maxillary central incisor which was severely affected by inflammatory root resorption. This case was treated by conventional nonsurgical pulp space therapy. Calcium hydroxide dressing was given as an intra-canal medicament. The entire root was obturated with mineral trioxide aggregate. The radiographic follow up at 12 months showed arrest of root resorption and initiation of periapical healing in the absence of clinical symptoms and mobility. From the present case, it can be concluded that mineral trioxide aggregate obturation can be a viable option that can enhance the healing in cases of severe inflammatory root resorption.

Reston EG, Bueno R, Closs LQ, Zettermann J. Fifteen-year clinical follow-up of restoration of extensive cervical resorption in a maxillary central incisor. Oper Dent. 2017; 42:55-8.

Abstract

Internal bleaching in endodontically treated teeth requires care and protection to prevent harm to the periodontal ligament due to peroxide and may result in external root resorption. There is a myriad of treatment options when this occurs, such as monitoring, extraction, and subsequent rehabilitation with implants or fixed prosthodontics. In some cases, such as the one described here, a conservative attempt to maintain the tooth as a single structure can be made by sealing the resorptive defect. In the present case, we show a multidisciplinary approach where orthodontics, periodontics, and restorative dentistry were involved in treating the maxillary right central incisor (#8) of a 65-year-old patient with extensive cervical resorption, whose chief complaint was esthetics. The proposed treatment was extrusion of the tooth followed by curettage and restoration of the defect with glass ionomer cement. The patient has been followed for 15 years with no signs of recurrence, maintenance of periodontal health, and patient satisfaction with the esthetic outcome.

Ambu E, Fimiani M, Vigna M, Grandini S. Use of bioactive materials and limited FOV CBCT in the treatment of a replanted permanent tooth affected by inflammatory external root resorption: a case report. Eur J Paediatr Dent. 2017; 18:51-5.

Abstract

Background: Inflammatory external root resorption is one of the possible complications of replantation of an avulsed tooth. Several studies have shown that limited FOV CBCT is an efficient diagnostic support and in treatment planning of these cases in paediatric patients because of its high resolution combined with low radiation doses. The recent literature has suggested that Biodentine is an effective material for resolution of inflammatory root resorption. **Case report:** This article describes the successful therapy of a replanted tooth affected by inflammatory root resorption. In the present case, a CBCT exam was performed to

detect the extent of the damage, and the canal was filled with Biodentine in the apical third. At present, the threatened tooth is asymptomatic, and the twelve months follow-up examination showed healing of periradicular hard tissues.	
Kusgoz A, Yildirim T, Alp CK, Tanriver M. Management of root resorption with mineral trioxide aggregate complicated by a luxation injury: report of a case with six-year follow-up. J Pak Med Assoc. 2017;67:134-6. Abstract Trauma to the oral region occurs frequently, comprising 5% of all injuries. The most common dental injuries are lateral luxations which can be seen with a prevalence of up to 27% among dental injuries. Ectopic eruption of maxillary canines can lead to root resorption on maxillary lateral incisors especially on apical and middle thirds of the roots. Half of these resorbed lateral incisors show severe resorption, in which the pulp is exposed. This case report describes non-surgical treatment with mineral trioxide aggregate (MTA) and a six-year follow-up of a maxillary lateral incisor, resorbed by ectopic eruption of the canine and affected by lateral luxation injury. The tooth was asymptomatic, and radiographic examination showed that the resorbed region had been successfully repaired with new hard tissue deposition within the six-year follow-up. MTA can be considered an effective repair material in nonsurgical treatment of this type of root resorption.	
TEMATICA	RESORCION RADICULAR EXTERNA
BASE DE DATOS	EMBASE
ALGORITMO FINAL	((#2 OR #3 OR #7) AND tooth AND root* AND resorpt*)
artículos preseleccionados Referencia -estilo Vancouver y abstract	
Tzanetakakis GN. Management of intruded immature maxillary central incisor with pulp necrosis and severe external resorption by regenerative approach. J Endod. 2018; 44:245-9. Abstract Introduction: intrusive luxation is one of the most severe traumatic injuries of permanent teeth that may adversely affect the pulp and the periodontium. pulp necrosis and root resorption are the main pathologic entities associated with this injury. the present report describes the endodontic management of an intruded immature maxillary central incisor presented with pulp necrosis and severe inflammatory root resorption by using the regenerative approach. methods: a 7-year-old boy with dental trauma to the anterior maxillary region was referred for the management of a traumatized maxillary central incisor. clinical examination revealed an uncomplicated crown fracture, whereas radiographic examination showed that the tooth was immature, confirming the intrusion that was calculated between 3 and 4 mm. the tooth was left to re-erupt, but after 2 months the boy presented with intraoral swelling. radiographic examination showed initial signs of root resorption. the tooth was treated by using a regenerative endodontic approach. results: clinical and radiographic examinations during the initial follow-up period showed resolution of the signs and symptoms as well as inhibition of the resorption process. at the follow-up examinations, the tooth remained free of signs and symptoms and completely functional. the radiographic recall examinations showed a gradual thickening of the root canal walls but incomplete apical closure. conclusions: the present case shows that severely injured teeth with uncertain prognosis may have a considerable percentage of chance to remain functional and free of signs and symptoms by using a regenerative endodontic procedure, confirming the efficacy of this procedure as a viable treatment option.	
Discacciati JA, de Souza EL, Costa SC, Sander HH, Barros Vde M, Vasconcellos WA. Invasive cervical resorption: etiology, diagnosis, classification and treatment. J Contemp Dent Pract. 2016; 13:723-8. Abstract background: invasive cervical resorption (icr) is not well understood by the professional, being misdiagnosed, leading to inappropriate treatment and unnecessary loss of tooth. introduction: icr is defined as a localized process of resorption, which begins in the cervical area of the tooth, just below the epithelial junction and above the ridge crest in the area of the connective tissue insertion. possible predisposing factors include external trauma, orthodontic movement, surgical procedures, periodontal disease and its treatments, endogenous bleaching, pressure generated by wind instruments and herpes virus infection. different approaches have been suggested for the treatment of icr, depending on the extent of the lesion and its location. however, in some cases due to the severity of the injury, there is no alternative but to tooth extraction,	

followed by restoration of the edentulous area.aim and objective: discuss etiology, diagnosis and classification of the icr, as well as different treatment options. also is presented a case in which extraction was carried out, installation of the implant and ceramic crown, subsequent to a treatment approach that resulted in failure in the short-term period.Conclusion: early diagnosis of the icr is critical to proper treatment and favorable prognosis. interdisciplinary treatment should be instituted as soon as possible, avoiding the loss of the affected tooth. in advanced cases, treatment involving the installation of osseointegrated implants should be considered the first choice of treatment.clinical significance:early diagnosis of the icr is critical to prevent unnecessary tooth loss, once the prognosis for advanced cases is doubtful.
Byakod P, Shaikh S, Mota I. Nonsurgical treatment of external root resorption and furcal perforation using MTA: A magical wand in endodontics. Pravara Med Rev 2014; 6:29-33 Abstract Mineral trioxide aggregate (MTA) is well known for its great biocompatibility, has demonstrated excellent sealing ability in studies of deep penetration and bacterial leakage even under blood contamination condition. It is widely applied currently in root end filling, perforation repair and pulp capping. It can induce regeneration of periradicular tissue such as bone and cementum. In the present case series, a 40-year-old male was diagnosed with idiopathic External Root Resorption with tooth #24 on IOPA. Non-surgical root canal therapy was completed by filling the root canal and the resorption defect with mineral trioxide aggregate (MTA). Another case of a 25-year-old female suffered from iatrogenic furcal perforation in tooth #26 which was also treated non-surgically by sealing the perforation with MTA. Thus, this case series aims to demonstrate the application and results obtained by MTA in various endodontic clinical situations.
Subramanyappa SK, Parthasarathy B, Manjegowda PG, Rajeev S. Management of perforating invasive cervical resorption: Two case reports. JIAOMR, 2012; 24:346-349 Invasive cervical resorption (ICR) is a type of external resorption that is not well understood or well known in the dental community. It is often misdiagnosed, leading to improper treatment or unnecessary loss of the tooth. Treatment may involve the periodontium as well as the tooth and pulp, and management can be complex. Early diagnosis and appropriate treatment are the keys to a successful outcome. This case reports elaborates the surgical management of the perforating ICR.
Santiago CN, Pinto SS, Sassone LM, Hirata R, Jr., Fidel SR. Revascularization technique for the treatment of external inflammatory root resorption: A report of 3 cases. J Endod. 2015; 41:1560-4. Abstract The current external inflammatory root resorption treatment protocol, which uses calcium hydroxide dressing, usually comprises multiple and long-term applications. In addition to the need for multiple appointments for calcium hydroxide replacement, the long-term maintenance of this compound in the root canal weakens dental structures. A modification of this therapy would be advisable. In this clinical investigation, 3 patients with external inflammatory root resorption were submitted to revascularization therapy protocol usually used in teeth with necrotic pulp and open apices. The teeth were treated with revascularization therapy protocol, which consisted of disinfecting the root canal system with triantibiotic paste, filling it with blood clot, and sealing of the root canal with mineral trioxide aggregate and bonded resin restoration. During the follow-up, the pathologic process was arrested with tissue repair in pre-existing radiolucent areas. Reduced mobility was observed in the treated teeth. The 3 cases were followed up for 30, 18, and 15 months, respectively. All teeth remained asymptomatic and retained function and physiological mobility. The therapy used in the revascularization procedure was efficient in the treatment of external inflammatory root resorption, reducing the number of appointments and increasing patient compliance.
Saoud TM, Mistry S, Kahler B, Sigurdsson A, Lin LM. Regenerative endodontic procedures for traumatized teeth after horizontal root fracture, avulsion, and perforating root resorption. J Endod. 2016; 42:1476-82 Abstract Introduction:traumatic injury to the teeth can cause horizontal root fractures and inflammatory root resorptions (external and internal). traditionally, traumatized teeth with horizontal root fractures resulting in pulp necrosis and inflammatory root resorptions are treated with conventional root canal therapy. methods:a 15-year-old boy had a history of traumatic injury to mature tooth #8 resulting in horizontal root fracture and pulp necrosis of the coronal fragment. a 7-year-old girl suffered an avulsion injury

to immature tooth #9, which developed inflammatory replacement resorption and subsequently root fractured 15 months later. another 16-year-old boy also suffered a history of traumatic injury to mature tooth #8, resulting in perforating root resorption. all teeth were treated with regenerative endodontic procedures using chemomechanical debridement, calcium hydroxide/triple antibiotic paste dressing, edta rinse, induction of periapical bleeding into the canal space, and a coronal mineral trioxide aggregate plug. in the tooth presenting with horizontal root fracture, only the coronal fragment was treated to preserve pulp vitality in the apical fragment for possible pulp tissue regeneration. results: after regenerative endodontic procedures, clinical signs/symptoms subsided, and inflammatory osteolytic lesions resolved in all traumatized teeth. two teeth were followed for 19 months and 1 tooth for 5 years. at the last review of the teeth with horizontal root fractures, the first case showed healing by calcified tissue and the second case showed healing by fibrous connective and hard tissue. tooth with perforating root resorption demonstrated a decrease in size of the resorptive defect. conclusions: Based on these case reports, regenerative endodontic procedures have the potential to be used to treat traumatized teeth with horizontal root fracture and inflammatory root resorption.

Shemesh A, Ben Itzhak J, Solomonov M. minimally invasive treatment of class 4 invasive cervical resorption with internal approach: A case series. J Endod. 2017; 43:1901-8

Abstract

Invasive cervical resorption (ICR) is a type of external resorption that can involve the coronal, middle, and apical parts of the root in its advanced stages. The diagnosis and treatment of ICR depend on the extent of the resorption into the dentin. The treatment of advanced ICR is challenging, and these teeth have poor prognoses. This article describes 4 cases of class 4 ICR diagnosed by using cone-beam computed tomography and treated with a minimally invasive internal approach with sodium hypochlorite irrigation and calcium hydroxide dressing. All cases were followed for at least 3 years.

Machado R, Leoni GB, Yarid P, Cruz-Filho AM, Sousa-Neto MD. Idiopathic external apical root resorption: clinical report of 2 cases. Gen Dent. 2017; 65:62-5.

Abstract

External root resorptions are characterized by progressive destruction of hard tissue due to clastic activity. This article reports 2 cases that involved the nonsurgical treatment of mandibular molars with idiopathic external root resorption. In the first case, clinical and radiographic examination showed irreversible inflammation of the pulp tissue and resorption of the distal root. Chronic inflammatory infiltrate and necrosis were identified by histopathologic examination of the pulp tissue. In the second case, inadequate endodontic treatment and a resorptive process were observed in the mesial and distal roots. In both cases, mineral trioxide aggregate (MTA) was used as the filling material. Clinical and radiographic follow-ups of 1 and 7 years, respectively, showed a favorable trend, including interruption of the resorptive process and periradicular normality. More longitudinal studies are necessary to analyze the performance of MTA in treating external root resorptions.

Inicialmente, cuatro revisores (LXL, VJG, LMS, FPU) examinaron de forma independiente los títulos, resúmenes y textos completos de los resultados de búsqueda. Los autores de la revisión no fueron cegados con respecto a él/los autores, sus afiliaciones institucionales y el sitio de la publicación de los reportes. El reporte completo fue obtenido por todos los estudios que aparentemente cumplían con los criterios de inclusión o en instantes presentaban una información insuficiente en el título, palabras claves y abstract para poder tomar la decisión clara. Todos los estudios fueron asesorados independientemente por ambos autores de la revisión. Los desacuerdos entre los autores de la revisión fueron resueltos por medio de una

discusión con otro autor de la revisión (LFG). En el caso de tener una falta de datos, los autores de los artículos identificados fueron contactados para proveer mayores detalles. Los estudios que cumplían con los criterios de inclusión se sometieron por una evaluación de validación y extracción de datos. Los datos de las siguientes cuestiones fueron extraídos y se guardó el duplicado (LXL, FPU) usando formatos de evaluación especialmente diseñados para la extracción de datos: I) citación, estado de publicación y año de publicación.; II) lugar del ensayo; III) características de los participantes; IV) tipos de intervenciones; V) las medidas de resultado; and VI) fuente de financiación y conflictos de interés.

Los datos de todos los artículos fueron organizados en tablas, se resumieron estos datos para determinar las características de cada estudio, el tratamiento empleado en cada uno de estos estudios y los resultados. Este proceso facilitó el análisis de la similitud de los estudios y la aplicación de otros métodos de síntesis.

7. Consideraciones éticas

- Los autores declaran su responsabilidad de solicitar los permisos correspondientes por el uso de derechos tanto de material impreso o electrónico, y se responsabilizan por el pago de cualquier gravamen relacionado con el uso de estos permisos.
- Adicionalmente declaran que no tienen intereses económicos relacionados con el presente trabajo que pueda crear cualquier conflicto de intereses.
- El archivo de los datos y las condiciones de publicación se establecerán según la normativa dada por la “Guía para autores” del grupo editorial Elsevier.
- El cumplimiento del presente protocolo es responsabilidad ética y legal de los autores, así como la garantía de preservar la confidencialidad de los participantes.

8. Resultados

Descripción de los estudios Resultados de búsqueda

El flujograma (Figura 1) demuestra el proceso de selección del artículo. Inicialmente, la estrategia de búsqueda arrojó 27277 publicaciones (con exclusión de los duplicados). Después de la evaluación de los títulos y los resúmenes de cada artículo, 27207 resultados fueron excluidos inmediatamente. Los 70 artículos restantes fueron examinados y excluidos si no cumplían con los criterios de inclusión. Por último, un total de 33 artículos fueron incluidos para su revisión.

Estudios incluidos

33 publicaciones, de las cuales 26 son reportes de casos y 7 series de casos fueron analizados. En la Tabla 1 se describen las características más importantes de los estudios incluidos.

Características metodológicas de los estudios incluidos

Dado el tipo de estudios incluidos (reportes de casos y series de casos) y sus deficiencias inherentes a la calidad metodológica, no se realizó ninguna evaluación formal de calidad. (Todos ellos fueron considerados como en "un alto riesgo de sesgo" o de "baja calidad metodológica"). De los 33 estudios incluidos, 26 informes de casos y 7 series de casos indicaron el número de pacientes, el género, la edad y el número de dientes afectados por ERR, si presentaban o no un tratamiento ortodóntico previo, blanqueamiento intracoronario, historia de trauma, infección o si era una lesión idiopática. Estos estudios describen el instrumento de medición, que era el examen clínico, imágenes radiográficas, CBCT, las pruebas de sensibilidad, palpación y percusión. De la misma manera, estos estudios describieron períodos de seguimiento que van desde 3 (Mittal, 2011) 180 meses (Restonet *al.*, 2017). En general, el período medio de seguimiento fue de 32 meses.

Resultados individuales y las estimaciones combinadas de los estudios

33 publicaciones, de las cuales 26 son reportes de caso y 7 series de caso fueron analizadas.

Donde se evidencio que los 33 reportes de caso, tanto para la resorción radicular y cervical, 18 (54.5%) de los casos fueron manejados con tratamiento endodontico. En cuatro (33.3%) casos, el tratamiento para la resorción radicular externa consistió en revascularización, 11 (12.1%) casos no reportaron tratamiento endodontico convencional y solo un (0.33%) estudio no reporto éxito.

18 (54.5%) casos fueron reportados con tratamiento endodontico convencional en los cuales 8 (44.4%) reportaron el uso de medicación intraconducto con Hidróxido de calcio, 1 (5.5%) con pasta triantibiotica y 1(5.5%) con pasta ledermix. Se utilizó en 14 (77.7%) como sustancia irrigadora NaOCl junto con EDTA en 6 (33.3%) de los casos. También se evidencio el uso de CHX en 2 (11.1%) de los estudios reportados, Acido trichloroacetico en 3 (16.6%) de los reportes de caso donde fue realizado un selle directo del defecto y tratamiento endodontico convencional.

Se encontró que en 4 (12.1%) de los reportes de caso se manejó con tratamiento alternativo de Revascularizacion, usando como irrigante NaOCl en 4 (100%) de los casos y EDTA 3 (75%) en conjunto, medicación intraconducto con hidróxido de calcio en 2 (50%) y pasta triantibiotica en 2 (50%) de los casos, finalizando para cada tratamiento un selle coronal con MTA.

En cuanto al manejo de la resorción radicular externa con tratamiento endodontico no convencional, otras alternativas fueron propuestas según lo encontrado en 11 reportes de caso en esta revisión (33.3%); obturando en su totalidad 3 (27.2%) casos con MTA, microcirugia apical en 1 caso, el reimplante intencional, tracción ortodontica (30), Adicionalmente realizando un selle directo del defecto con MTA en 2 (18.1%) de los casos reportados, ionómero de vidrio, resina, y poste en fibra de vidrio en uno de los casos como restauración definitiva en ionómero y resina. se encontró que en 3 (27.7%) utilizaron NaOCl como irrigante y 1 (9%) con EDTA. 5 (45.4%) reportes realizaron medicación intraconducto hidróxido de calcio y cemento CEM 1 (9%) como material de retro obturación para reimplante intencional.

9. Discusión

La mayoría de los estudios proporcionan evidencia del manejo endodóntico de la ERR. El MTA es el material más utilizado (63.6%) para sellar el tipo de defecto creado por el proceso de resorción y para promover la cicatrización y regeneración de tejidos puesto que este material mostró una mayor tasa de éxito. Por otro lado, el uso de la medicación intraconducto (57.5%) en conjunto con el tratamiento endodóntico convencional (54.5%); El manejo mediante revascularización (12.1%) fue una alternativa de tratamiento en ápices inmaduros para el manejo de las resorciones, También se utilizaron ionómero de vidrio y resina fotopolimerizable, para el selle de resorciones cervicales. (Tabla 5).

Calidad de la evidencia

Todos los casos incluidos en esta revisión sistemática fueron reportes de casos y series de casos (que podría contener una debilidad metodológica significativa) y su inclusión en una revisión sistemática puede conducir a datos imprecisos en cuanto a la pregunta de investigación. (Chambrone *etal.*, 2009; Chambrone *et al.*, 2010; Needleman *et al* 2012). La exclusión de los estudios debido a la metodología limitada puede evitar el sesgo, sin embargo, y en casos como esta revisión sistemática, cuando las fuentes adecuadas de pruebas no están disponibles, todos los niveles de evidencia podrían ser incluidos en el proceso de revisión. La evaluación detallada de la evidencia actual reveló que los estudios individuales no proporcionan suficiente información por motivos de raza, ubicación, comportamiento, y la gravedad de la lesión. Los métodos utilizados para evaluar el estado de la resorción eran adecuados, ya que todos los estudios incluidos dieron un diagnóstico correcto mediante el uso de parámetros clínicos y radiográficos, tales como pruebas de sensibilidad, el sondeo, percusión, palpación y las radiografías desde diferentes angulaciones. Sin embargo, los datos de los diferentes estudios fueron diversos, ya que se basan en diferentes criterios de inclusión / exclusión y realizaron diferentes procedimientos. (Tabla 5).

Todos los estudios incluidos reportaron los resultados de los pacientes tratados con MTA, CEM, biodentine, ionómero/resina. Se puede argumentar que esta condición requiere los datos

originales de cada paciente para realizar un análisis adecuado del estudio y de esta manera establecer una tasa de éxito/fracaso válido. El fracaso/éxito del tratamiento para la ERR debe ser determinado por una buena evaluación clínica y radiográfica, como la profundidad de la bolsa, la presencia de sangrado, supuración, movilidad, y la ausencia de síntomas después de un período de seguimiento adecuado. (Needleman *et al* 2012).

Las limitaciones y sesgos potenciales en el proceso de revisión

Esta revisión sistemática es una actualización de una revisión de Cochrane, que tuvo como criterios de inclusión ensayos clínicos aleatorizados ⁽¹⁾. Debido al tema estudiado, este trabajo incluye reporte de casos y series de casos con el fin de determinar el tratamiento adecuado para la ERR. Debido a consideraciones éticas, no es posible incluir otro tipo de estudios (es decir, ya que esta patología tiene una baja incidencia, es imposible esperar a que un número mínimo de pacientes sean tratados y seguidos por los estudios de intervención o de observación). Como consecuencia de ello, los reportes de casos fueron revisados en cuanto a opciones de tratamiento para la ERR con el propósito de establecer las directrices para el tratamiento de esta patología. Además, no se realizó una "Evaluación de la Calidad" de los estudios incluidos. A pesar de no ser capaz de reducir o alterar el efecto del tratamiento en sí, estos asuntos pueden ser considerados como la principal limitación de la presente revisión sistemática y deben tenerse en cuenta al interpretar los resultados actuales. (Solow, 2019)

Acuerdos y desacuerdos con otros estudios o revisiones

En esta revisión, el número de estudios que tuvieron éxito y los que terminaron en fracaso se observaron; sólo uno de los 33 estudios terminó en fracaso. En este estudio, el manejo de ERR fue con la colocación de ionómero de vidrio sobre el defecto y posteriormente se realizó tratamiento endodóntico, pero la severidad y extensión de la resorción no se evaluó. Los autores de este caso indicaron que cuando hay una gran pérdida de estructura dental, cualquier tratamiento podría terminar en fracaso. Sin lugar a dudas, esto sería un factor importante a tener en cuenta al tomar una decisión con respecto al tratamiento de la ERR. (Discacciatiet *al.*, 2016)

Los documentos analizados en esta revisión indicaron un protocolo de manejo para la resorción, que incluye tratamiento endodóntico en conjunto con la colocación de un medicamento en el interior del conducto para controlar la infección y detener la lesión, junto con un material de selle adecuado, tal como el MTA, que al mismo tiempo promueve la cicatrización. Este es el tratamiento que ha tenido mayores tasas de éxito para el manejo de esta condición. Sin embargo, no se recomienda el uso de MTA en dientes anteriores debido a que su uso podría comprometer la estética del paciente(Mozynska *et al.*, 2017); en estos casos se debe utilizar ionómero de vidrio y/o resinas. El tratamiento del conducto radicular es esencial en el protocolo de tratamiento para la ERR debido a que el sistema de conductos radiculares contiene una carga considerable de microorganismos que, si no se trata adecuadamente, podrían agravar la condición y prevenir la regeneración de los tejidos circundantes. La mayoría de los estudios incluidos en esta revisión implementó el tratamiento endodóntico para el manejo de la ERR.

Informes recientes han relacionado la hipoxia con el inicio y la propagación de la ECR. Se ha planteado la hipótesis de que la hipoxia en una lesión de la ECR puede ocurrir debido a alteraciones locales de la microcirculación en el área afectada debido a la distribución de la gradiente de la hipoxia en la lesión de la ECR, lo que también podría indicar Que diferentes factores pueden desempeñar diferentes papeles en los canales radiculares. (Mavridou *et al.*, 2019).

Un último factor debe ser discutido. Los informes de casos se han utilizado en la investigación odontológica para describir diagnóstico/condiciones inusuales y su tratamiento alternativo como "información de piloto" antes del desarrollo/diseño de ensayos clínicos adecuados que implican el mismo tema. Ciertamente, se sabe que la fuerza de la traducción de estos resultados a la práctica regular puede ser cuestionable; Sin embargo, estos datos pueden ser de interés cuando los resultados clínicos y radiográficos son evaluados en condiciones particulares que no se pueden encontrar fácilmente en ambas clínicas privadas y académicas. En consecuencia, una fuerte evaluación de los procedimientos del manejo no se puede lograr, por lo tanto, una respuesta definitiva podría no ser obvia.

10. Conclusiones

Dentro de los límites de esta revisión sistemática, se observó que dependiendo de la situación clínica presentada en los casos de ERR, el tratamiento endodóntico convencional y tratamientos regenerativos (revascularización) en casos de ápice inmaduro en combinación con medicación intraconducto y un material de sellado se utilizaron como tratamientos, en los casos donde el acceso era posible a través del conducto. Otras alternativas fueron propuestas por los autores debido al limitado acceso cameral al conducto o al defecto, como extrusión ortodóntica, abordaje quirúrgico, reimplante intencional, microcirugía apical en combinación con un material de sellado bioactivo el cual parece promover la regeneración de tejidos y la cicatrización.

11. Referencias

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12. Anexos

Tabla 5 - *Características de los estudios seleccionados*

	Method	Participants	Treatment of External Resorption	Results
Aggarwal et al., (2010)	Case Report; 48 months follow-up	12-year-old male; avulsion of tooth 11; diagnosis: IERR	RCTx; irrigation with NaOCl 2;5%; use of intracanal medication 10 days with ciprofloxacin; metronidazole paste; apical barrier of MTA and coronal sealing: glass ionomer base and composite resin.	Success; no mobility after 48 months follow-up; no root resorption from the baseline radiograph; was arrest of root resorption
Araújo et al., (2010)	Case Report; 12 months follow-up	34-year-old male; RCTx tooth 21; presented ERR	RCTx; Irrigation with NaOCl 2;5%; calcium sulfate matrix to prevent extravasation of MTA and a 3mm apical barrier; canal filled with gutta-percha.	Success; no signs or symptoms after 12 months follow-up.
Cunha et al., (2010)	Case report; 24 months follow-up	11-year-old male; avulsion of tooth 21 six months earlier; diagnosis: severe IERR	RCTx; irrigation of hypochlorite 2;5% and passive ultrasonic irrigation with EDTA 17%; Ca(OH) ₂ combined with propylene glycol for 30 days; 60 days for intracanal medication; filled with gutta-percha; coronal sealing with resin.	Success; after 24 months ; osteogenesis and periodontal ligament formation; no signs or symptoms
Lux et al., (2010)	Case report; 24 months follow-up	13-year-old female; large cystic lesion combined with cervical and external apical resorptions of tooth 11; history of avulsion and orthodontic treatment; diagnosis: ECRR	RCTx; placement of Ledermix for 7 days and changed to Ca(OH) ₂ ; RCTx after 14 weeks, root canal filling was done with gutta-percha and an apical barrier with MTA; use of resin as a coronal sealer	Fast recovery of the bony defect; condition improved after 2 years follow-up.
Yilmaz et al., (2010)	Case report 12 months follow-up	59-year-old male; history of guided-tissue regeneration tooth 23; diagnosis: ICR	Combined technique; RCTx and surgical procedure using MTA as a sealer in resorption zone; intracanal irrigation using chlorhexidine 2%.	Success; mild mobility with normal probing depth after 12 months; no gingival recession; no loss of clinical attachment
Fernandez et al., (2011)	Case report; 72 months follow-up	67-year-old male; tooth 25; history of SRP; diagnosis: ICR	Surgical technique; Chlorhexidine 2%; 90% trichloroacetic acid solution over the lesion for 2 minutes; direct sealing using MTA in resorption zone.	Success; complete healing after 72 months
Saeed et al., (2011)	Case report; 40 months follow-up	11-year-old male; history of avulsion of tooth 22; diagnosis: IERR	RCTx; intracanal medication with calcium hydroxide; RCTx was performed; using sodium hypochlorite 2;5% as irrigation; root filled with CEM; restored with composite	Success; tooth 22 functional after 40 months follow-up; no sensitivity; physiologic mobility; normal probing depths
Sin-Young et	Case report; 12	22-year-old male; teeth 21; 22 history of	Surgical technique, full-thickness flap; curettage; apical microsurgery;	12 months after surgery; radiographic

<i>al.,</i> (2011)	months follow-up	trauma; diagnosis: IERR	retreatment; resorption area repaired with resin modified glass-ionomer cement; retrograde filling with white MTA	examination revealed complete healing of the lesion
Vinothkuma ret al., (2011)	Case report; 12 months follow-up	15-year-old male; history of trauma tooth 21 Diagnosis: ICR	RCTx combined with surgical technique; sodium hypochlorite 3%; clorhexidine 2%; EDTA 17% irrigation; trichloroacetic acid solution 90%; glass ionomer at resorption zone; final sealing wit resin.	Success; no recurrence after 1 yr follow-up; normal probing depth
Discacciati; et al. (2012)	Case report; 6 months follow-up	40-year-old male; no history of trauma or other etiologic factor; diagnosis: ICR	RCTx and direct resorption sealing;using glass ionomer.	Failure after 5 mos; significant gingival inflammation in the vestibular region; extensive cavitation in the lingual region that extended below the gingival and extraction.
Kqiku et al., (2012)	Case Series; 6 months follow-up	Case 1: 31-year-old female; gingival swelling and pink spot localized in the labial cervical area tooth 21; no history of orthodontic treatment; dental trauma; or bleaching; diagnosis: ICR Case 2: 16-year-old male; subluxation of teeth 11 and 21; under orthodontic treatment; diagnosis: ICR	Case 1: clorhexidine solution over the defect; MTA to seal the defect (mixed with clorhexidine); direct sealing with glass ionomer and resin; cephalosporin for 4 days; not RCTX performed. Case 2: clorhexidine solution over the defect; MTA to seal the defect (mixed with clorhexidine); direct sealing with glass ionomer and resin	Success; 6mos after; there were no symptoms; no pathologic changes to teeth or surrounding tissues
Subramanya ppaet al., (2012)	Case series; 28 months follow-up	Case 1: 31-year-old female; pain and discoloration tooth 11; history of trauma; diagnosis: ICR Case 2: 19-year-old male; tooth 11 with history of trauma. Diagnosis: ICR	RCTx; sealing with ionomer; RCTx; resorptive tissue removed; dentin scrubbed for 1 minute with 90% trichloroacetic acid on a cotton ball; canal packed with resin-modified glass ionomer cement	Periapical healing in both cases after 2 yrs.
Ya Ching et al., (2012)	Case report; 11 months follow-up	41-year-old male; history of RCTX tooth 21;no history of trauma; orthodontic treatment; or tooth bleaching; diagnosis: ICRR	Surgical repair first; then RCTx; sodium hypochlorite 2.5%; calcium hydroxide; MTA sealing at resorption zone; coronal sealing; resin	Success; good healing of the periodontal and periradicular conditions at 11 mos follow-up

Gandiet <i>et al.</i>, (2013)	Case report; 18 months follow-up	24-year-old male; history of trauma tooth 21; diagnosis: ECRR	RCTx; hypochlorite 5.23%; NSS to remove smear layer; MTA sealing at the resorption area; tetracycline; bony defect grafted	Success; good healing after 18mos follow-up; no periapical changes
Ikhar <i>et al.</i>, (2013)	Case report; 48 months follow-up	19-year-old male; history of trauma tooth 21; diagnosis: ICR	RCTx; resorptive area rinsed with NaOCl 5% and EDTA 17%; MTA used as sealing material in resorption defect; coronal sealing: composite	Success; no signs or symptoms after 48 mos follow-up
Mittal, (2013)	Case report; 3 months follow-up	12-year-old female; severe pain and draining sinus related to teeth 11 and 21 with history of avulsion and intentional reimplantation; diagnosis: ERR	RCTx and MTA as an apical barrier; intracanal medication with Ca(OH) ₂ ; RCTx and sodium hypochlorite (2;5%) irrigation; gutta-percha with eugenol as a sealing material; resin as a coronal sealer	Success; no symptoms or signs at 3mos follow-up
Harris <i>et al.</i>, (2014)	Case Report ; 30 months follow-up	78-year-old male; history of trauma tooth 21; diagnosis: ICR	RCTx; NaOCl 1.25%; EDTA 17%; trichloroacetic acid solution 90% concentration over the lesion for 30 seconds; glass ionomer in resorption zone; full crown	Success; no complications after 30 months follow-up
Kheiriet <i>et al.</i>, (2014)	Case report; 12 months follow-up	22-year-old female; symptomatic tooth 25 3mos after completion of orthodontic treatment; diagnosis: IERR	CEM retrograde with intentional reimplantation; NaOCl 5; 25% for 15 minutes in root canal; Ca(OH) ₂ 7 days; chlorhexidine rinsing 0; 12% at the beginning; then amoxicillin for 7 days	Success; satisfactory clinical function after 12 mos follow-up; no signs of inflammation or infection
Zheng <i>et al.</i>, (2014)	Case report; 36 months follow-up	40-year-old female; extensive resorption area of tooth 23; unremarkable dental history; diagnosis: idiopathic ERR	RCTx; sodium hypochlorite 5.25%; sealed with gutta-percha; perforation and the upper part of the root canal filled with white MTA; sealing with glass ionomer.	Success; complete healing of the resorption region 36 mos POP
Byakodet <i>et al.</i>, (2014)	Case Series; 12 months follow-up	Case 1: 40-year-old male; mobility of tooth 24 with no history of trauma; orthodontics; bleaching or periodontal surgery; diagnosis: IERR	Case 1: Filled with MTA; first visit: NaOCl 3%; Ca(OH) ₂ 12 days; third visit MTA (ProRoot) filling root canal and resorption defect; coronal sealing: glass ionomer	Success; 12 mos follow-up; periapical healing
Santiago <i>et al.</i>, (2015)	Case series; followed for 30; 18; and 15 months	Case 1: 9-year-old male; history of trauma teeth 11 and 21; diagnosis: EIRR Case 2: 9-year-old male; avulsed tooth; dental splint for 21 days; diagnosis: EIRR Case 3: 8-year-old; avulsion of 11 and 21; replantation 2 hours after trauma; dental	Revascularization; all patients received the same treatment; sodium hypochlorite 2.5% solution; 10 mL sterile saline solution; triantibiotic paste and glass ionomer; irrigation with 5.25% NaOCl and sterile saline; sealing with MTA; glass ionomer and resin	Success; in each case 3 months after the procedure; teeth were asymptomatic Case 1 & 2: hard tissue ingrowth after 3 months Case 3: hard tissue ingrowth after 6 months

		splint for 30 days; diagnosis: EIRR		
Lo Giudice et al., (2016)	Case report; 36 months follow-up	24-year-old female; ICR lesion of teeth 11 and 12; diagnosis: ICR	Surgical exposure; debridement; and restoration without RCTX. Etching with orthophosphoric acid 37%; bonding and composite	Success; asymptomatic after 1 year follow-up; good healing of gingival tissues; normal probing depth; no gingival recession; and no loss of clinical attachment
Machado et al., (2016)	Case report; 60 months follow-up	26-year-old male; history of trauma and RCTx tooth 21; diagnosis EARR	Fiber post; 2.5% NaOCl; 7 % EDTA; Ca(OH) ₂ ; MTA; fiber post; final restoration with resin	Success; apexification and periradicular normality 5 years after retreatment
Chaniotis et al., (2016)	case report; 24-month follow-up	7-year-old female; history of avulsion tooth 31; diagnosis: EIRR	Revascularization; 6% NaOCl; 17%; EDTA; formation of blood clot; sealing with MTA; restored with resin	Success; healthy soft tissues; normal mobility after 2 years
Saoud et al., (2016)	Case series; 15 months follow-up	Case 2: 7-year-old female; avulsion of immature tooth 21; which developed inflammatory replacement resorption Case 3: 16-year-old male; history of traumatic injury to tooth 11; resulting in perforating root resorption	Revascularization; all teeth treated with regenerative endodontic procedures; calcium hydroxide/triple antibiotic paste dressing; 2.5% NaOCl 17% EDTA; formation of blood clot; sealing with MTA; restoration with resin	Success; symptoms subsided; inflammatory osteolytic lesions resolved in all traumatized teeth; 2 teeth were followed for 19 mos and 1 tooth for 5 years. Case 2: fibrous connective and hard tissue healing
Ionta et al., (2016)	Case report; 36 months follow up	9-year-old female; history of avulsion teeth 21- 21; diagnosis: ERR	RCTX; Ca(OH) ₂ with paramonochlorophenol for 5 mos; sealing with MTA as apical barrier; gutta-percha filling; glass ionomer to seal; resin restoration	Success; no mobility or soft tissue alterations 3 years follow-up; no radiographic signs of resorption
Reston et al., (2017)	Case report; 180 months follow-up	65-year-old patient; subgingival cavity in the root surface of tooth 21; history of internal bleaching; diagnosis: ICR	Orthodontic traction; surgical access; glass ionomer cement into the cavity	Success; 15-year follow-up with no evidence of recurrence of resorption
Shemesh et al., (2017)	Case series a 36	Case 1: 22-year-old male; history of trauma	RCTX; same treatment to all cases; 3% NaOCl for irrigation; Ca(OH) ₂ dressing for 4	Success; all cases asymptomatic after 3

al., (2017)	months follow up	tooth 21; diagnosis: ICR Case 2: 44-year-old male; no history of orthodontic treatment or trauma; an unusual radiolucency found on tooth 21; diagnosis: ICR Case 3: 37-year-old male; no history of trauma or orthodontic treatment; 3 mm of buccal recession found in tooth 23; diagnosis: ICR Case 4: 41-year-old female; no history of orthodontic treatment or trauma; a pink spot on the gingival third of tooth 21; diagnosis: ICR	weeks; canal sealed with gutta-percha	years
Ambu et al., (2017)	Case report; 12 months follow-up	11-year-old patient; avulsion of tooth 21; diagnosis IERR	RCTx; NaOCl 5; 25%; EDTA solution (17%); Ca(OH) ₂ ; bi dentine placed as apical barrier; thermoplastic gutta-percha filling; final restoration with resin	Complete healing of the periradicular hard tissues of both teeth 12 months POP
Kusgoz et al., (2017)	Case report; 72 months follow-up	12-year-old male; history of trauma tooth 22; diagnosis: ERR	Filled with MTA; 2.5% NaOCl; calcium hydroxide; resorbable membrane placed by endodontic plugger in the periodontal area to prevent the overflow of material; filled with MTA to coronal 2 mm; rest of the canal filled with glass ionomer; final restoration with composite	Success; at the time of root filling; tooth 22 showed no symptomatic response to percussion and palpation. At 24 mos; hard tissue formation began to be seen radiographically near the MTA plug. At the end of the 38 and 72 mos follow up periods; the resorption area was almost surrounded by new hard tissue formation
Machado et al., (2017)	Cases series; 84 months follow-up	Case 1: 21-year-old female; history of orthodontic treatment; symptomatic tooth 37; diagnosis: ERR Case 2: 28-year-old male; apical resorption tooth 36; diagnosis: ERR	Case 1: RCTx 1% NaOCl 1%; EDTA 17% in apical portion MTA; filled with gutta-percha and sealed with glass ionomer Case 2: RCTx retreatment; NaOCl 1% EDTA 17%; Ca(OH) ₂ paste placed for 14 days; second visit: 1% NaOCl irrigation; both canals filled with MTA; sealed with light-cured resin 5 days later	Case 1: At a 12-month follow-up; the patient had no symptoms; radiography showed integrity of the periradicular tissues Case 2: radiographic and clinical follow-up 7 years later indicated normal periradicular tissue and bone

				formation
Tzanetakiset <i>al.</i>, (2018)	Case report; 24 months follow up	7-year-old male; history of traumatic injury; clinical examination revealed an uncomplicated crown fracture of tooth 21; diagnosis: ERR	Revascularization; NaOCl 1%; Ca(OH) ₂ for 2 weeks; EDTA 17%; formation of blood clot; sealing with MTA; sealed with glass ionomer cement and light-cured resin	3; 12 months PAs with signs of healing; inhibition of root resorption; periodontal ligament repair; development of calcified bridge below MTA at final follow-up; radiopaque deposits inside the canal at 18 and 30 months recall; without completion of root development at the apical third
Leneena <i>et</i> <i>al.</i>, (2018)	Case Report; 12 months recall	25-year-old male; history of trauma 10 years prior on tooth 11; diagnosis: EIRR tooth 13.	Filled with MTA; Ca(OH) ₂ MTA; sealed with composite	Radiographic follow up - 12 months ; resorption stopped; periapical healing; asymptomatic; composite placed for esthetic purposes

12.2 Figura 1 -Diagrama de flujo de los manuscritos seleccionados durante el proceso de revisión

