GRADUATION PROJECT

Degree in Dentistry

INVASIVE CERVICAL RESORPTION:

AN UPDATE ON DIAGNOSIS AND TREATMENT

Madrid, academic year 2025/2026

Identification number: 151

RESUMEN

Introducción : La reabsorción cervical invasiva (RCI) es poco frecuente, que puede producirse con o sin factores predisponentes. Rara vez se detecta en una fase temprana, lo que explica la complejidad de su diagnóstico y tratamiento, y cuanto más avanzada está, más difícil resulta tratarla sin métodos invasivos; **Objetivo:** El objetivo es evaluar una comparación entre los métodos modernos y convencionales de diagnóstico, de tratamiento y materiales para la RCI y sus resultados clínicos; **Material y métodos:** Se seleccionaron artículos de las bases de datos Medline, Pubmed y Dentistry & Oral Sciences Sources. Mediante el uso de criterios de inclusión y exclusión, se seleccionaron un total de 19 artículos de los 127 iniciales, todos publicados en los últimos 10 años; **Resultados:** La mayoría de los estudios han utilizado la radiografía 2-Dimensional y el Cone-Beam Computed Tomography (CBCT) como herramientas de diagnóstico; cuando la vitalidad pulpar se veía afectada, se realizaba una endodoncia, y en casos de reabsorción avanzada, la extracción era el tratamiento de elección; **Conclusiones:** La radiografía 2D convencional ha sido ampliamente superada por el CBCT, mediante la visualización en 3-Dimensional, lo que ayuda a clasificar la lesión según el sistema de Heithersay. El tratamiento depende de la gravedad de la lesión y de la afectación pulpar, lo que determina si se opta por un abordaje interno o externo. Aunque el Mineral Trioxide Aggregate (MTA) sigue muy utilizado, nuevos materiales como Biodentine y Cemento Ionómero de vidrio ofrecen mejores resultados estéticos y clínicos.

PALABRAS CLAVE

Odontología, CBCT, Biodentine, Heithersay

ABSTRACT

Introduction: Invasive cervical resorption (ICR) is an uncommon lesion, that can happen due to predisposing factors or not. It is rarely detected at an early stage, explaining the complexity to diagnose and treat it, as it gets more advanced, the more challenging it is to treat it without being invasive; **Objective:** The objective is to assess a comparison between modern and conventional diagnostic methods, treatment and material option for ICR and their clinical outcomes; **Material and Methods:** Articles were selected from Medline, Pubmed, Dentistry & Oral Sciences Sources databases. With the use of the inclusion and exclusion criteria, a total of 19 articles out of the initial 127 articles were selected, all published in the last 10 years; **Results:** Most of the studies have used 2D and Cone-Beam Computed Tomography (CBCT) as diagnostic tools, when pulp vitality was affected, an RCT has been performed, and in advanced resorption, extraction were the treatment of choice; **Conclusions:** Conventional 2D radiography has been largely surpassed by CBCT, by giving 3D visualization, helping to classify the lesion in the Heithersay's system. Treatment depends on lesion severity and pulpal involvement, defining either internal or external approaches. While Mineral Trioxide Aggregate (MTA) remains widely used, newer materials like Biodentine and Glass Ionomer Cement (GIC) offer improved aesthetic and clinical outcomes.

KEYWORDS

Dentistry, CBCT, Biodentine, Heithersay

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1. INTRODUCTION

1.1 Invasive Cervical Resorption (ICR) definition

Invasive Cervical Resorption (ICR) is defined as a slow to rapid degradation of dental structure, specifically of dentine, caused by multinucleated giant cells. These clastic cells resorb the cementoblast and odontoblast found in the dentin. Even though here, the focus is on the cervical area, this resorption can happen in any area along the root (1–4).

This resorptive activity may lead to subsequent inflammation of pulp tissue, resulting in an increased internal pulp space (5,6). It is important to consider that internal resorption is less common, compared to the external resorption, and as a result, its etiology is not as extensively studied (2). If ICR is left untreated, it can lead to further complications, such as a communication between the tooth structure and periodontal tissue. This occurs due to the invasive progression of resorptive process, which may destroy the most superficial wall of the tooth. Such advancement can cause patient discomfort, and in the most severe cases, a loss of the tooth (1,6).

To help the clinician to correctly manage ICR, based on its severity, a classification system has been created in 1994 by Heithersay. It is divided into 4 classes: the first one being used when small resorption area and affecting a bit the dentin. In class 2, it is defined as well-defined and getting deeper in the dentin. When involving fully the coronal dentin and spreading to the root, the case is classified as class 3. And finally, class 4 is reported when the resorption reach the middle or apical third of the root (7–9).

Another classification is the one of Patel, it is more detailed and helps to get a full 3-Dimensional (3D) classification, with indication of the location, the spread and its proximity to the root canal of the resorption. There are 4 level of height going from supra-crestal (level 1) to apical third (level 4). The second criterion are the circumferential spread, divided into grade A with less than 90°, grade B between 90° and 180°, grade C from 180° to 270° and finally grade D when above 270°. And when there is a pulp involvement it is noted with the letter “p” , and “d” when only the dentin is affected (8,10).

Relation between ICR and the pulp is very close, however there is a peri-canalar resorption-resistance sheet (PRRS) around the pulp that protects it from the resorption to go further and getting closer to the root canal. This PRRS is composed of odontoblastic and predentin layers (10,11). In some cases the resorption crosses the PRRS barrier and creates new tooth conditions like irreversible pulpitis, necrosis, and in the worst case, tooth loss (10).

1.2 Origin and causes

ICR is an uncommon situation, that is why its frequency in general population is very low, between 0,02% and 2,3%. Contrary to the age and sex, where no predilection has been found, there is a clear relevance about the most usual location of ICR. In general, it is most frequently found in the superior jaw. More specifically the central incisors and the maxillary canine. It can be explained as the anterior maxillary teeth are the most exposed to dental trauma or internal bleaching procedures for aesthetic purposes (12).

Although ICR is unusual, some predisposing factors increase its risk like dental trauma, orthodontic or periodontal treatment (12,13). Actually, the primary cause of ICR is dental trauma, however other contributing factors have been identified, including orthodontic treatment, chronic inflammation and auto transplantation (1,2,14).

When looking more closely, dental trauma, such as intrusion or extrusive luxation, is identified in about 15% of cases, and orofacial shock causing 33% of cases. ICR is usually initiated by destruction of the cement layers, more specifically, the unmineralized pre-dentin and prementum layers, that are close to the Cement-Enamel junction (CEJ). Any impact is going to harm this protective layer and will result in an exposure of the dentin to possible odontoblastic cells that will initiate a process of absorption or destruction of the tissue (12).

Periodontal treatment is also a common factor of the initiation of ICR, by being responsible for about 27% of cases. This treatment can be the cause of a defect in the prementum, and so, exposing the dentin to periodontal ligament, especially at the level of cervical root surface (12).

Orthodontic treatment was being described as the most common factor of ICR, however, new research disagrees with it. It has been the predisposing cause of about 16% and

24% of cases, caused by the sustained forces exerted on teeth during the orthodontic treatment, or after it, causing necrosis (12). Like the other factors, the dentin is exposed to a resorption process due to some parafunctional forces that weaken the protective barrier, and so, stimulating clastic cells. Some movements are the cause of this damage, such as torquing and intrusion, that cause the progression of the resorption by osteoclastic activities. To reduce ICR risk, the forces applied should be as light as possible and reducing its period of action (15).

Besides the major predisposing factor, just talked about, others, less common, can also predispose to ICR. For example, internal bleaching, containing hydrogen peroxide whose permeability can alter the dentin at the level of CEJ, and when combined with another factor, it increases the chances of ICR (12).

Anatomical defects at the CEJ, cause a weak barrier to avoid destruction of tooth by odontoclastic cells. Some damage can happen due to systemic conditions like bisphosphonate intake, presence of some viruses, endocrine disorders or even systemic sclerosis (12). This shows the multifactorial characteristics of an ICR defect, knowing that there are lots of other origins like bruxism, restorative treatment, idiopathic factors and more (12,15). But it is said that in 16% of cases, there has been no identification of the origin of the ICR, and supposing that can be due to the CEJ anatomy (12).

1.3 Diagnostic

ICR is often detected through radiographic examination, usually appearing at the CEJ as a radiolucent halo. Over time, this radiolucency can expand, until possibly involving the whole coronal region of the tooth (3). This radiolucency results from the destruction of hard dentin, composed of dentinal tubules and the pre-dentine matrix, being then replaced with granulated tissue and cementoid materials (1).

Radiographic evaluation plays an important role when it comes to the diagnosis of ICR, that later, determine the treatment planning and prognosis assessment (6). Periapical radiographs were seen as the traditional method of choice for the diagnosis of invasive resorption (6). However, due to its asymptomatic characteristics and the limitation to a two-dimensional radiograph, ICR's diagnosis is very challenging. Unfortunately, due to the lack of

evidence and early symptoms of the resorption, the diagnosis is often delayed until the lesion is advanced (14).

On casual radiographic examination, invasive cervical root resorption is found as a single lucent and oval image, usually defined as an enlargement of the pulp canal (2,16). The early detection of resorptive lesions is critical to achieving a favorable prognosis. Subsequently, when treated in an early stage it prevents further damage like perforation and limiting the advancement of the resorption (2,14). In cases where perforation has occurred, the prognosis is known to be poor and the effectiveness of a conservative treatment as well (2).

Cone-Beam Computed Tomography (CBCT) has recently been more developed in diagnosis of ICR as it resolves the two-dimensional issue that had the periapical radiographs. Compared with it, CBCT shows a higher sensitivity and specificity, and so, reducing possible errors of diagnosis (2,16,17). This three-dimensional visualization offered by the CBCT, helps clinicians to get a better assessment of the type of resorption (internal or external), its location (cervical, mid-root, or apical), size, and proximity to the root canal or periodontal space. Getting all the important and useful information about the resorption to get a good prognosis and treatment planning (2,18).

Moreover, the treatment plan is mostly influenced by the location, size of the lesion, and so, the tooth structure resistance and the possible perforation. Dentists must have sufficient knowledge to categorize different ICR cases, to avoid irrigation issues, inadequate obturations that can compromise the treatment outcome (14). Therefore, CBCT allows clinicians to carry a three-dimensional diagnosis, which is crucial for achieving a favorable prognosis and a conservative management of ICR (2,14,17,18).

Another visual detection of ICR is the “Pink spot”. It is a pinkish coloration of the tooth that is due to the fibrovascular granulation tissue being extremely vascularized, and the dentin and enamel losing their thickness. That explains why the affected teeth get this pinkish color visible during examination. But this characteristic is not usually found at early stages of ICR, and sometimes not present at all (9,13,19,20).

1.4 Material

The two mainly discussed materials in the treatment of ICR are Mineral Trioxide Aggregate (MTA) and Biodentine, both being defined as traditional materials. Their effectiveness lies in their ability to promote healing of the resorptive activity, providing good sealing capacity and demonstrating high biocompatibility. These bioceramic materials are particularly suitable because of their elasticity close to the one of the dentin, allowing an uniform propagation of occlusal stress and so, enhancing their resistance to fracture (1).

About Biodentine, compared to MTA, it has shown better efficacy of stress distribution. This contributes to an improvement of mechanical performance under functional loading. However these materials are not always sufficient on their own, and may need a reinforcement structure like a fiber post or overlay to spread the forces (1). As for the MTA, despite the mechanical capacity of Biodentine, some clinicians still prefer the use of MTA in cases of dental ICR. This preference is mainly due to its high biocompatibility, especially to peri-radicular tissue, but it also has a strong bioactivity and great sealing. These factors are important when planning a treatment plan, as they reduce the risk of avoidable complications (16).

1.5 Treatment

It is essential to clearly define the objectives of the treatment, that are, the control of inflammation and the promotion of internal tissue repair. To achieve a successful outcome, it is crucial to ensure a thorough three-dimensional cleaning, disinfection and sealing of all canals present within the affected tooth (6).

In cases where the chance of success is high, conventional Root Canal Treatment (RCT) remains the treatment of choice. When both mechanical instrumentation and chemical irrigation are properly carried out, the procedure is highly effective in the elimination of infection and achieving a high success rate (21).

In cases of ICR with perforation, lasers offer a safer alternative, as chemical irrigants like Sodium Hypochlorite (NaOCl) and Ethylenediaminetetraacetic acid (EDTA) may damage periodontal tissues. Laser therapy enables effective cleaning, smear layer removal, and deep disinfection

while avoiding surgery and harmful chemicals, making it a more conservative approach (18,21). Another technique is the topical application of a chemical agent, Trichloroacetic acid (TCA) at 90% and for 5 minutes with a cotton pellet, for a deep cleaning of the resorptive tissue, and to enhance the material adherence to the lesion (12,15,22)

Knowing that patients coming to the clinic with ICR are challenging to treat mainly because they are detected in an advanced stage and because the treatment can be hard to perform and with unknown prognosis of the results. For all these reasons, having knowledge on how to manage an ICR case is essential as dental clinicians, for that, dentists need of to be aware of advancement on the new diagnosis and treatment methods (6,12,14,15).

1.6 Subject justification

ICR, in addition to being hard to detect, is also rare, so clinicians need to learn how to detect and manage it at an early stage. If left untreated for a long time, the resorption continues to grow and cause tooth destruction that sometimes can be irreversible. The challenge of this lesion is its asymptomatic characteristic. Moreover, traditional radiographies are not sufficient to detect ICR, but new imaging methods like CBCT are helping a lot to get a good diagnosis of the ICR. Also, the improvement of materials and treatment procedures, allows a new contextualization of the management of ICR for clinicians.

The necessity to get an update on the new tools and approaches of this lesion is essential for the dentists, by comparing modern approaches with more traditional ones. This will help to get a correct view of the case and to adapt the treatment with the best material possible, by being the most conservative possible but still without recurrences of the resorption.

2. OBJECTIVE

To compare modern and conventional diagnostic methods, treatment and material options for invasive cervical resorption and their clinical outcomes.

3. MATERIAL AND METHODS

The objective was defined by following the PICO framework, selecting a specific target of patients with Invasive cervical resorption (ICR) and comparing the different diagnostic methods and evaluating their different outcomes. Therefore, the following objective is formulated; In patients with teeth affected by ICR, do the new diagnostic and treatment materials, compared to the conventional ones, result in a higher success rate?

P: Teeth affected by ICR
I: Diagnostic methods and material used to treat ICR
C: Conventional x-ray diagnosis and traditional treatment techniques
O: Better long-term stability of the treatment and the success rate, related to a better and earlier diagnosis.

This research has been conducted on December 7th, 2025, with the help of articles found on Medline, Pubmed, Dentistry & Oral Sciences Sources. These databases are available thanks to the university's library resources. At the beginning of the search, a total of 127 articles appeared, later, with the help of exclusion criteria, a result of 19 texts were found that can be used for this study. The search was performed using meSH terms:
((internal cervical resorption) OR (invasive cervical resorption)) AND ((diagnosis) OR (detection) OR (imaging)) AND ((treatment) OR (management) OR (therapy) OR (conventional) OR (traditional) OR (new materials) OR (modern)) NOT ((neck) OR (fracture) OR (skeletal))

For the research the following inclusion criteria were used "cervical area", "invasive resorption", "Case reports", "Analysis study", "Published in the last 10 years", "In English, Spanish or French", "Human teeth", "Complete text".
And the exclusion criteria were "Apical resorption", "Animal teeth", "Children", "External resorption".

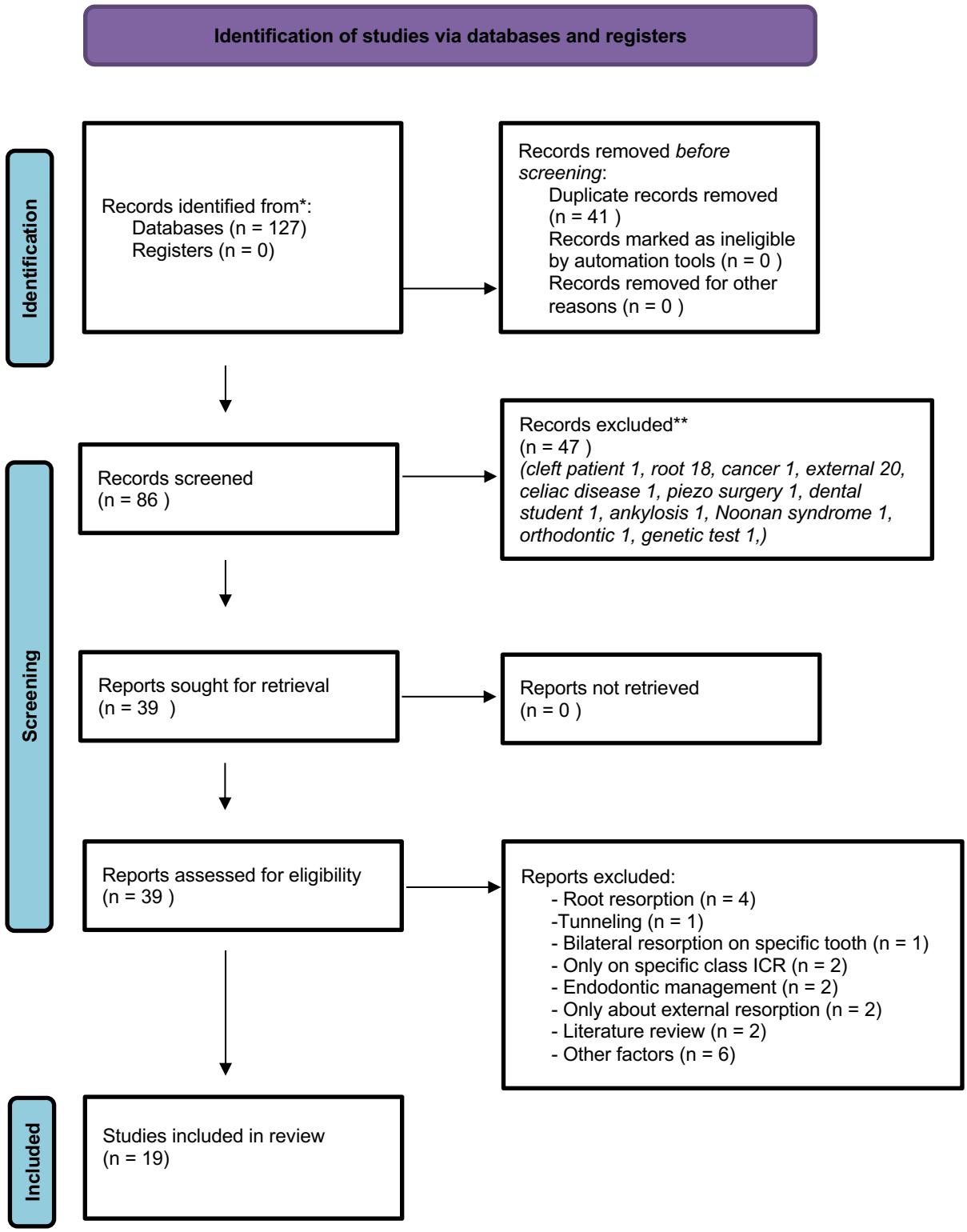


Figure 1: PRISMA Flow chart of article selection

4. RESULTS

Table 1: Comparison table on ICR case, their diagnostic method, treatment and outcomes (F: Female; M: Male; N/A: non-applicable)

Author (year)	Type of study	Age & gender	Follow-up period	Diagnostic methods	Pulp status	Treatment approach	Surgical/ non-surgical	Outcome	Recurrence	Classification	Pink spot
Espona et al. (2018) (7)	Case series (3 cases)	17M 33F	2 to 7 years (yrs)	2D & CBCT	vital	External, Internal And Replantation	Both	Success	No	Heithersay	Yes
Isaltino et al. (2023) (8)	Case Report	43M	2 yrs	2D & CBCT	Asymptomatic irreversible pulpitis	Surgical debridement + RCT	Surgical	Success	No	Heithersay 2, Patel 1BP	N/A
Eftekhar et al. (2017) (9)	Case Report	51F	2 yrs	2D & CBCT	Necrosis	Surgical + RCT	Surgical	Success	No	Heithersay 3	N/A
Tamuli et al. (2025) (10)	Case Report	45F	1 yr	2D & CBCT	Non-vital	Surgical debridement + TCA (90%) + endodontics	Surgical	Success	No	Heithersay 4, Patel 3Ap	N/A
Ehlinger et al. (2019) (11)	Case Series (4 cases)	15–30F	1–3 yrs	2D & CBCT	Vital/ Necrosis	Internal & External access	Both	Success	No	Heithersay 2, 3, 4	Some case
Jeng et al. (2020) (13)	Retrospective Study (63 teeth)	18–81 (Mean 45.7)	10-yr period collection	2D (multi-angle) + CBCT	Vital (73.02%)	Varied (analysis of predisposing factors)	Varied	Clinical analysis	Successive lesions	Heithersay	Some case

Table 1: Continuation

Author (year)	Type of study	Age & gender	Follow-up period	Diagnostic methods	Pulp status	Treatment approach	Surgical/ non-surgical	Outcome	Recurrence	Classification	Pink spot
Iandolo et al. (2025) (19)	Case Report	30M	1yrs	2D & CBCT	Irreversible acute pulpitis	Minimally invasive endodontics + microsurgery	Surgical (Flap)	Success	No	N/A	Yes
Alqedairi (2019) (20)	Case Report	21F	1 yr	2D & CBCT	Necrosis	Non-surgical (Orthograde)	Non-surgical	Success	No	Heithersay 3	N/A
Yoshpe et al. (2016) (23)	Case Report	14M	4–8 months	2D & CBCT	Vital/ Necrosis	Forced Eruption	Surgical	Failure	Yes	Heithersay2, 3	N/A
AlAttas et al. (2023) (24)	Case Report	55F	6 yrs	2D & CBCT	Irreversible pulpitis	Surgical + RCT	Surgical	Success	Yes (one tooth)	Heithersay 3	N/A
Nogueira Filho et al. (2024) (25)	Case Report	15M	3 yrs	2D & CBCT	Pulp necrosis	Intentional replantation + extraoral restoration + RCT	Surgical	Success	No	N/A	N/A
Rathi et al. (2025) (26)	Case Report	33M	6 months	2D & CBCT	Non-vital	Surgical + RCT	Surgical	Success	No	Heithersay 3; Patel 2Bp	Yes
Steffel (2016) (27)	Case Series (4 cases)	44–59F	6 weeks	2D & CBCT	Vital/ Necrosis	Extraction	Surgical	Success/ Extraction	No	Heithersay 1–4	Some case

Table 1: Continuation

Author (year)	Type of study	Age & gender	Follow-up period	Diagnostic methods	Pulp status	Treatment approach	Surgical/ non-surgical	Outcome	Recurrence	Classification	Pink spot
Perlea et al. (2017) (28)	Case Series (3 cases)	-27F -25F -39F	-N/A -6 months -N/A	2D & CBCT	-N/A -Necrosis -Vital	-Intentional replantation -Extraction	Surgical	Case 2: Success	N/A	Heithersay 3 & 4	N/A
Asgary & Nosrat (2016) (29)	Case Report	28F	24 months	2D	Symptomatic apical periodontitis	Non-surgical orthograde approach	Non-surgical	Success	No	Heithersay 4	N/A
Shemesh et al. (2019) (30)	Retrospective Analysis (23 cases)	N/A	2011 to 2016	CBCT	N/A	Internal approach (narrow entry) vs Surgical (wide)	Both	Success in decision making	N/A	Heithersay 3 & 4	N/A
Mashyakhy et al. (2018) (31)	Case Report	18F	2 yrs	2D & CBCT	Vital	Non-surgical + RCT	Non-surgical	Success	No	Heithersay 3	N/A
Vasconcelos et al. (2016) (32)	Case Report	16F	6 yrs	2D & CBCT	Vital	Monitoring (postponed RCT)	Non-surgical	Progression	Yes	Heithersay 3	N/A
Lo Giudice et al. (2016) (33)	Case Series (5 patients)	24F	3 yrs	2D	Vital	Surgical debridement (papilla preservation flap)	Surgical	Class 2 :100% Class 3: 50%	Complications in Class 3	Heithersay 2,3 & 4	N/A

Table 2: Material used in ICR cases and their characteristics

Author (year)	Type of study	Material used	Biocompatibility	Sealing	Long-term outcome
Espona et al. (2018) (7)	Case series (3 cases)	Nanohybrid Composite	Well-polished it reduce plaque retention	Clean with 90% Trichloroacetic Acid (TCA) to have better sealing	Success up to 7 years
Isaltino et al. (2023) (8)	Case Report	Glass Ionomer (GIC) (& Composite)	-Fluoride release -Chemical adhesion to dentin -Subgingivally not efficient cement and bone regeneration	-Seals the subgingival defect - Supra-gingivally use composite for esthetic	Success at 2 years
Eftekhar et al. (2017) (9)	Case report	Biodentine	Bioactive and block osteoclastic activity	Fast setting time = less leakage	Success at 2 years
Tamuli et al. (2025) (10)	Case Report	Biodentine & Bioceramic Sealer	Biodentine: -highly bioactive -help periodontal ligament (PDL) reattachment -stimulate formation of dentin-like tissue	- good sealing properties -rapid setting time (under 12 minutes)	Success at 1 year
Ehlinger et al. (2019) (11)	Case Series (4 cases)	Biodentine (& Composite resin)	Highly biocompatible	Good endo-periodontal sealing	Success up to 3 years
Iandolo et al. (2025) (19)	Case Report	Biosealer (& Adhesive Composite)	Good healing of gingival and periapical tissues	Better sealing with use of irrigant activation protocols (3D Cleaning)	Success at 1 year

Table 2: Continuation

Author (year)	Type of study	Material used	Biocompatibility	Sealing	Long-term outcome
Alqedairi (2019) (20)	Case Report	MTA	Good biocompatibility	Hermetic seal	Success at 1 year
Yoshpe et al. (2016) (23)	Case report	MTA & IRM	MTA: biocompatible IRM: less	MTA better sealing capacity than IRM	Recurrence at 4-8 months
AlAttas et al. (2023) (24)	Case report	Total Fill Putty (Bioceramic)	Biocompatible and hydrophilic	N/A High pH = inactive clastic cells	Mixed results
Nogueira Filho et al. (2024) (25)	Case Report	Composite Resin (& Bio-C Sealer)	nanoparticle composite: -Highly polished, smooth surface	Good sealing and adaptation when reimplanted	Success at 3 years
Rathi et al. (2025) (26)	Case report	MTA (& Ribbond fiber)	Good + fast reparative dentin formation	Good sealing	Success at 6-month
Steffel (2016) (27)	Case series	Geristore (RMGIC)	Histological biocompatibility	Good in subgingival restorations	Correct success except in class 4 cases
Asgary & Nosrat (2016) (29)	Case Report	CEM Cement (Calcium-Enriched Mixture)	-highly biocompatible -help periodontal and osseous regeneration	-Long-lasting seal -Releases calcium hydroxide	Success at 24 months (class 4)
Shemesh et al. (2019) (30)	Retrospective Analysis (23 cases)	Gutta-percha & Epoxy Sealer	Use of NaOCl and Calcium Hydroxide to chemically dissolve resorptive tissue	Warm gutta percha compactation for good obturation of resorptive area	Success at 36 to 48 months

Table 2: Continuation

Author (year)	Type of study	Material used	Biocompatibility	Sealing	Long-term outcome
Mashyakhy et al. (2018) (31)	Case report	Geristore (RMGIC)	Release fluoride	Good sealing to microleakage	Success at 2 years
Lo Giudice et al. (2016) (33)	Case Series (5 patients)	Nanofilled Composite	When well-polished high success with papilla preservation flap	Good sealing when using strict adhesive protocol (total etching and bonding)	Success at 3 years (100% in class 2 and 50% in class 3)

5. DISCUSSION

In 2020, Jeng et al. (13) reported a percentage of 73,02% of cases of Invasive cervical resorption (ICR) with a vital pulp state. No relation has been made between the pulp states, vital or not, and the treatment intervention, surgical or non-surgical. In all cases except the one reported in 2016 by Yoshpe et al. (23), they all resulted with a great success rate. So, no link has been demonstrated, about the importance of the pulp vitality with the selection of the treatment. However, in all the cases of irreversible pulpitis, only surgical intervention has been used to treat the ICR.

Most of the cases have treated ICR on vital teeth, and, only 3 out of the 19 studies like the one followed by AlAttas et al. (24) were diagnosed with an irreversible pulpitis. In the other reports, the teeth are described as non-vital, or even specified as necrotic like in the study reported by Alqedairi (20). In case of non-vital tooth, the decision is to treat it in a non-surgical method, unlike the other necrotic teeth that used surgery.

About the pink spot, only 6 works reported the presence of these characteristics, for example Espona et al. (7) or in 2025 by Iandolo et al.(19). However, it is important to remember that in all the other cases reported like the one Nogueira Filho et al. (25), there have been no reports of a pink spot appearance. This can be due to multiple factors, like the palatal localization of the resorption or the thickness of the wall. So it is important to not discard ICR even though this clinical sign is not present (24).

Almost all the studies like Rathi et al.(26) in 2025 and Steffel et al. (27) in 2016 have used both 2-Dimensional (2D) and Cone-Beam Computed Tomography (CBCT) methods when diagnosing ICR. Usually, they started with a 2D image and when a suspicion of ICR had been raised, they needed to complete this examination with a 3-Dimensional (3D) imaging, here the CBCT. Traditional imaging has some limitations that can be overcome with the use of CBCT. In particular, it allows for a more accurate assessment of the progression of the resorption, including whether it has extended to the pulp or not. However, some studies, like in the one of Jeng et al. (13) also diagnosed a case by taking multi-angle 2D radiographies. This correct diagnosis of the case is very important for then adapting the correct treatment depending on the ICR advancement. Studies have shown that when using 2D imaging, only about 40% of ICR cases have been diagnosed, while with the use of CBCT around 80% of cases were examined

(23,28). Many consider CBCT as the gold standard for the diagnosis of ICR and so, getting a better management protocol. It is also described as helpful when determining the portal of entry and is crucial for the treatment protocol to be followed, meaning treating the case in the most conservative way possible (7,11).

As it can be seen on table 1, most of the studies reported cases of ICR with Heithersay class 3 or 4, some of class 2 and few class 1. It is mostly due to the asymptomatic characteristics of the ICR, and so, its difficulty to diagnose it at an early stage, that is followed by a late diagnosis of ICR, as the progression of the resorption has advanced (29). This ICR classification is being helpful for the treatment selection, as class 1 and 2 ICR have a 100% chances of success compared to more advanced stages (78% success in class 3 and about 12% in class 4), that present more failed conservative treatment and outcomes (23,29).

Patel classification system helps the clinician to choose between an internal access (with less than 1mm entry) and an external approach when the case is broader (30). This 3D classification system is rarely used, however recent studies, published from 2023 to 2025 are starting to use it. Isaltino et al (8), Rathi et al. (26) and Tamuli et al.(10) being the only authors that used Patel classification, have nonetheless accompanied it with the Heithersay classification.

Out of the 19 studies reported, 10 of them , like Mashyakhy et al. (31), used root canal treatment (RCT). Most of them didn't perform RCT alone, it was accompanied with another approach. For example, Nogueira Filho et al. (25) did both RCT and an intentional replantation. However, in advanced Heithersay ICR classification, the treatment of choice has been to extract the tooth like performed by Steffel et al. (27), Perlea et al. (28) and Shemesh et al. (30). Authors like Yoshpe et al. (23), used forced eruption approach that caused recurrence of ICR but it is also the only study that resulted with a failed results. To avoid failure in more advanced resorption, it has been demonstrated that in cases with an ICR Heithersay classification of class 3 and 4, the use of RCT was selected, like by Rathi et al. (26).

Majority of the studies employed a surgical intervention, only 4 cases did not undergo surgical approach for the management of ICR, like RCT in 2018 by Mashyakhy et al. (31) and an orthograde approach described in 2016 by Asgary & Nosrat (29). All non-surgical cases involved lesions classified as Heithersay class 3 or 4. In contrast, surgical approaches were utilized across all Heithersay classifications.

On the other hand, studies have shown that usually, in Heithersay class 3 and 4, the treatment of choice would be the extraction of the tooth and possible replacement with implant, due to its advanced stage of resorption getting it hardly treatable (27,28,30). The cases of recurrence of ICR have been found in both treatment techniques, surgical with Yoshpe et al. (23) and non-surgical like in Vasconcelos et al. (32) report. If talking about a specific case, in 2016, Vasconcelos et al.(32), postponed RCT and has reported multiple recurrence. While in cases where the RCT has been performed without delay, no recurrence of ICR has been reported.

When possible, clinicians use a non-surgical approach, also called internal access (type I), because it avoids the destruction of the cervical structure of the tooth. For example, in the case studied in 2019 by Alqedairi (20), with a Heithersay class 3, performed a type I procedure, allowing to get the least invasive intervention possible. However, this cannot be applied in all ICR cases, the portal of entry needs to be narrow, less than 1mm, or when the defect is localized at the proximal region. Like in 2019, Ehlinger et al. (11) studied a case with Heithersay class 3 but in the proximal region, and decided to not use surgery which would have meant removing dental tissue unnecessarily.

Regarding the surgical approach it is usually used in extensive ICR cases, especially when the resorption has touched or is close to the pulp. This external approach (type E), has been used by AlAttas et al. (24) when confronted with a tooth with irreversible pulpitis and Heithersay class 3, he performed a mucoperiosteal flap to get a better vision of the tooth's resorptive tissue. This flap is important to get a correct treatment procedure in extensive ICR lesions. However, it can cause aesthetic challenges, that is why Lo Giudice et al. (33) used a papilla preservation flap for better cicatrization and aesthetic outcome without interfering with the correct removal of the resorptive tissue. In 2018, Espona et al. (7) was confronted with a case where the resorption was hardly accessible, and performed an intentional reimplantation (type N). But for that, an atraumatic extraction of the tooth is essential, explaining why very few cases were reported. Moreover, within 7 minutes the RCT must be done, to avoid the death of the periodontal ligament.

Material selection is essential to have a correct biological integration with the defect. In the study made my Yoshpe et al.(23), in the first two cases, he did not use Trichloroacetic acid (TCA), but instead Sodium Hypochlorite (NaOCl) but a recurrence of the ICR has been shown still presenting a resorption process, while when in the third case he used TCA, the success was much higher. In 2023, Al Attas et al.(24), Lo Giudice et al. (33) in 2016, and Tamuli et al. (10) in 2025,

explain the importance of using TCA at 90% with a cotton pellet or micro brush for 3-4 minutes. It enables to get an optimal removal of necrotic tissue and resorptive cells without causing risks to the soft tissue, plus a deep disinfection, where the mechanical cleaning cannot reach (7,9,10). Tamuli et al. (10) explained the risk of TCA damaging the adjacent tissue, for that, glycerol is applied in these areas and used as a protective layer, this advice is also described by Lo Giudice et al. (33) to isolate the tissue. This limitation explains why in 2016, Yoshpe et al.(23) did not use TCA in his first cases and used NaOCl instead, that showed less risk for the surrounding tissue, but its treatment had low success rate. And for a good removal of the possible remaining resorptive tissue, a rinse with sterile saline solution is recommended. Finally, Al Attas et al. (24), Lo Giudice et al. (33) and Tamuli et al. (10), on the exposed dentin, after TCA use, the structure is very demineralized, so to refresh it, all have refreshed it with a rounded bur for a good bonding of the material that will be used, like Glass Ionomer Cement (GIC) with Lo Giudice et al. (33).

The two main traditional materials used in the studies are Mineral Trioxide Aggregate (MTA) and composite, each one of them being present in 3 cases. MTA has been the material of choice of Alqedairi (20), Yoshpe et al. (23), Rathi et al. (26) and Mashyakhy et al. (31) because of its great dentin reparation, high biocompatibility, antibacterial and sealing capacity, and great chemical and physical properties. However, in 2018, Mashyakhy et al. (31) explains that MTA is not recommended when the resorptive lesion communicates with the oral cavity because all of its capacities are diminished. But when it is located subcrestally like with Nogueira Filho et al.(25) it can be a material of choice. Other inconveniences are its long-setting time and its low esthetics capacity, causing discoloration, like in 2017 when Eftekhar et al. (9) compared a restoration of MTA with one of Biodentine. This material shows controversy between the different studies made.

GIC is used in studies followed by Isaltino et al. (8) and Mashyakhy et al. (31) for its capacity to release fluoride, its good adhesion to dentin and its high resistance to possible microleakage, however, Isaltino et al. (8) and Ehlinger et al. (11) used GIC with composite, because GIC can cause plaque retention and needs to be well polished, so it's easier to use GIC subgingivally and resin-based composite supra-gingivally. In 2025, Tamuli et al. (10) also followed the same process to get a great sealing and good aesthetic at the same time.

In 2016, Asgary & Nosrat (29) concentrated their studies on calcium-enriched mixture (CEM) cement. They explain that besides having great biocompatibility, it also has a great capacity to stop the resorption. Its main characteristics are having a long-lasting sealing, plus, a great

periodontal regeneration. So when RCT filling is needed or resorption material, CEM cement becomes a great option. Once set, it releases calcium hydroxide that creates an alkaline environment and so destroys clastic cells that stop the initial resorption that was enhanced due to its acidic environment. With this case, using a new material for ICR, Asgary & Nosrat (29) showed a possible successful management, without using a surgical intervention and preserving the surrounding tissue even when ICR is at an advanced stage, here, Heithersay class 4. But very recent cases mention the use of this material.

More recent materials are also being used for ICR treatment, the most known one being Biodentine. Like GIC, it can cause plaque retention, that explains why in cases like by Espona et al. (7) has been used for a subgingival resorption area, or in cases where the lesion is juxta-crestal with a necessity to seal an endo-periodontal communication like reported by Ehlinger et al. (11). In 2016 Yoshpe et al. (23) shows the aesthetic advantage of biodentine over MTA, for its color stability. However, Eftekhar et al. (9) and Tamuli et al. (10) continue to find new advantages of this material, like stopping the resorption, having a compressive strength very similar to the one of the dentin, a quick setting time, and help to get a good periodontal ligament (PDL) reattachment. Furthermore, when compared to MTA, a better physical and biological capacities have been demonstrated.

Authors like Espona et al. (7) conclude that composite is not as complete compared to new material like Biodentine or GIC, but for aesthetic purpose it is a great option, that explains why Isaltino et al. (8) combined it with biodentine. However composite can retain plaque, so a correct polish is mandatory when using the material. Nanohybrid when well-polished, are widely used in supra-gingival cases, especially for anterior and esthetic area (8), but needs to be used with 90% TCA for a good sealing (7). Finally in 2025, Rathi et al. (26) presented a case with a massive destruction of the tooth structure, and used Ribbond fiber-reinforced composite additionally to previous MTA, to get a strong tooth structure combined with a correct aesthetic outcome with a great success and outcome.

Resin-Modified Glass Ionomer (RMGIC), releases fluoride, has a very good adherence to dentin and so decrease the possible microleakage. It also helps the attachment of the gingival and fibroblast that then reduces the pocket depth (27). In 2018 Mashyakhy et al. (31) presented a case with RMGIC showing more advantages than the traditional GIC, as a less soluble material. Moreover, Steffel et al. (27) also used this material in one of his cases in 2016, on a subgingival restoration. But even if this material has shown no contraindication, its use is still rare.

Other research have used uncommon material for ICR management, like recently, in 2025, Iandolo et al. (19) used Biosealer and described its capacity to heal the gingival and periapical tissues, with the complement of a good irrigation and 3D cleaning, the sealing has shown to have a good efficacy. Finally, in 2016 Yoshpe et al. (23) used the combination of two materials, MTA and IRM. However, signs of recurrence were observed, being possibly related to the inferior biocompatibility and lower sealing ability of IRM compared to MTA.

6. CONCLUSIONS

First, the focus was on diagnostic tools, while 2D radiographies have limitations, Cone-Beam Computed Tomography (CBCT) provides better visualization through a 3D image and allows assessment of proximity to the pulp, essential for proper ICR classification. Among classifications, Heithersay remains the most widely used and helps guide treatment decisions.

The choice between internal or external access depends on the severity of ICR and may need flap elevation for better visualization. If the pulp is affected, Root Canal Treatment (RCT) must be performed.

Regarding materials, Mineral Trioxide Aggregate (MTA) and composite are commonly used, while newer materials such as Biodentine and Glass Ionomer Cement (GIC) offer improved aesthetic and clinical outcomes. Finally, for deep cleaning, Trichloroacetic acid (TCA) 90% has replaced Sodium Hypochlorite (NaOCl), improving material adhesion to the tooth.

7. SUSTAINABILITY

The sustainability of managing ICR includes the three Sustainable Development Goals (SDGs), social, environmental, and economic perspectives.

Socially, it improves diagnostic tools like CBCT, and modern treatment approaches enhance patient outcomes, reduce complications, and preserve natural teeth, so, improving quality of life and patient satisfaction. Minimally invasive procedures also reduce discomfort and treatment time, increasing accessibility and acceptance of care.

From an environmental perspective, conservative treatments help limit the use of materials and reduce clinical waste associated with extensive surgical procedures or repeated interventions. The use of durable biomaterials, like Biodentine and GIC, also decreases the need for retreatment, and therefore, lowering the environmental footprint of dental care.

Finally, economically, early and correct diagnosis combined with effective treatment reduces long-term costs for both patients and healthcare systems. Avoiding complex surgeries or the need for prothesis, lowering the cost of the dental act, while durable materials and efficient techniques contribute to cost-effective and long-lasting outcomes.

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