RESEARCH PAPER

SINGLE-VISIT REGENERATIVE ENDODONTICS IN IMMATURE PERMANENT TEETH: A Narrative Review

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Abstract

Background: Regenerative endodontic procedures (REPs) represent a biological alternative to conventional treatment of necrotic immature permanent teeth, with the principal objectives of infection control, continued root development and preservation of the structural integrity of the immature root. One of the recent approaches in RET is to complete the whole root canal system disinfection in a single visit which could overcome the drawbacks of the traditional disinfection techniques and their concentration-dependent cytotoxicity to stem cells.

Objectives: To map the evidence specifically addressing single-visit regenerative endodontic treatment in non-vital immature permanent teeth and to integrate the disinfection literature needed to interpret these protocols.

Methodology: A narrative review of English-language literature was conducted using PubMed & Scopus. Systematic reviews, Randomized controlled trials (RCTs), Case reports, case series and an animal study published till July 2026 were eligible for inclusion.

Results: The preliminary 2017 randomized trial initially favored delayed induction (71% versus 33% at 12 months), In contrast, the 2021 comparative study of traumatized immature teeth found no significant difference between single-visit and interappointment-dressing protocols. Successful single-visit revascularization endodontic procedures commonly include the use of high concentrations of sodium hypochlorite and EDTA combined with the use of agitation systems.

Conclusion: The successful single-visit reports often used rigorous irrigation, relatively high NaOCl concentrations, EDTA and activation. Further clinical trials with long term follow up are needed to confirm the results of the current review.

Keywords: regenerative endodontics; single visit; immature permanent teeth; revascularization; revitalization; disinfection protocol; sodium hypochlorite; EDTA; irrigant activation; laser activation; blood clot; platelet-rich plasma; platelet-rich fibrin.

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Introduction

The nonsurgical endodontic management of mature teeth has shown favorable outcome rate in teeth diagnosed with both irreversible pulpitis and necrotic cases. However, necrotic immature permanent teeth caused either by caries or trauma, stay with questionable prognosis due to thin dentinal walls that are prone to fracture. Moreover, open apices are difficult to seal either by thermo plasticized or lateral condensation methods. Thus, there was a paradigm shift in the treatment protocol to regenerative endodontic treatment (RET), a biological procedure that offers a huge potential for hard tissue formation in such teeth.

One of the recent approaches in RET is to complete the whole root canal system disinfection in a single visit which could overcome the drawbacks of the traditional disinfection technique using long-term calcium hydroxide applications to form apical barriers in immature teeth to avoid calcium hydroxide's detrimental effect on dentin strength and may increase tooth susceptibility to root fracture. Furthermore, the use of TAP, DAP or calcium hydroxide have shown negative effects on the proliferation of dental pulp stem cells on dentin which may lead to a decreased success of regenerative procedures.

The number and impact of regenerative endodontic publications have increased rapidly in recent years. Although the research in this area is looking for high levels of evidence, many clinicians have used published case reports to develop their regenerative procedures with different disinfection protocols within single visit. Immature necrotic teeth can be successfully treated by REPs in the short-term, but the long-term outcome is still missing. Despite being successful, case reports are of lower evidence compared with clinical studies.

Rationale for Regenerative Endodontic Procedures in Immature Teeth

Immature permanent teeth with pulp necrosis present a major clinical challenge because the incompletely formed root has thin dentinal walls and remains structurally vulnerable, while conventional apexification can establish an apical barrier but does not reliably reproduce continued physiological root development [[1], [2]. Regenerative endodontic procedures were developed to control infection while creating a biologically favorable environment for continued root maturation through the interaction of viable cells, a scaffold, and signaling molecules [3]. The biological foundations of this approach can be traced to experimental studies demonstrating tissue formation after pulp removal and induced bleeding, followed by clinical reports of continued root development in necrotic immature teeth and the structured revascularization protocol proposed by Banchs and Trope [4], [5], [6], [7]. In immature teeth, stem cells of the apical papilla are an important endogenous cell source, while intracanal bleeding can provide a fibrin-rich scaffold containing cells and growth factors; dentin conditioning with EDTA may additionally expose dentin-derived bioactive molecules and support cellular adhesion, migration, and differentiation[8] [9] [10] [11] Therefore, regenerative treatment requires a balance between effective microbial disinfection and preservation of the biological potential of the apical tissues, which provides the principal biological rationale for investigating single-visit protocols that aim to complete disinfection, scaffold induction, and coronal sealing during the same appointment [3][8] [11]

Evolution and Development of Regenerative Endodontic Treatment Over Time

The biological foundation of regenerative endodontics can be traced to Nygaard-Østby, who in 1961 experimentally investigated the role of the intracanal blood clot and provided early evidence that tissue could grow into the root canal following pulp removal [4]In 1971, Nygaard-Østby and Hjortdal further demonstrated histologic formation of vascularized connective and mineralized tissues following intracanal bleeding, supporting the potential of the blood clot as a scaffold for tissue ingrowth [5]. A major clinical milestone followed in 2001, when Iwaya et al. reported revascularization of an infected immature permanent tooth with apical periodontitis, demonstrating continued root development, increased root-wall thickness, and apical closure following disinfection and revascularization [6] In 2004, Banchs and Trope proposed a clinical revascularization protocol that combined canal disinfection, induction of intracanal bleeding to provide a blood-clot scaffold, and an effective coronal seal [7].During the 2010s, regenerative endodontics evolved from the concept of simple revascularization toward a tissue-engineering approach centered on cells, scaffolds, and signaling molecules[3] [4][12] More recently, from 2019 onward, increasing clinical and systematic-review evidence has focused on single-visit regenerative endodontics, exploring whether the interappointment medicament can be eliminated while maintaining adequate disinfection and scaffold formation. [13] [14] [15][16]

Intracanal Medicament & Its Effect on Stem Cell Viability

Calcium hydroxide remains an accepted intracanal medicament in regenerative endodontics because of its antimicrobial activity, although prolonged exposure may affect dentinal strength; importantly, recent evidence suggests that short-term use does not significantly compromise human root dentine strength[17], [18], [19]. Compared with antibiotic pastes, calcium hydroxide may also be more favorable for SCAP viability, whereas TAP and DAP can exert concentration-dependent cytotoxic effects, with TAP showing greater cytotoxicity and genotoxicity at higher concentrations[8], [20], [21]. Minocycline-containing TAP additionally carries a risk of tooth discoloration and other concerns related to medicament removal and antibiotic exposure[8], [20], [22], [23], [24]. Therefore, regenerative disinfection should balance antimicrobial efficacy with preservation of viable stem cells and dentin-derived regenerative signals rather than maximizing antimicrobial activity alone[3].

Disinfection Protocols in Single-Visit Regenerative Endodontics

Single-visit REP places greater reliance on effective disinfection because no interappointment medicament is used. Current evidence primarily supports controlled NaOCl irrigation followed by EDTA conditioning as dentin conditioning with high concentrations of NaOCl has a profound negative effect on the survival and differentiation of SCAPs. However, this effect can be prevented with the use of 1.5% NaOCl followed by 17% EDTA[25]. EDTA, particularly 17%, contributes to smear-layer removal and dentin conditioning and may enhance the release of bioactive molecules such as TGF-β1 that support cellular attachment, migration, and differentiation[10], [26]. CHX and hydrogen peroxide

have been used in earlier protocols but are not considered essential components of contemporary regenerative disinfection because of biological and protocol-related limitations[27], [28], [29]. Overall, the preferred approach is effective but biologically controlled chemical disinfection rather than aggressive antimicrobial treatment[13][26].

Irrigation Activation

Irrigant activation is particularly relevant in minimally instrumented immature teeth because it improves irrigant distribution and microbial/debris removal while limiting mechanical dentin removal[30], [31], [32]. Ultrasonic and sonic activation, as well as negative-pressure irrigation, may enhance cleaning and irrigant delivery, with negative pressure potentially reducing extrusion risk in teeth with open apices[33], [34]. Laser-activated irrigation, including PIPS and SWEEPS, can further enhance irrigant movement, but current evidence remains heterogeneous and has not demonstrated clear superiority in clinically relevant regenerative outcomes[35], [36]. Activation of EDTA using PUI, EDDY, or SWEEPS enhanced dentin surface roughness, which may influence clot adhesion and stability in RET.[37]Thus, activation should currently be considered an adjunct to, rather than a replacement for, carefully controlled chemical irrigation. EDTA-treated dentine positively influences TGF-β release, cell migration, attachment and differentiation[38].However 10% citric acid was effective as a final irrigant for releasing TGF-β1 with good biocompatibility in regenerative endodontics.[39]

Laser-Assisted Approaches

Lasers have been investigated as adjuncts for antimicrobial disinfection, laser-activated irrigation, photodynamic therapy, and photobiomodulation. Although laser-based approaches may enhance microbial reduction and irrigant activation, current clinical evidence is insufficient to demonstrate superiority over conventional disinfection or improved regenerative outcomes[35], [36], [40]. A 2024 systematic review found limited evidence for laser-assisted disinfection in regenerative endodontics, while more recent evidence continues to support its use mainly as an adjunct rather than a replacement for conventional irrigation[40]. Photobiomodulation may enhance stem-cell viability, proliferation, and differentiation under appropriate parameters, but these findings are predominantly laboratory-based and remain highly parameter-dependent[41], [42]. Therefore, laser technology remains a promising but investigational adjunct in single-visit REP, particularly as a potential antibiotic-sparing approach, until adequately powered clinical trials demonstrate meaningful improvements in root development and other regenerative outcomes[35], [43], [44].

Scaffold Selection in Single-Visit REP

The induced intracanal blood clot remains the most commonly used scaffold in single-visit regenerative endodontics because it is simple, autologous, requires no additional preparation, and provides fibrin, platelets, growth factors, and circulating cells. However, its volume and quality are variable, and excessive bleeding may complicate control of the scaffold and placement of the coronal barrier[3], [45]. Autologous platelet concentrates, particularly platelet-rich plasma (PRP) and platelet-rich fibrin (PRF), may provide a more standardized scaffold with a higher and more controllable concentration of platelets and growth factors. PRP, however, requires venipuncture and additional preparation, while PRF provides a fibrin-rich matrix with sustained growth-factor release but remains technique- and protocol-dependent[45], [46]. The 2016 case series by Topçuoğlu et al. reported successful single-visit regenerative treatment of three immature mandibular molars using PRP and Biodentine, supporting its clinical feasibility in immature teeth[46].In the specific context of single-visit regenerative endodontics in immature teeth, the available clinical evidence has predominantly supported an induced blood clot as the scaffold, with satisfactory clinical and radiographic outcomes reported following immediate scaffold induction[15][47]. However, successful single-visit protocols using platelet-rich plasma (PRP) have also been reported, including cases demonstrating continued root-wall thickening and apical closure, although the evidence remains largely limited to case reports and small clinical studies[46]

Coronal Barrier and Final Restoration

A regenerative procedure is biologically pointless if the treated canal is subsequently recontaminated. MTA and calcium-silicate cements such as Biodentine are frequently used over the scaffold. The direct single-visit reports used both MTA and Biodentine. Biodentine may be attractive in esthetic areas because of its reduced discoloration potential compared with traditional bismuth oxide-containing MTA formulations, although material selection should also consider handling, sealing, setting and tissue response[48], [49].

The coronal barrier should be placed without unnecessarily compressing or destroying the scaffold. A well-sealed definitive coronal restoration is an essential part of the regenerative treatment rather than a separate restorative afterthought[45], [46].

Clinical and Radiographic Outcomes

REP outcomes should be evaluated using distinct primary, secondary, and tertiary endpoints, as these measures are not equivalent. Primary outcomes include resolution of pain, swelling, sinus tract, tenderness, and periapical inflammation, representing the minimum requirements for clinical and radiographic success; however, healing of apical periodontitis does not by itself confirm true tissue regeneration[1], [3], [14], [15][13] [14]**.**Secondary outcomes reflect continued root development in immature teeth, including increased root length, increased root-wall thickness or radiographic root area, and reduction or closure of the apical foramen. These changes represent important potential biological benefits and may improve resistance to fracture, although they are influenced by the baseline stage of root development and patient age, while two-dimensional radiographs may underestimate three-dimensional changes[13], [14]. Tertiary outcomes include the return of positive sensibility responses to cold or electric pulp testing, which may suggest the presence of neurosensory tissue but can be affected by false-positive or false-negative responses and therefore cannot confirm pulp regeneration[1], [13]. Ultimately, histologic demonstration of a functional pulp–dentin complex remains the biological gold standard for regeneration, but it is generally unavailable in clinical practice. Therefore, radiographic root maturation, apical closure, or positive sensibility responses should not be interpreted as definitive evidence of true pulp regeneration[3], [13], [14].

Methodology

The literature search was updated through July 2026 using web-indexed biomedical sources with emphasis on PubMed & Scopus. Search concepts included combinations of regenerative endodontics, revascularization, revitalization, single visit/one step, immature permanent teeth, randomized clinical trial, case report, sodium hypochlorite, EDTA, chlorhexidine, irrigation activation, calcium hydroxide and antibiotic pastes. Studies involving mature teeth only were excluded, although selected mature-tooth studies are mentioned where they clarify a disinfection or biological principle[15], [16], [47].

Because the direct single-visit literature is sparse and heterogeneous, quantitative pooling was not attempted in this document.

Rossi-Fedele et al. (2019) [13]searched PubMed and Scopus from inception to July 2018 and reported 7 eligible studies: 5 case reports, 1 randomized clinical trial and 1 animal study. Their five case-report entries were Shin 2009[27], McCabe 2014[50], Aldakak 2016[28], Chaniotis 2016[51] and Topçuoğlu 2016 [52](the latter reported 3 cases). A broader research and updates beyond that search date identified older single-visit reports that were not represented in the Rossi-Fedele table, as well as several post-2018 case reports publications as shown in table no.1.

Contemporary clinical evidence suggests that single-visit regenerative endodontic procedures can achieve favorable clinical and radiographic outcomes in immature permanent teeth; however, the available evidence remains limited by small sample sizes, heterogeneous protocols, and a predominance of case reports and non-randomized studies. Comparative clinical studies have reported outcomes comparable to multivisit protocols, but adequately powered randomized trials remain scarce as shown in table no. 2.

Table 1: Single-visit clinical literature — case reports / case series

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
Shin et al., 2009[27]	Mandibular right second premolar; caries + dens invaginatus	Partially necrotic pulp; chronic periapical abscess; open ape	Single treatment approach; 10 mL 6% NaOCl + saline + 10 mL 2% CHX for 5 min; no	Blood clot; white MTA	2 wk, 3 wk, 7, 13, 19 mo	Asymptomatic; complete periradicular healing; root maturation; resolution of condensin

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
		x (~2 mm); large periradicular rarefaction	instrumentation			gosteitis
Fujita et al., 2013[53]	Mandibular left second premolar; etiology not emphasized	Immature permanent tooth with apical periodontitis	Coronal-root irrigation with 5% NaOCl + 3% H2O2, without instrumentation; calcium hydroxide placed coronally in same visit	Calcium hydroxide in coronal canal	5 and 15 mo	Apical closure began by 5 mo; canal-wall thickening and complete apical closure by 15 mo
McCabe, 201	Maxillary left centr	Necrotic pul	30 mL 5% NaO	Induced blood clot; MTA;	6 wk, 3,	Asymptomatic;

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
4/2015 [50]	al incisor; trauma with oblique root fracture	p; acute apical periodontitis; wide open apex	Cl for 20 min with ultrasonic agitation; 17% EDTA; final NaOCl/EDTA rinse	GC Fuji IX	6, 12, 18 mo	progressive root-wall thickening, root lengthening and apical closure
Chaniotis, 2015/2016 [51]	Mandibular central incisor; avulsion/replantation with severe inflammatory external resorption	Immature replanted tooth with severe inflammatory external root resorption	Single-step regenerative approach; EndoVac-based disinfection is reported in the paper	Blood clot; thick MTA plug; composite	24 mo	Healing of severe inflammatory resorption; continued root development/dentin-wall thickening; no ankylosis
Aldakak et al., 201	Mandibular right second	Necrotic pulp; im	Root canal cleaning/shaping;	Blood clot; Biodentine; temporary	6, 12, 24	Complete root maturation; no

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
6[28]	premolar; secondary caries	mature open apex	bleeding induced to ~2 mm short of CEJ; clot allowed to form for 10 min	GIC; permanent restoration at next visit	mo	sinus tract, pain or swelling
Topçuoğlu & Topçuoğlu, 2016[52]	Three mandibular first molars; caries	Necrotic pulp; asymptomatic; healthy periapical tissues; wide open apices	20 mL 2.5% NaOCl + 10 mL saline + 10 mL 17% EDTA	PRP scaffold; Biodentine barrier	Every 3 mo for 18 mo	No percussion/palpation sensitivity; normal mobility/probing; no periapical lesions; canal-wall thickening and apical closure
Alsofi, 201	Two maxillary	Loss of pul	One-visit cons	Reported as single-	3 y	Successful

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
9[54]	central incisors; traumatic injury	pal vitality; immature traumatized incisors	ervative revascularization approach	visit regenerative/revascularization treatment; details should be checked against full text before manuscript-level protocol table	ears	revascularization; continued maturation; increased radicular dentin length and width
Abdel Hafiz Abdel Rahim et al., 2019/2020[55]	Maxillary right central incisor; trauma/fracture	Necrotic immature permanent tooth; open apex	1.5% NaOCl + saline; photo-activated disinfection with photosensitizer/low-power laser; EDTA final rinse	Induced bleeding; collagen resorbable matrix; white MTA	3, 6, 9, 12 mo	No pain/swelling; increased root length and apical thickness; complete apical closure at 12 mo
Pace et	Two necro	Necrot	Single-	Regenerative	6 a	Both cases

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
al., 2021[56]	tic immature permanent teeth; apical lesions	ic immature permanent teeth with incomplete root development and apical pathology	appointment REP using HybenX desiccant antibacterial cleanser as the novel disinfection agent	scaffold /barrier protocol	nd 12 more reported	clinically successful with radiographic evidence of favorable healing/root development
Kim et al., 2023[57]	Dens evaginatus and dens invaginatus; open apices	Pulp necrosis with acute apical abscess or symptomatic api	Single-visit revascularization without intracanal medicaments or antibiotics	Blood clot / coronal sealing protocol	8 years & 6 months for one case & 1	Apical lesions healed and root dentin thickening observed
		cal periodontitis; periapical radiolucency			0 years follow up for these second case	
Alsharqawi & Austah, 2023[58]	Immature lower permanent molar; acute apical abscess	Necrotic immature molar with acute apical abscess	Single-visit REP; case report specifically addressing acute apical abscess	Regenerative scaffold and coronal barrier	20 months	Successful clinical/radiographic outcome
Mansour & Al Omari, 202	Immature permanent tooth with traumatic	Immature permanent toot	Single-visit pulp + bone regenerat	I-PRF / biomaterials for pulp and bone regeneration	12 months	Reported successful clinical/radiographic

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
5[59]	buccal bone loss	h; complete buccal bone loss after traumatic dental injury	ive therapy using Dual Rinse HEDP and injectable PRF			management
Abang Ibrahim & Abu Bakar, 2025[60]	Maxillary right central incisor; etiology not emphasized	Necrotic immature permanent tooth	Single-step regenerative endodontic approach; no mechanical canal cleaning; saline irrigation; calcium hydroxide used for	Calcium hydroxide; no induced blood-clot scaffold	36 mo	Asymptomatic; reported vitality; complete root formation

Study	Tooth / etiology	Diagnosis & pre-op status	Single-visit protocol / disinfection	Scaffold / barrier	Follow-up	Main outcome
			disinfection; no blood clot induction			

Table 2. Comparative Clinical Evidence

Study	Design	Sample	Protocol	Main result
Boteroet al., 2017[47]	Randomized clinical trial; preliminary 12-mo data	28 teeth enrolled; 15 delayed, 13 immediate; 19 completed 12-mo follow-up	Immediate: blood clot induced at first appointment. Delayed: AAE-style protocol with Ca(OH)2 before induction.	Delayed 71% vs immediate 33% success in preliminary 12-mo data.
Cerqueira-Neto et al., 2021[15]	Comparative clinical study; 24-mo follow-up	20 traumatized immature necrotic teeth; 11 interappointment dressing, 9 single visit	Both groups: 6% NaOCl + 2% CHX + 17% EDTA. Dressing group: Ca(OH)2 +	One tooth showed persistent infection; no significant differences in primary, secondary, tertiary or quantitative radiographic outcomes.

Study	Design	Sample	Protocol	Main result
			2% CHX gel for 21 days. Single-visit group: scaffold induced during same appointment.	
Karam et al 2023 [61]	Comparative clinical study	40 immature non-vital single-rooted teeth	Single-visit vs multiple-visit REP	Single-visit treatment showed comparable regenerative/radiographic outcomes, with somewhat faster apical closure reported

Among the three included clinical studies, two showed low risk (Botero 2017, Cerqueira-Neto 2021) and one showed high risk (Karam 2023)[62].

A completed 2026 randomized clinical trial registry (NCT07427615) reports a study of 30 patients aged 9–25 years with non-vital immature maxillary anterior teeth. Participants were assigned to groups involving laser-activated irrigation and single- versus multiple-visit regenerative protocols, with 12-month clinical and CBCT assessment. The registry indicates completion, but a peer-reviewed results paper was not identified in the evidence search used for this review; therefore, no numerical treatment effect is incorporated into the evidence synthesis

Animal Study

The animal study included in the 2019 systematic review evaluated revascularization and periapical repair after apical negative-pressure irrigation compared with conventional irrigation plus triple-antibiotic intracanal dressing in dogs. It reported favorable histologic findings after single-visit treatment, but animal models cannot be directly translated into clinical success in human immature teeth. Its greatest value is mechanistic: it supports the hypothesis that sufficiently effective irrigation can sometimes substitute for an interappointment antimicrobial dressing[13].

Fouad et al. (2024) evaluated a single-visit regenerative endodontic protocol in immature canine teeth using photodynamic therapy (PDT) for canal disinfection followed by immediate blood-clot induction and MTA placement. In the experimental group, photobiomodulation (PBM) was subsequently applied in seven sessions over the following days. Histological evaluation demonstrated greater vital tissue infiltration and hard-tissue deposition and lower inflammatory cell scores with PBM, although no significant difference in apical closure was observed. These findings provide preclinical support for combining enhanced disinfection with adjunctive PBM in single-visit RET, while the repeated PBM sessions should be considered when interpreting the single-visit nature of the protocol.[63]

Results

The direct evidence supports feasibility more strongly than superiority. The five early case reports all reported favorable outcomes, but case reports are highly vulnerable to publication bias and lack a control group. The preliminary 2017 randomized trial initially favored delayed induction (71% versus 33% at 12 months)[47], but the study was small and explicitly underpowered for definitive conclusions. In contrast, the 2021 comparative study of traumatized immature teeth found no significant difference between single-visit and interappointment-dressing protocols across clinical and radiographic outcomes over 24 months, with only one tooth showing persistent infection[15].

The apparent discrepancy between the 2017 and 2021 clinical studies is not necessarily contradictory. The protocols differed in irrigation, patient selection, trauma characteristics, sample size, outcome assessment and follow-up. Most importantly, the 2021 single-visit protocol incorporated 6% NaOCl, 2% chlorhexidine and 17% EDTA before scaffold induction, suggesting that a carefully executed one-appointment disinfection strategy may be capable of replacing an interappointment medicament in selected cases[15], [47].

The evidence also suggests that 'single visit' should not be equated with 'minimal disinfection'. In fact, the successful single-visit reports often used rigorous irrigation, relatively high NaOCl concentrations, EDTA and activation. The defining difference is not a weak versus strong protocol; it is whether antimicrobial control is achieved without leaving an intracanal medicament between appointments[13], [15]

Conclusion

If the single-visit approach is selected, the literature most consistently supports meticulous chemical disinfection with controlled NaOCl, a final EDTA

conditioning step, adequate irrigant activation, preservation of apical tissues, reliable scaffold induction and an excellent coronal seal. In other words, the success of a single-visit REP is more likely to depend on the quality of the biological protocol than on the mere fact that treatment was completed in one appointment.

Limitations

Evidence for single-visit REP remains limited by small sample sizes, predominance of case reports, and potential publication bias. Significant heterogeneity exists in patient/tooth characteristics, disinfection protocols, scaffold selection, and coronal barriers, while inconsistent outcome definitions and relatively short follow-up limit comparisons and assessment of long-term outcomes. Moreover, the absence of routine histologic confirmation in human studies means that radiographic maturation or positive sensibility responses should not be considered definitive evidence of true regeneration.

Future Recommendations:

Future RCTs should standardize root-development stage, etiology, apical diameter, periapical status, irrigation volume/concentration, activation, EDTA exposure, scaffold and barrier material. The most useful trial would compare a standardized single-visit NaOCl–EDTA–activation protocol with a standardized two-visit protocol containing an intracanal medicament, rather than comparing two broadly different clinical protocols. This would isolate the effect of the number of visits.

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