Content available at: https://www.ipinnovative.com/open-access-journals

IP Indian Journal of Conservative and Endodontics

Journal homepage: https://www.ijce.in/

Review Article

Success and failure of non-surgical endodontic treatment –A literature review

Shouvik Ganguly[1]*, Vaishali Waghmare[1], Sumanthini M.V[1], Anuradha Patil[1], Aditya Shinde[1], Jimish Shah[1]

[1]*Dept. of Conservative Dentistry and Endodontics, MGM Dental College and Hospital, Navi Mumbai, Maharastra, India*

ARTICLE INFO

Article history:
Received 09-06-2024
Accepted 13-08-2024
Available online 05-09-2024

Keywords:
Infection control
Apical periodontitis
Endodontic treatment
Root canal obturation
Treatment outcome

ABSTRACT

The aim of endodontic treatment is to prevent and treat apical periodontitis. To determine the outcome of endodontic treatment, clinical and radiographic evaluations need to be done at the follow up appointments. After complete assessment, the result of endodontic treatment can be categorized as successful or failed based on clinical and radiographic features. It can also be classified as healed, healing or diseased depending on the periapical status of the treated tooth. This review article includes both these criteria. It explains the clinical and radiographic features and their role in differentiating successful and failed cases. It also emphasizes on the importance of patient related factors, iatrogenic errors and post treatment factors like coronal seal that can directly influence the outcome of endodontic treatment.

1. Introduction

The goal of root canal therapy is to completely remove any diseased pulp tissue from the root canal system by debridement and chemical cleaning. This allows the root canal space to be shaped and made ready for the obturation of the canal with an inert material, thereby eliminating or significantly reducing the risk of reinfection. Endodontic treatment is predictable, with documented success rates ranging up to 98%, if proper protocol is followed.[1] The 4 to 6 year outcome of initial endodontic treatment was assessed for phase III of the Toronto Study.[2] Outcomes were examined as healed or diseased. The overall healed rate was 85%, but the authors noted that 95% of the teeth were asymptomatic and fully functional. They also noted that if slight tenderness to percussion were eliminated from the criteria, then 99% of the teeth would be functional.[2] The research hasn't, however, come to a precise agreement on standard definition of what constitutes "success" in endodontic treatment. The endodontic treatment process does not come to an end when the root canal system is sealed. However, in order to track any changes, routine follow-ups must be done to evaluate the long term outcome. Nonetheless, being meticulous in the treatment phase may pay off in the long term for both the patient and the dentist.

1.1. Depending on Clinical, Radiographic and Histologic features

1.1.1. Criteria for successful endodontic treatment outcome

1.1.1.1. Clinical features.

While the lack of discomfort or any other symptoms does not prove the healthy status, the existence of symptoms does indicate that pathology is present. There is some association between the periapical disease and the existence of symptoms.[3]

1. No tenderness to percussion or palpation
2. Normal tooth mobility

* *Corresponding author*.
E-mail address: shouvikg.dr@gmail.com (S. Ganguly).

https://doi.org/10.18231/j.ijce.2024.027

3. No evidence of subjective discomfort
4. The teeth exhibit normal form, function and aesthetics
5. No sign of infection or swelling
6. No sinus tract or integrated periodontal disease
7. Minimal to no scarring or discoloration.

1.1.1.2. Radiographic features.
To assess success or failure, the radiographs taken at different times should be comparable.

Radiographic standards for success of endodontic treatment[3]

1. Normal or slightly widened periodontal ligament space
2. Reduction of any preoperative radiolucency, if present.
3. No evidence of resorption.
4. Normal lamina dura.
5. A three dimensional obturation of canal space that is dense.

1.1.1.3. Histologic features.
The severity of periradicular inflammation is related to presence of bacteria in the root canal. Even though root canal treatment failures have been attributed to positive preobturation cultures, a correlation between positive preobturation cultures and bacteriologic status in the canal could not be established from surgical histopathologic specimens[4]. However, it is not possible to demonstrate such a link between histologic examination and pain in live patients. According to article published in 1991 by Lin LM, histologic features of a successful endodontic treatment are as follows[4]

1. No inflammation
2. Regeneration of periodontal ligament fibers
3. The presence of bone mending
4. Cementum repair
5. Lack of resorption
6. Area repair that had previously undergone resorption

1.1.2. Criteria for failure of endodontic treatment

According to article published by Ashley M in 2001, failure is characterized by the return of clinical symptoms combined with periapical radiolucency.[5] Following are some of the reasons for failure of endodontic treatment

1. Inadequate filling of the canal
2. Overextensions of root filling materials
3. Improper coronal seal
4. Untreated canals both major and accessory
5. Iatrogenic procedural errors such as poor access cavity design
6. Complications of instrumentation such as ledges, perforations, or separated instruments.

1.2. Depending on healing, healed and disease status

The treatment results may be influenced by a number of pre-operative, intra-operative and post-operative conditions; teeth with minor lesions and overly short or overextended root canal fillings may have better results as compared to teeth with extensive lesions.

The labels "healed," "healing," and "disease," as opposed to relying on interpretations of "success" and "failure," accurately characterize the actual observation, as follows:

1. Healed: Complete clinical and radiographic normalcy, which means that there are no signs, symptoms or residual radiolucency.[6]
2. Healing in progress: Reduction in radiolucency size and return to clinical normality following a follow-up of less than four years.[7]
3. Diseased: New, increasing, unchanged, or diminished radiolucency after observation longer than 4 years, irrespective of clinical presentation; symptoms present regardless of radiographic appearance.[8]

1.3. Factors affecting outcome of endodontic therapy

1.3.1. Patient factors

1.3.1.1. Systemic health of patient.

1. Genetic factors and the patient's systemic health status have a significant influence on the biological mechanisms involved in tissue regeneration.[9]
2. After root canal treatment the repair of periapical tissues can be affected or interfered with by gene polymorphism and systemic factors such as nutrition, stress, hormones, vitamin intake, hydration state and systemic diseases like diabetes, cardiovascular disease, osteoporosis, smokers' habits and others, etc.[10]
3. Periapical wound healing may be inhibited or delayed by some systemic disorders due to their alteration of bone turnover and fibroblast function. Other systemic diseases may change the microvasculature, which would limit the periapical tissues' access to nutrients and oxygen.[11]
4. Consequently, these systemic conditions can reduce the success rate of root canal treatment and lead to incomplete wound healing for example granulomatous tissue formation in the periapical region.[12]
5. This is not just a possibility; the results of other articles have mentioned lower success rate of root canal treatment, with higher percentage of post-operative radiolucent periapical lesions and higher proportion of no retained root filled teeth, in patients with systemic diseases.[13]

1.3.1.2. Oral care by patient.

1. The patient should be motivated to follow all the post-operative instructions as guided by the endodontist.

2. The patient should take enough care to maintain the coronal restoration and come for follow up evaluation.
3. Patient should maintain oral hygiene for periodontal maintenance.

1.3.2. Treatment factors

1.3.2.1. Effect of operator skill and knowledge.

1. Clinicians must to be up to date on the expected course of endodontic treatment as well as its prognosis.
2. Highly educated or trained clinicians exhibit result rates commensurate with their level of training and experience such as general dentistry practitioners, postgraduate students, undergraduate students, and specialists.
3. The overall understanding of the biological problem, in particular the motivation and integrity, with which the procedure is carried out, the refined and insightful technical execution, but also the impact of the overall understanding of the biological problem on the intraoperative decision making of the operators is difficult to measure.[14]
4. Regardless of the criteria, the data showed that treatment provided by postgraduate students and professionals had the greatest weighted pooled estimate of success.[15]

1.3.2.2. Effect of rubber dam isolation.

1. An observational study on endodontic retreatment discovered a considerably higher periapical healing rate when rubber dam was utilized, compared with cotton roll isolation.[16]
2. Retreatment when performed with aseptic tooth isolation yields better results possibly, because using a rubber dam allows for more efficient irrigation of the root canal.[17]
3. A different study found that, in endodontically treated cases, the occurrence of periapical lesion formation was much lower under rubber dams.[18]

1.3.2.3. Effect of use of magnification and illumination.

1. In endodontic practice, advancements in technology have revolutionized the way clinicians perceive and treat root canal complexities.[19]
2. The introduction of microscopes, offering magnification ranging from 3x to 30x, coupled with superior illumination, has notably improved both surgical and conventional endodontic procedures.[20]
3. Magnification plays a crucial role in traditional root canal procedures, aiding in various tasks such as crafting and refining the access cavity, accurately shaping the root canal, and ensuring thorough filling of the canal system in three dimensions.
4. Additionally, it facilitates detecting root canal orifices, pinpointing missed canals, and addressing challenges like removing fractured posts and instruments, as well as repairing perforations.[19]
5. Overall, the integration of magnification into endodontic practice represents a significant stride toward enhancing diagnostic accuracy and treatment efficacy.

1.3.2.4. Effect of access cavity design.

1. Access cavity preparation is defined as creating an unobstructed opening to reach canal orifices and the apical foramen.
2. Even though there are numerous studies evaluating advantages and disadvantages of ultraconservative access cavity designs, whether they compromise root canal system preparation, debridement and obturation, in the meantime conventional access cavities are useful for facilitating endodontic therapy in a predictable manner without compromising periapical healing or survival rates.[21]
3. However, outcome of endodontic therapy gets affected if procedural errors happen while access opening.
4. Some of these procedural errors are
   (a) Incomplete removal of caries
      i. In cases where a clinician is preoccupied with locating canal orifices, they may neglect to fully excavate the caries. Especially common in maxillary molars, where the canal orifices are situated in the mesial portion so the clinician neglects to remove the distal portion of the caries.
      ii. Incomplete removal of caries leads to secondary caries, which ultimately weakens the tooth and increasing its susceptibility to fracture or in some cases this leads to periapical infection even after completion of root canal treatment.
      iii. Removal of old restorations is also important as there can be secondary caries beneath the restoration.
   (b) Missed canals
      i. Inability to carefully examine the preoperative radiograph and incomplete deroofing are the main causes of missed canals.
      ii. Clear periapical radiographs both before and after root canal contouring and cleaning. Examine radiographs with a magnifying glass.
      iii. Several radiographs taken at different angles can assist the endodontist in tracking additional canals and the tooth's architecture.
      iv. Any missed canals must be found using magnification, microexcavation techniques,

and most importantly, the knowledge of root canal anatomy

v. To find the orifices, use size 06/08/10 ISO K-file instruments or the DG16 explorer. The C+ and Profinder files are the two files that function well in these circumstances.

(c) Iatrogenic cervical perforation

i. A perforation is a communication that arises between the periodontium and the root canal space. Iatrogenic cervical perforation can occur as a result of incorrect bur orientation or pulp chamber calcification.[22]

ii. Misidentifying canals and removing too much coronal dentine can easily lead to perforation in the coronal or furcation regions.[22]

iii. The main strategy for management of cervical perforations consists of using 1:50,000 epinephrine to stop bleeding followed by tricalcium silicate cements or mineral trioxide aggregate (MTA) for perforation healing.

1.3.2.5. Calcified canals.

1. The normal aging process causes the root canal system to become more calcified, which may result in more untreated canals that could become havens for bacteria as a response to this aging process, pulp chambers in the tooth's crown shrink in size and form more quickly on the roof and floor of posterior teeth.[23]
2. The calcification of root canals usually starts at the coronal aspect and decreases as the canal moves apically.
3. CBCT can help with the perioperative therapy of calcified canals, but magnification and illumination are necessary tools for their detection and management.[24]
4. Using software-based measurement tools, preoperative evaluation of calcified teeth using CBCT can provide the optimal strategy for detecting calcified canals in the chamber floor and roots.
5. The increased sensitivity and specificity provided by CBCT can also help in the determination of the PA status of calcified root canals that may not require measures that can lead to procedural errors, such as off-course access, instrument fracture, or root perforation.

1.3.2.6. Effect of negotiating & canal enlargement till the terminus of the canal.

1. As it was linked to the removal of "infected material and dentine," mechanical canal preparation was given priority over other debridement techniques in the first conceptualization of root canal therapy. According to Grossman, the canal endpoint diameter ought to be increased by at least three file sizes.[25]
2. Smith and colleagues discovered that a "flared" preparation had notably greater chance of success than a "conical" preparation, based on a loose set of criteria for success determination. The precise degree of taper was not disclosed, and the effects of additional treatment and non-treatment parameters were not controlled.[26]
3. By using precise criteria, Hoskinson and associates[27] and Ng and colleagues[28] did not find any difference in the treatment outcome between narrow (0.05) and wide (0.10) canal tapers.
4. Ng and associates also examined the effects of these preparation tapers (0.05 and 0.10) with tapers (0.02, 0.04, 0.06, and 0.08), which are typically obtained by employing larger taper nickel-titanium instruments. They discovered no discernible differences in the course of therapy.[28]

1.3.2.7. Effect of root canal irrigation.

1. Adding more particular irrigants had a major impact on success rates, even though a higher concentration of sodium hypochlorite had no effect on treatment outcome.
2. Surprisingly, nevertheless, the treatment's effectiveness was greatly decreased by the extra irrigation of 0.2% chlorhexidine solution.[28]
3. It is believed that the interaction product of sodium hypochlorite and chlorhexidine is an insoluble precipitate that contains the cytotoxic and carcinogenic compound parachloroaniline.[29]
4. The precipitate may induce long-term periapical tissue irritation and obstruct dentinal tubules and accessory architecture in addition to mutually depleting the active moiety in the two solutions for bacterial inactivation. This could also account for the observed reduced success rate in such situations.[30]

1.3.2.8. Deviation from normal canal anatomy.

1. Root canal system is always multiplanar curved and not as simple as is visualized in a two dimensional radiograph.
2. The most frequent operator error during shaping of root canals is causing deviation of the canal from the natural anatomy.
3. These deviations can lead to formation of ledge, transportation, zipping, elbow or strip perforation.
4. All of these deviations can easily be prevented by taking preoperative radiograph to assess and anticipate the unusual root canal curvature.
5. During biomechanical preparation, the canal's patency needs to be preserved and precurving of files should be done.
6. Preparing of the canal should be done by sequential use of files and timely recapitulation.

1.3.2.9. Effect of number of treatment visits and intra appointment medicaments.

1. Studies indicate that the success rates of single-visit and multiple-visit endodontic therapy are comparable.[31]
2. A study recorded 89% of healed outcome following single-visit endodontic therapy. Soltanoff studied one hundred thirty five single visit cases and 195 multiple visit cases selected at random .They reported incidence of pain with single visit endodontic treatment to be 56%, whereas in multiple visit cases it was only 38%. Irrespective of different pain levels, it was seen that both techniques provided success rates exceeding 85%.[31]
3. In 81% of the cases treated in a single visit and 71% of the cases treated in two visits, Peters and Wesselink report that full radiographic healing was observed.[32]
4. Comparable percentage of radiographic healing was seen in both the treatment protocols, but the calcium hydroxide multiple-visit group showed fewer failed and more improved cases.

1.3.2.10. Effect of acute exacerbation during treatment.

1. A flare-up is described as "an acute exacerbation of periradicular pathosis after initiation or in continuation of root canal treatment".[33]
2. Endodontic flare-ups can significantly impact the outcome of endodontic treatment, as highlighted in recent research. These flare-ups, characterized by post-operative pain, swelling, or discomfort, can compromise the success of root canal therapy.[29]
3. A study conducted by Smith et al. emphasized that patients experiencing flare-ups were more likely to exhibit increased treatment failure rates and decreased healing compared to those without such complications.[26]
4. Mechanical injuries from overinstrumentation, insufficient debridement, or insufficient removal of pulp tissue are among the factors that cause flare-ups.
5. Debris extrusion from the periapical region, chemical damage to the periapical tissues from irrigants, intracanal medications, overextended root filling, or microbiological injury are the most important factors in the etiology of flare-ups.
6. It is also possible for iatrogenic and microbiological factors to interact resulting in inter-appointment pain.
7. Management of flare-ups can be categorized as preventive and definitive.
8. Preventative management includes: proper diagnosis, long acting local anesthesia, determination of proper working length, complete debridement, occlusal reduction, placement of intracanal medicament in case of multi-visit root canal treatment, medications, closed dressing, behavioural management.
9. The definitive management includes: drainage through coronal access opening, incision and drainage, proper instrumentation, trephination, intracanal medicaments, analgesics and antibiotics, when indicated.

1.3.2.11. Impact of quality control on root canal disinfection and persistent bacteria.

1. The use of inter-appointment, antibacterial intra-canal dressings, increased the frequency of negative cultures at the subsequent visit to an average of 71% of cases.[26]
2. The technique of utilizing an interappointment culture test to verify the quality of bacterial disinfection before root-filling was developed earlier. Only in the event that a negative culture test result was obtained, "confirming" the absence of bacteria in the root canal system, would obturation be initiated.[34]
3. As time went on, the perceived predictability and favourable prognosis of root canal therapy without microbiological sampling became apparent, and this quality control method lost clinical favour due to perceived flaws like time-consuming, difficult to perform, sometimes inaccurate and requiring a wealth of laboratory resources, as well as uncertainties about cost-effectiveness and business imperatives.[35]

1.3.2.12. Effect of iatrogenic errors.

1. Perforation
   (a) Endodontic failure is frequently caused by mechanical perforation.
   (b) Perforation usually happens when the dentist is confused about the bur's direction and how it relates to the pulp chamber or root's structure.
   (c) The molar and two-rooted maxillary premolars with thin roots mesiodistally and broad bucco-lingually with curved canals have the most potential for furcation perforation.
   (d) Due to periodontal communication, furcation perforation repair is unpredictable and happens more frequently in high-stress scenarios.
   (e) The outcome of endodontic treatment is favourable if the perforation is Apical or supracrestal, Small in size and immediate repair has been done.
   (f) In cases where the perforation is Equi-crestal, Large in size and repair has been delayed, the outcome is unfavourable.
2. Instrument Separation
   (a) Whether a clinician employs hand-operated or engine-driven instruments, or instruments made of stainless steel or nickel-titanium, there is always a chance of separation.[36]
   (b) Inefficient use, physical property restrictions, insufficient access, root canal anatomy, and

potentially manufacturing flaws are the most frequent reasons for file separation.
(c) Nevertheless, a number of issues could arise throughout the procedure and have an impact on the tooth's prognosis.
(d) Surgery or tooth loss is not always required in cases where an instrument separates.
(e) The prognosis depends on the existence of any necrotic, diseased pulp tissue that is present within canal.
(f) When the separation happens, the results are better if the canal was cleaned up to a later level of preparation.
(g) The prognosis shouldn't be influenced by the separated instrument if the preoperative pulp was healthy, noninfected and free of apical periodontitis.[37]

3. Incomplete debridement of canal and over instrumentation

(a) The primary irritant to the periapical tissues is the presence of necrotic and diseased pulp tissue in the root canal.
(b) Complete root canal system debridement is necessary for the removal of these irritants.
(c) Inadequate debridement can result in the recolonization of leftover microorganisms, their metabolites, and tissue debris, all of which can worsen endodontic failure.
(d) Often clinicians tend to do overinstrumentation during endodontic therapy.
(e) However, over-instrumentation damages the periodontal ligament and alveolar bone, which lowers the success rate.

1.3.2.13. Effect of root filling material and technique.

1. Teeth obturated using the lateral condensation technique evenly fills the apical and midroot spaces creating compact obturation.[38]
2. There is no proof that the type of root filling material or the method of placement has a major impact on the course of treatment.
3. Outcome of endodontic treatment depends on apical extent of the root filling and three dimensional obturation quality more than depending on root filling material or technique

1.3.2.14. Effect of apical extent of root filling.

1. The effect of the apical extension of root fillings can be grouped as three groups for statistical analyses: extended beyond the radiographic apex (long), 0 to 2 mm within the radiographic apex (flush), and greater than 2 mm short of the radiographic apex (short).[39]
2. Irrespective of the periapical condition, the apical extent of root filling had a substantial impact on treatment success rates.
3. The best success rates were linked to flush root fillings, while the lowest success rates were linked to apically extruded root fillings.

1.3.2.15. Effect of root-filling quality.

1. In Toronto study done by Mahsa Farzaneh in 2004, it was discovered that compact root fillings gave more successful result than inadequate root fillings.[40]
2. The goal of completely obturating the root canal system is to stop newly invasive bacteria or residual infection from colonizing and recontaminating the area.
3. According to study done by Hoskinson et al in 2002, theoretically both are avoided by a "tight" seal with the canal wall and the absence of cavities in the material's body.[41]
4. Because excellent obturation depends on correctly carried out initial steps in canal preparation, the quality of root filling can therefore be viewed as a proxy for either inadequate root filling technique or the quality of the complete root canal treatment.

1.3.3. Post root canal treatment factors

1. Effect of coronal seal

(a) As shown in in vitro study done by Trope et al.in 1993 the endotoxin can predictably move through an obturated root canal, thus with a leaking or absent restoration, it is conceivable that the appropriate bacteria would only have to populate the coronal aspect of the tooth and the smaller endotoxin particles, or other bacterial products, could move to the apex stimulating the inflammatory response.[42]
(b) So after the initial chemo-mechanical phase of root canal treatment, the quality of the work of the restorative dentist appears most important for periapical health of the tooth.[43]
(c) Many studies done on endodontic failures consider coronal leakage to be as a potential factor resulting in endodontic failure.[44]
(d) For an endodontically treated tooth to have a good prognosis the coronal area must have an impermeable seal.
(e) Teeth with satisfactory restorations have a greater pooled success rate than teeth with subpar restorations.

2. Conclusion

The success or failure of endodontic treatment can be evaluated based on clinical and radiographic features as

well as the healing status of the periapical region. The primary goal of endodontic treatment is to eliminate microorganisms from the root canal system to encourage periapical healing. Success and failure of non-surgical endodontic treatment is influenced by factors such as patient factors, the effectiveness of the infection control, and procedural complications, as well as overall response to treatment. Root canal treatment usually fails when treatment falls short of acceptable standards. Both poorly treated and well-treated root canals might fail because of chronic intraradicular or secondary infections. However, carefully adhering to treatment protocols enhances the success rate as well as the quality of endodontic treatment.

3. Source of Funding

None.

4. Conflict of Interest

None.

References

1. Song M, Kim HC, Lee W, Kim E. Analysis of the cause of failure in nonsurgical endodontic treatment by microscopic inspection during endodontic microsurgery. *J Endod*. 2011;37(11):1516–9.
2. Marquis VL, Dao T, Farzaneh M, Abitbol S, Friedman S. Univ of Toronto) Treatment Outcome in Endodontics: The Toronto Study. Phase III: Initial Treatment. *J Endod*. 2006;32(4):299–306.
3. Garg N, Garg A. Textbook of Endodontics. Boydell & Brewer Ltd; 2010.
4. Lin LM, Pascon EA, Skribner J, Gängler P, Langeland K. Clinical, radiographic, and histologic study of endodontic treatment failures. *Oral Surg Oral Med Oral Pathol*. 1991;71(5):603–11.
5. Ashley M, Harris I. The assessment of the endodontically treated tooth. *Dent Update*. 2001;28(5):247–52.
6. Friedman S, Mor C. The success of endodontic therapy- healing and functionality. *J Calif Dent Assoc*. 2004;32(6):493–503.
7. Friedman S. The prognosis and expected outcome of apical surgery. *Endod Topics*. 2006;11(1):219–62.
8. Friedman S. Prognosis of initial endodontic therapy. *Endod Topics*. 2002;2:59–88.
9. Morsani JM, Aminoshariae A, Han YW, Montagnese TA, Mickel A. Genetic predisposition to persistent apical periodontitis. *J Endod*. 2011;37(4):455–9.
10. Holland R, Filho JG, Cintra LTA, Queiroz I, Estrela C. Factors affecting the periapical healing process of endodontically treated teeth. *J Appl Oral Sci*. 2017;25(5):465–76.
11. Márton IJ, Kiss C. Overlapping protective and destructive regulatory pathways in apical periodontitis. *J Endod*. 2014;40(2):155–63.
12. Sasaki H, Hirai K, Martins CM, Furusho H, Battaglino R, Hashimoto K, et al. Interrelationship between periapical lesion and systemic metabolic disorders. *Curr Pharm Des*. 2016;22(15):2204–15.
13. Cabanillas-Balsera D, Segura-Egea JJ, Bermudo-Fuenmayor M, Martín-González J, Jiménez-Sánchez MC, Areal-Quecuty V, et al. Smoking and radiolucent periapical lesions in root filled teeth: systematic review and meta-analysis. *J Clin Med*. 2020;9(11):3506. doi:10.3390/jcm9113506.
14. Ericsson KA, Hoffman RR, Kozbelt A, Williams AM. The Cambridge handbook of expertise and expert performance. Cambridge: Cambridge University Press; 2018.
15. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature - part 1. Effects of study characteristics on probability of success. *Int Endod J*. 2007;40(12):921–39.
16. Van Nieuwenhuysen J, Aouar M, D'Hoore W. Retreatment or radiographic monitoring in endodontics. *Int Endod J*. 1994;27(2):75–81.
17. Goldfein J, Speirs C, Finkelman M, Amato R. Rubber dam use during post placement influences the success of root canal-treated teeth. *J Endod*. 2013;39(12):14814–4.
18. European Society of Endodontology, Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J*. 2006;39(12):921–30.
19. Kumar R, Khambete N. Surgical operating microscopes in Endodontics: Enlarged vision and possibility. *Int J Stomatological Res*. 2013;2(1):11–5.
20. Neha. An insight into magnification. *Guident*. 2012;p. 49–53.
21. Tufenkci P, Yilmaz K. The effects of different endodontic access cavity design and using XP-endo finisher on the reduction of Enterococcus faecalis in the root canal system. *J Endod*. 2020;46(3):419–4.
22. Saed SM, Ashley MP, Darcey J. Root perforations: aetiology, management strategies and outcomes. The hole truth. *Br Dent J*. 2016;220(4):171–80.
23. Slade GD. Derivation and validation of a short-form oral health impact profile. *Community Dent Oral Epidemiol*. 1997;25(4):284–90.
24. Buchbinder M, Wald AH. An improved method of culturing root canals. *J Am Dent Assoc*. 1939;26(10):1697–9.
25. Grossman LI. Preparation of the root canal. In: Endodontic practice. Philadelphia: Lea & Febiger; 1970. p. 216.
26. Smith CS, Setchell DJ, Harty FJ. Factors influencing the success of conventional root canal therapy - a five-year retrospective study. *Int Endod J*. 1993;26(6):321–33.
27. Hoskinson SE, Ng YL, Hoskinson AE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2002;93(6):705–15.
28. Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. *Int Endod J*. 2011;44(7):583–609.
29. Basrani BR, Manek S, Sodhi RN. Interaction between sodium hypochlorite and chlorhexidine gluconate. *J Endod*. 2007;33(8):966–9.
30. Bui TB, Baumgartner JC, Mitchell JC. Evaluation of the interaction between sodium hypochlorite and chlorhexidine gluconate and its effect on root dentin. *J Endod*. 2008;34(2):181–5.
31. Jurcak JJ, Bellizzi R, Loushine RJ. Successful single-visit endodontics during Operation Desert Shield. *J Endod*. 1993;19(8):412–3.
32. Peters LB, Wesselink PR. Periapical healing of endodontically treated teeth in one and two visits obturated in the presence or absence of detectable microorganisms. *Int Endod J*. 2002;35(8):660–7.
33. Siqueira-Jr JF. Microbial causes of endodontic flare-ups. *Int Endod J*. 2003;36(7):453–63.
34. Buchbinder M, Wald A. An improved method of culturing root canals. *J Am Dent Assoc*. 1939;26(10):1697–9.
35. Molander A, Reit C, Dahlen G. Microbiological root canal sampling: diffusion of a technology. *Int Endod J*. 1996;29(3):163–7.
36. Iqbal MK, Kohli MR, Kim JS. A retrospective clinical study of incidence of root canal instrument separation in an endodontics graduate program: a PennEndo database study. *J Endod*. 2006;32(11):1048–52.
37. Bence R, Madonia JV, Weine FS, Smulson MH. A microbiologic evaluation of endodontic instrumentation in pulpless teeth. *Oral Surg Oral Med Oral Pathol*. 1973;35(5):676–83.
38. Athkuri S, Mandava J, Chalasani U, Ravi RC, Munagapati VK, Chennareddy AR, et al. Effect of different obturating techniques and sealers on the removal of filling materials during endodontic retreatment. *J Conserv Dent*. 2019;22(6):578–82.
39. Al-Nuaimi N, Patel S, Davies A, Bakhsh A, Foschi F, Mannocci F, et al. Pooled analysis of 1-year recall data from three root canal treatment outcome studies undertaken using cone beam computed tomography. *Int Endod J*. 2018;51(3):216–26.

40. Halse A, Molven O. Overextended gutta-percha and Kloroperka N-ö root canal fillings: Radiographic findings after 10-17 years. *Acta Odontol Scand*. 1987;45(3):171–7.
41. Hoskinson SE, Ng YL, Hoskinson AE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. *Oral Surg Oral Med Oral Pathol*. 2002;93(6):705–15.
42. Trope M, Chow E, Nissan R. In vitro endotoxin penetration of coronally unsealed endodontically treated teeth. *Endod Dent Traumatol*. 1995;11(2):90–4.
43. Bayram HM, Celikten B, Bayram E, Bozkurt A. Fluid flow evaluation of coronal microleakage intraorifice barrier materials in endodontically treated teeth. *Eur J Dent*. 2013;7(3):359–62.
44. Swanson K, Madison S. An evaluation of coronal microleakage in endodontically treated teeth. Part I. Time periods. *J Endod*. 1987;13(2):56–9.

Author biography

Shouvik Ganguly, Lecturer https://orcid.org/0000-0002-5638-0458

Vaishali Waghmare, Endodontics Fellowship Student https://orcid.org/0009-0002-0458-5707

Sumanthini M.V, HOD https://orcid.org/0000-0002-2313-7021

Anuradha Patil, Professor https://orcid.org/0000-0001-9007-2611

Aditya Shinde, Lecturer https://orcid.org/0000-0002-2730-1976

Jimish Shah, Lecturer https://orcid.org/0000-0002-0752-3096

Cite this article: Ganguly S, Waghmare V, Sumanthini M.V, Patil A, Shinde A, Shah J. Success and failure of non-surgical endodontic treatment –A literature review. *IP Indian J Conserv Endod* 2024;9(3):121-128.