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Guided tissue regeneration in endodontic periapical surgeries: a systematic review

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HENRY M. GOLDMAN SCHOOL OF DENTAL MEDICINE

THESIS

GUIDED TISSUE REGENERATION IN ENDODONTIC PERIAPICAL SURGERIES: A SYSTEMATIC REVIEW

By

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Finally, I would like to thank everyone who helped and supported me during this journey.

ABSTRACT

GUIDED TISSUE REGENERATION IN ENDODONTIC PERIAPICAL SURGERIES: A SYSTEMATIC REVIEW

KASRA DABESHLIM

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Background:

Guided Tissue Regeneration has been proposed in conjunction with endodontic periapical surgeries. Several studies have examined the combination of GTR and endodontic periapical surgeries to achieve osseous healing post-surgery.

Studies examined the use of GTR in conjunction with periapical surgeries have different outcomes, methods, follow up protocols and conclusions.

The differences in the outcomes, protocols and findings of existing studies provides an opportunity for the author to evaluate, compare and assess the quality of existing studies by conducting a systematic review.

Aim of Study:

The aim of this research project is to examine the use of guided tissue regeneration in conjunction with endodontic periapical surgeries.

Material and methods:

In initial searching phase, an advanced search using PubMed, Cochrane and Embase was performed. Using the following keywords (periapical surgery, apicoectomy, guided tissue regeneration, grafting materials, osseous healing, grafting in endodontics) the initial search yields to 478 studies.

Secondary screening was performed to exclude duplicate studies and irrelevant literature.

In advanced phase, after applying our exclusion criteria (studies in languages other than English, studies on animals, in- vitro literature and irrelevant studies) our search result will narrow down to 16 studies to be reviewed. Each article then was evaluated and summarized thoroughly for the next step. A flowchart was made to illustrate the process.

Quality Assessment:

JBI Critical Appraisal scale was used to evaluate the quality of each study.

Conclusion:

Based on this review, there is no solid agreement that guided tissue regeneration will significantly change the outcome of Endodontic Surgeries.

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LIST OF ABBREVIATIONS

Endo: Endodontics

GBR: Guided bone regeneration

GTR: Guided Tissue Regeneration

JBI: Joanna Briggs Institute

NSRCT: Non-surgical root canal treatment

PAI: Peri apical Index

RCT: Root Canal Treatment

SRCT: Surgical root canal treatment

INTRODUCTION

An Overview of Root Canal Treatment:

The goal of root canal treatment is to eliminate the bacterial infection and promote healing in the peri radicular area. According to a study by Ng *et al.* (1), the probability of success of this treatment could be up to 93%. Endodontic therapy primarily addresses the issue of infection. The main objective of treatment is to resolve root canal infections, ensuring the long-term maintenance of the tooth without giving rise to inflammatory conditions or adverse effects on systemic health. This perspective has been the prevailing view in the field of endodontics for many years, supported by numerous scientific reports (35, 36). Notably, the works of Moller et al. (37) and Fabricius et al. (38) hold particular significance.

In experiments involving monkeys, specific strains of 4–5 bacterial organisms were introduced into teeth with devitalized pulps, and observations were made 2–2.5 years after the completion of root canal treatment and filling. Histological examination of periapical tissue revealed a significantly higher success rate in cases where root canals were culture-negative compared to those harboring bacteria at the time of root filling 72% versus 21%. Importantly, in teeth without cultivable bacteria at the time of filling, the outcome was unaffected by the adequacy of root filling or its status.

Infection occurs when the invasion of microbes leads to tissue damage. Endodontic disease, encompassing both pulpal and periradicular conditions, arises from the combined pathogenic effects of microbes and the host's response. Clinicians aim to intervene by disrupting and eliminating the microbial ecosystem associated with the disease process. Endodontic infections

comprise a combination of obligate anaerobes and facultative anaerobes, with obligate anaerobes being the predominant microorganisms involved (39).

The primary objective of root canal instrumentation is to mechanically clean the root canal system and establish a path for delivering irrigation agents. Additionally, a well-formed root canal system eases the precise placement of root canal filling materials, preventing the re-colonization by oral microflora (40).

Certainly, the primary contributors to endodontic treatment failure include the continued presence of microbial infection within the root canal system and/or the surrounding periapical region. Many teeth fail to react to root canal treatment due to procedural error that hinder the treatment of intracanal endodontic infection. However, there are instances where treatment adheres to the highest technical standards, yet still leads to failure. Scientific evidence suggests that certain elements may be linked to the unsatisfactory results of well-treated cases(43). These factors encompass microbial elements, which include extraradicular and/or intraradicular infections, as well as intrinsic or extrinsic nonmicrobial factors.

Treatment of endodontic failure includes, non- surgical retreatment, endodontic surgery or extraction.

Non-surgical retreatment:

Following the removal of the root canal filling materials, the endodontist will instrument and clean the canals and meticulously inspect the root canal system with the aid of magnification and illumination. This examination aims to identify any extra canals or unique anatomical features that may necessitate treatment. The microscopic evaluation may result in finding cracks if presence in the tooth.

It is widely reported that a some of teeth that have undergone endodontic treatment may require retreatment at some juncture due to the emergence or recurrence of periapical pathology (41). Even with a successful endodontic treatment or re treatment, sometimes the periapical lesion does not heal.

The causes of this occurrence remain not fully elucidated. Factors such as the intricate anatomy of the root canal system, unfilled isthmuses, leakage from fillings, inadequate instrumentation, or hard-to-reach areas can contribute to the persistence of apical periodontitis (41). Therefore, additional treatment such as periapical surgery might be indicated as an alternative to extraction (2-3).

Periapical surgery procedure:

Endodontic surgery is a treatment option for teeth with apical periodontitis and may be indicated for teeth with periapical pathology when non-surgical retreatment fails to properly heal the lesion (4). Modern endodontic surgical technique uses magnification, ultrasonic preparation, minimal bevel, and biocompatible root-end filling materials (5). Currently, there is no established method for preoperative distinction between a granuloma and a radicular cyst. The gold standard for definitively diagnosing apical lesions involves performing a biopsy followed by histopathological evaluation (42).

Periapical healing after endodontic surgery includes regeneration of bone, periodontal ligament, and cementum (6). Healing after periapical surgery has been the subject of several investigations. For many reasons the results are not always comparable. This might depend on differences in operation techniques, composition of the material or variations of criteria in the assessment of

healing. Furthermore, the indications for periapical surgery vary in different studies (7). Regarding the assessment of healing, radiography usually has been used, often in combination with clinical evaluation (7). The superior means to assess the healing after periapical surgery should be to study microscopically biopsies taken from the periapical region. For obvious reasons this method is not available except for cases where unsuccessful or uncertain healing is expected, and reoperation or extraction of the teeth has been performed (7).

To perform periapical surgery, a full thickness muco- periosteal flap will be used. Then flap will be elevated carefully and retracted properly as needed. The clinician should pay attention to tissue retraction and where to position the retractor to prevent from any possible damage to the vital tissue in the area. After access to the root end rea was achieved, osteotomy will be made using burs, ultrasonic tips, or other methods. Copious irrigation is needed at this stage to prevent any thermal damage as well as irrigating the area. 3 mm of root end will be removed with zero to minimal bevel. The peri radicular lesion will be removed with a sharp bone curette and will be placed in a preservative formalin solution for histopathologic evaluation.

Root end then will be sectioned at an approximate 3mm from the apex with a minimal bevel. Root end will be prepared using the ultrasonic tips and evaluated under proper magnification. Once preparation is ready, biocompatible root end filling material will be placed and packed into the prepared space. Rooth end will be burnished and polished to remove the excess material and then flap will be repositioned and sutured.

Area will be reevaluated as needed to monitor the healing and post op complications. Radiographic and clinical follow ups are strongly recommended to evaluate the effectiveness of the surgery and outcome.

Periradicular surgery leads to the restoration of the attachment apparatus, encompassing cementum, alveolar bone, and the periodontal ligament, thereby promoting periodontal regeneration.

The success rates of endodontic surgery conducted without guided tissue regeneration range from 59% with traditional surgical endodontic approaches to 94% with the application of modern microsurgical endodontic methods (43).

The findings from previous studies indicate that the incorporation of guided tissue regeneration (GTR) and/or graft enhances the clinical, radiographic, and histologic healing outcomes (43).

Guided Tissue Regeneration:

Guided tissue regeneration is a technique for enhancing and directing cell growth to repopulate specific parts of the periodontium that have been damaged by periodontal diseases, tooth diseases, or trauma (8). Guided tissue regeneration by using membrane barriers and bone grafting materials has been extensively used in periodontal treatments to induce new cell formation and in the damaged site to promote healing (8). Guided tissue regeneration, especially by using bone grafting materials, has also been widely used in implant dentistry to enhance new bone formation for placement of implants (8-9).

Graft Material:

Grafts are categorized according to their origins and ultrastructure. They can be autogenous or nonautogenous, and can also be cortical, cancellous, or corticocancellous, depending on their

composition. Autogenous bone is sourced from nearby or distant locations. Intraoral sites commonly used include the torus, symphysis, and ramus, while extraoral sites frequently utilized are the iliac crest, tibia, and calvarium (45).

Histologic assessments of guided tissue regenerative therapy in periodontal disease often show down growth of junctional epithelial cells between the membrane barrier and root surface (8-10). Application of guided tissue regeneration concepts to periapical surgery is primarily based on extensive studies of periodontal regenerative therapy (8-9).

Different material and bone grafts are being used in guided tissue regeneration in conjunction with endodontic surgeries. Some studies used non resorbable membranes, but most studies used resorbable membranes in conjunction with endodontic surgeries.

The use of guided tissue regeneration has been suggested as an adjunct procedure to endodontic microsurgeries to achieve a better healing.

Several studies have examined the combination of guided tissue regeneration and endodontic periapical surgeries to achieve osseous healing post-surgery. Studies examined the use of guided tissue regeneration in conjunction with periapical surgeries have different outcomes. The differences in the outcomes, protocols and findings of existing studies provides an opportunity for the author to evaluate, compare and assess the quality of existing studies by conducting a systematic review.

Research question:

Is there any difference in the radiographic outcome of the endodontic periapical surgeries in conjunction with guided tissue regeneration as compared to periapical surgeries alone?

Aim of the study:

The aim of this study is to evaluate the existing literature by means of systematic review to find out whether there is a difference in the radiographic outcome of the endodontic periapical surgeries if guided tissue regeneration is being used in adjunt to the periapical surgery.

Materials and Methods

In the initial searching phase, an advanced search using PubMed, Cochrane and Embase was performed. Using the following keywords (periapical surgery, apicoectomy, guided tissue regeneration, grafting materials, osseous healing, grafting in endodontics, bone grafting, membrane, periradicular surgery, root end surgery) the initial search yields 484 studies. Secondary screening was performed with an assistance from librarian utilizing Zotero software to exclude duplicate studies.

The abstract and title of each study were reviewed to exclude irrelevant studies.

At this stage, If the inclusion or exclusion decision could not be made by reviewing the abstract, complete text was reviewed to make the decision.

Exclusion Criteria:

Our exclusion criteria are as follow:

1) Studies in languages other than English.

2) Studies on animals.

3) In- Vitro studies.

4) Irrelevant studies.

5) Use of non-resorbable membrane

During the first stage of the projects, Initial search yields to 484 studies. Then studies in languages other than English, irrelevant studies and duplicates were excluded.

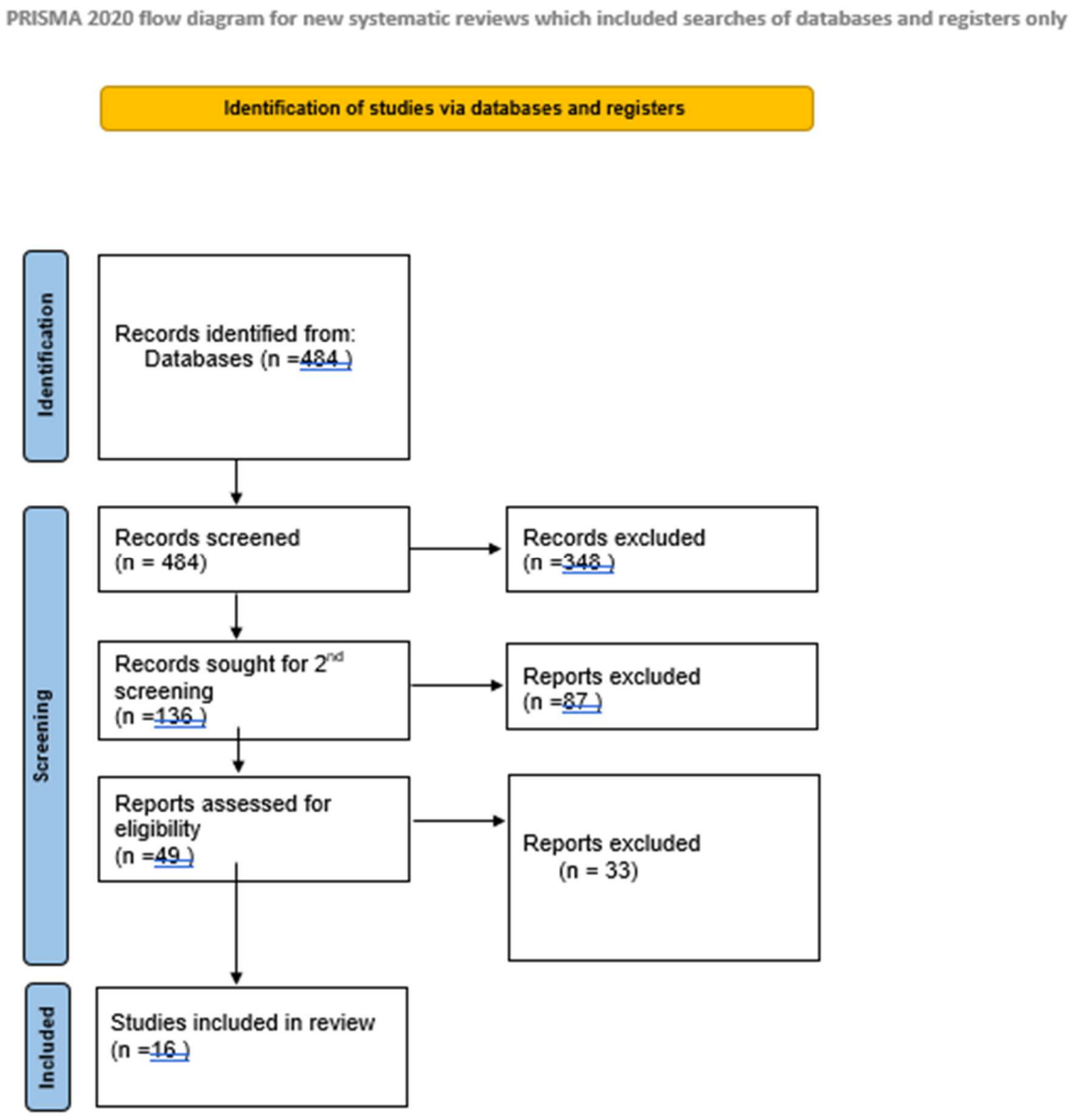
In the advanced phase, In-vitro studies, animal studies and studies that used non resorbable materials were excluded. After applying all mentioned exclusion criteria, our search result

narrowed down to 16 studies to be included in this review.

This review adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, a rigorous research protocol that establishes the rationale for the review and outlines a pre-planned methodological and analytical approach for systematic my reviews. **Figure 1** depicts the flowchart of the search results obtained through this PRISMA-based strategy.

Figure- 1

(PRISMA Flow Diagram)



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

PubMed search strategy:

Version 1:

("Guided Tissue Regeneration"[Mesh] OR "Guided Tissue Regeneration") AND ("Endodontics"[Mesh] OR "Endodontics") AND ("Alveolar Bone Grafting"[Mesh] OR "Bone Graft*" OR "membrane*")

Version 2:

("Endodontics"[Mesh] OR "Endodontics" OR "Endodontic Surgery") AND ("Guided Tissue Regeneration"[Mesh] OR "Guided Tissue Regeneration" OR "Bone Regeneration"[Mesh] OR "Bone Regeneration") AND ("Alveolar Bone Grafting"[Mesh] OR "Bone Graft*" OR "Alveolar Bone Graft*" OR "Membranes, Artificial"[Mesh] OR "Membrane*" OR "Artificial Membrane*")

Table 1 - Mesh Terms

Concept in Research Question	MeSH terms	Synonymous keywords/phrases
Guided tissue regeneration	"Guided Tissue Regeneration"[Mesh]	"Guided Tissue Regeneration"
Endodontics	"Endodontics"[Mesh]	"Endodontics" "Endodontic Surgery"
Bone grafting/ membrane	"Alveolar Bone Grafting"[Mesh] "Membranes, Artificial"[Mesh] "Bone Regeneration"[Mesh]	"Bone Graft*" "Alveolar Bone Graft*" "Membrane*" "Artificial Membrane*" "Bone Regeneration"

JBI Critical assessment:

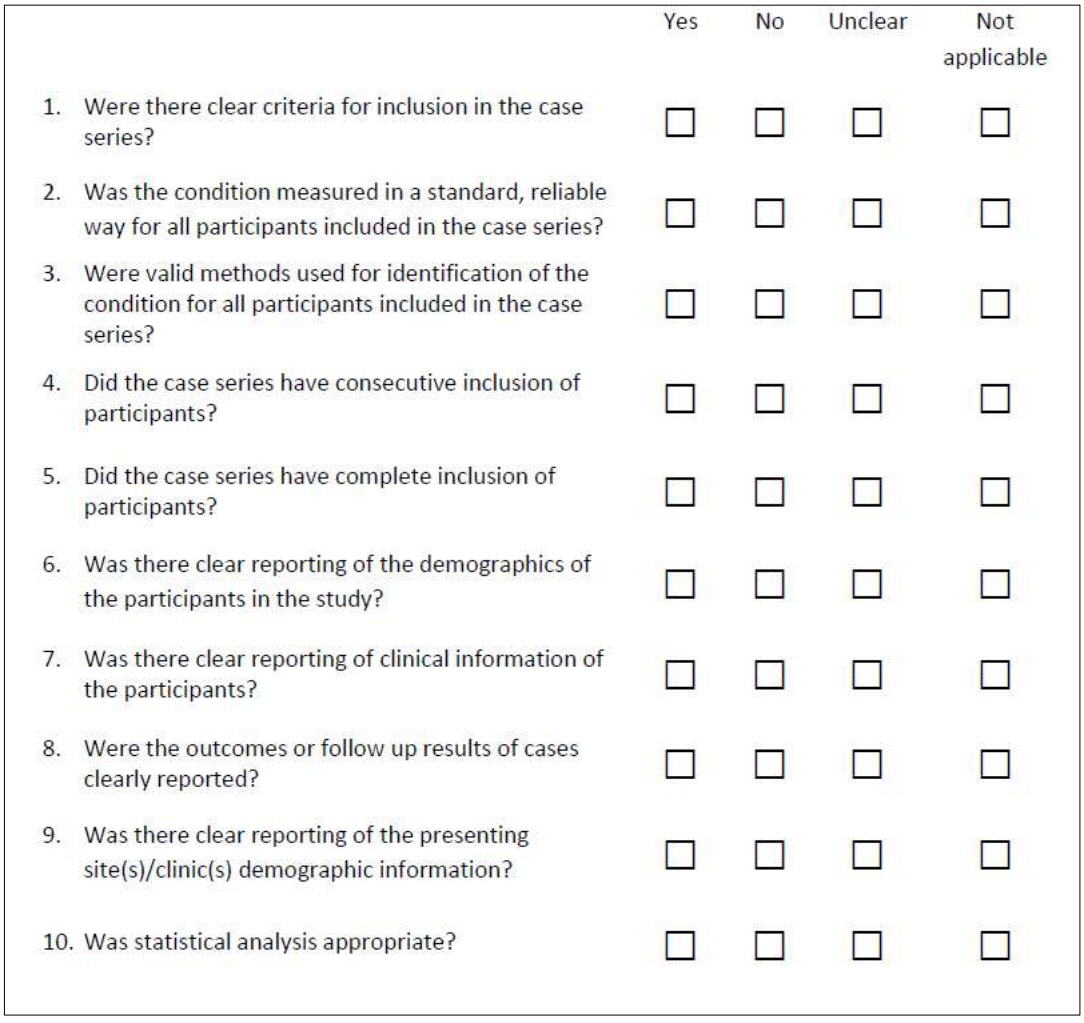
Each article was evaluated and scored using the Joanna Briggs Institute (JBI) Critical Appraisal Tools scaling system. The JBI is an international, membership-based research and development organization within the Faculty of Health Sciences at the University of Adelaide. The Institute specializes in promoting and supporting evidence-based healthcare by providing resources for professionals in nursing, midwifery, medicine, and allied health.

Systematic reviews form the core of evidence synthesis, as they involve a comprehensive analysis of the available literature on a particular intervention, condition, or issue. These reviews assess the effectiveness of a practice through a series of complex steps. JBI adopts a particular perspective on what constitutes evidence and the methods employed to synthesize various types of evidence. In line with this broader view, the Institute has developed theories, methodologies, and rigorous processes for the critical appraisal and synthesis of diverse forms of evidence to support clinical decision-making in healthcare. Consequently, JBI has established guidance for conducting reviews on effectiveness research, qualitative research, prevalence/incidence, etiology/risk, economic evaluations, text/opinion, diagnostic test accuracy, mixed-methods, umbrella reviews, and scoping reviews.

JBI Critical Appraisal Tools play a crucial role in all systematic reviews, as they incorporate a process of critique or appraisal of the research evidence. The purpose of this appraisal is to assess a study's methodological quality and determine the extent to which it has addressed the possibility of bias in its design, conduct, and analysis.

The articles were independently evaluated and graded by two dental examiners. In cases of discrepancies both examiners jointly evaluated the study in question to reach an agreement on the result.

Figure- 2: JBI Critical Appraisal



	Yes	No	Unclear	Not applicable
1. Were there clear criteria for inclusion in the case series?	☐	☐	☐	☐
2. Was the condition measured in a standard, reliable way for all participants included in the case series?	☐	☐	☐	☐
3. Were valid methods used for identification of the condition for all participants included in the case series?	☐	☐	☐	☐
4. Did the case series have consecutive inclusion of participants?	☐	☐	☐	☐
5. Did the case series have complete inclusion of participants?	☐	☐	☐	☐
6. Was there clear reporting of the demographics of the participants in the study?	☐	☐	☐	☐
7. Was there clear reporting of clinical information of the participants?	☐	☐	☐	☐
8. Were the outcomes or follow up results of cases clearly reported?	☐	☐	☐	☐
9. Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	☐	☐	☐	☐
10. Was statistical analysis appropriate?	☐	☐	☐	☐

Each study was carefully reviewed evaluated and summarized. Following Information collected from each study:

1) Study design
2) Year the study being published.
3) Sample size
4) Gender
5) Location
    - Mandible
    - Maxilla
6) Type of teeth
    - Anterior
    - Premolar
    - Molar
7) Type of lesion
8) Material used.
9) Assessment method
10) Follow up period.
11) Outcome

Each study was evaluated based on the JBI clinical appraisal scaling system. Outcome of this evaluation is summarized in Table-2.

Table- 2: JBI Critical appraisal

Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Taschieri et al. 11	Y	Y	Y	Y	Y	Y	Y	Y	N	NA
Taschieri et al. 12	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Kim et al. 13	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Garrett K et al. 14	Y	Y	Y	Y	Y	N	Y	Y	Y	NA
Silva SR et al. 15	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Pecora G et al. 16	Y	Y	Y	Y	Y	N	Y	Y	Y	NA
Lui JN et al. 17	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Parmar PD et al. 18	Y	Y	Y	Y	Y	N	Y	Y	N	NA
Dietrich T et al. 19	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Marín-Botero ML et al. 20	Y	Y	Y	Y	Y	Y	Y	Y	N	NA
Taschieri et al. 21	Y	Y	Y	Y	Y	N	Y	Y	Y	NA
Goyal B et al. 22	Y	Y	Y	Y	Y	N	Y	Y	Y	NA
Tobón SI et al. 23	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Del Fabbro M et al. 24	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA
Pantchev A et al. 25	Y	Y	Y	Y	Y	N	Y	Y	N	NA
Dominiak M et al. 26	Y	Y	Y	Y	Y	N	Y	Y	Y	NA

DISCUSSION

For each study, the following information was collected and summarized in Tale-3 and Table-4. Author, year, location of the teeth involved (maxilla or mandible), type of tooth (anterior, premolar, or molar), gender of the patients, material used, assessment method, follow up period and conclusions.

Table-3
Study information

Author	Year	Maxilla	Mandible	Anterior	Premolar	Molar	Male	Female
Taschieri ,et al.	2008	17	14	21	7	3	11	16
Taschieri ,et al.	2011	32	17	35	11	3	16	22
Kim, et al.	2008	183	80	147	70	46	76	151
Garrett, et al.	2002	Total 25	Total 25	Total 25	Total 25	Total 25	Total 25	Total 25
Ribeiro da Silva,et al.	2016	Total 30	Total 30	Total 30	Total 30	Total 30	Total 30	Total 30
Pecora,et al.	2001	Total 20	Total 20	Total 20	Total 20	Total 20	Total 20	Total 20

Lui, et al.	2014	63	30	47	17	29	36	57
Parmar, et al.	2019	29	21	48	1 (2 roots)	0	15	15
Dietrich, et al.	2003	9	14	6	4	13	15	7
Marin-Botero,et al.	2006	22	8	14	16 Posterior	16 Posterior	11	19
Taschieri, et al.	2007	39	20	26	20	13	13	28
Goyal,et al.	2011	Total 30	Total 30	Total 30	Total 30	Total 30	17	13
Tobon, et al.	2002	23	7	16	14	0	10	18
Taschieri, et al.	2008	17	14	21	7	3	11	16
Pantchev, et al.	2008	137	49	Total 186	Total 186	Total 186	Total 186	Total 186
Dominiak ,et al.	2009	82	24	78	18	10	34	72

Table- 4
Study Summary

Author	Year	Study Design	Sample Size	Material Used	Assessment Method	Follow Up	Conclusion
Taschieri, et al.	2008	Randomized clinical Study	73 teeth in 55 patients	Anorganic bovine bone with resorbable collagen membrane	Clinical and radiograph	One year	Grafting is not necessary for four wall defects but may be indicated for Trans osseous lesions
Taschieri, et al.	2011	Retrospective Cohort Study	43 teeth in 33 patients	Bone graft (xenogenic) with resorbable membrane	Radiographic and clinical	Four years (including 3,6,12,24, 36,48 months)	Association of apical surgery and GTR leads to excellent outcome
Kim, et al.	2008	Prospective Clinical study	263 teeth in 227 Patients	Graft with Absorbable collagen membrane (Colla Tape)	Clinical and radiographic	Every 6 months for two years	Strong effect on healing of bone and tissue.
Garrett, et al.	2002	Prospective Clinical study	25 patients	Graft with Bioresorbable membrane	Radiographic and clinical	3,6,12 months	Placement of resorbable GTR in 4 wall defects

							has no advantage and is just an added expense to the patient
Ribeiro da Silva,et al.	2016	Prospective Clinical study	30 Patients	Defect was filled Calcium Carbonate as a bone graft	Clinical and radiographic	6 months	may be used did not report significant difference
Pecora,et al.	2001	Randomized controlled clinical trial	20 Patients	Calcium Sulphate as a bone graft	Radiographic and clinical	12 months	Improves the quality outcome
Lui, et al.	2014	Retrospective study	93 patients	Resorbable collagen membrane (Biomed) Inorganic bovine bone(Bio Oss)	Radiographic and clinical	Recall visits 1-2 years	Resulted in healing over a period of 1-2 years of recall
Parmar, et al.	2019	Randomized controlled trial	32 patients	Resorbable collagen membrane (Healiguide)	2D Radiographic and 3D	Recall 12 months	GTR did not improve the outcome significantly
Dietrich, et al.	2003	Randomized clinical study	23 cases	Inorganic bovine bone(Bio Oss) and	Clinical and radiographic	12 months	GTR yields a good result in

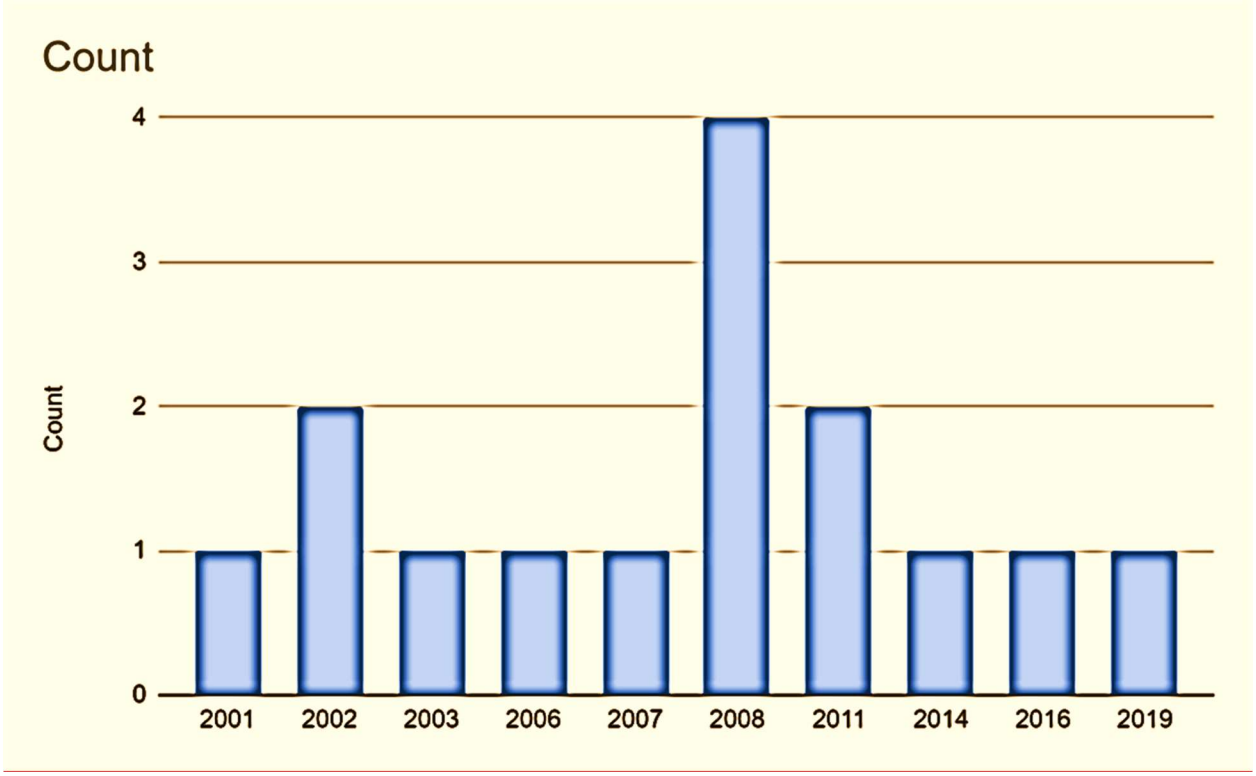
				Resorbable collagen membrane (Bio-Guide)			conjunction with apical surgeries and should be considered
Marin-Botero,et al.	2006	Double blind randomized - Clinical	30 Cases	Periosteal graft and bioabsorbable membrane	Clinical and radiographic	Every 3 months up to 12 months	Using GTR Led to similar enhancement of clinical outcome
Taschieri, et al.	2007	Prospective clinical trial	59 teeth	Inorganic bovine bone material (BioOss) covered with resorbable collagen membrane(Bio-Gide)	Radiographic and clinical	1 year follow up	Use of GTR in conjunction of inorganic bovine bone has no significant difference in the outcome of procedure
Goyal,et al.	2011	Clinical study	30 cases	Collagen membrane (Heliguide)			Lead to similar enhancement of clinical outcome
Tobon, et al.	2002	Prospective clinical study	30 cases	Synthetic bioactive resorbable	Clinical and radiographic	Every 3 months up to 12 months	The use of GTR improves the predictability of the

							outcome of periapical surgeries
Taschieri, et al.	2008	Prospective clinical studies	34 teeth	Inorganic Bovine bone with resorbable collagen membrane	Clinical and radiographic	1 year	Use of GTR in conjunction with bone grafting may positively affect the healing process
Pantchev, et al.	2008	Prospective clinical study	186 teeth	Synthetic absorbable grafting material	Radiographic and clinical	1 year	Did not significantly improve the outcome of the surgery
Dominiak,et al.	2009	Prospective clinical study	106 teeth	Resorbable membrane + Xenogenic bovine bone + PRP	Radiographic and clinical	6 months and 1 year	Difference was statically significant

Publication Year:

The range of articles being reviewed in this study is from 2001 to 2019. (Figure 3). The oldest study in this review is an article by Pecora et.al (16) and newest study reviewed in this paper is by Parmar et al. (18). Four studies included in this review were published in 2008.

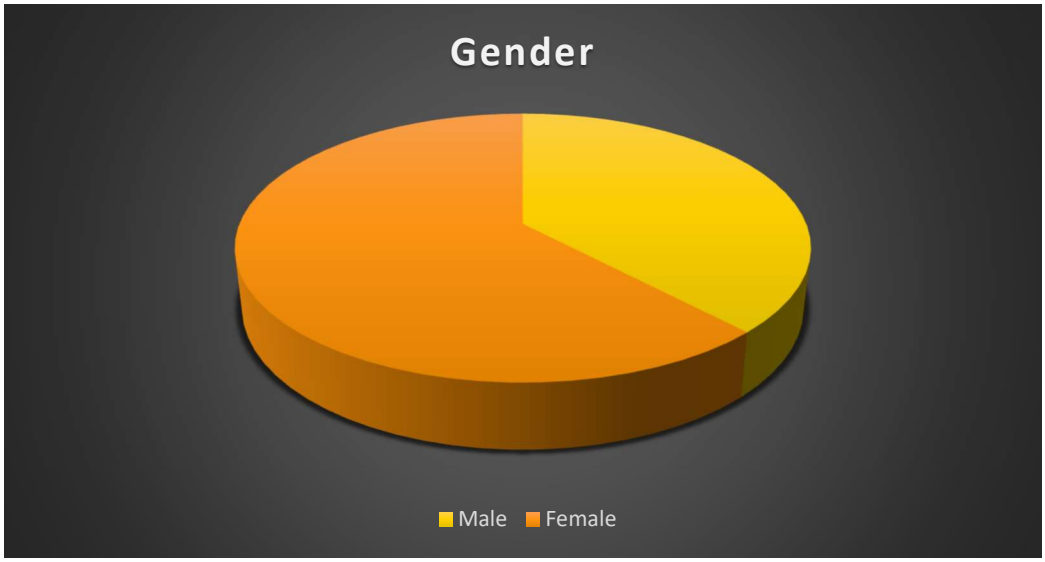
Figure 3
Publication Year



Gender Distribution:

Gender distribution of participant in these studies were not equal. 62 percent of participant were female, and 38 percent of participant were male. Study by Parmar et al. had equal number of male and female participants. (**Figure 4**)

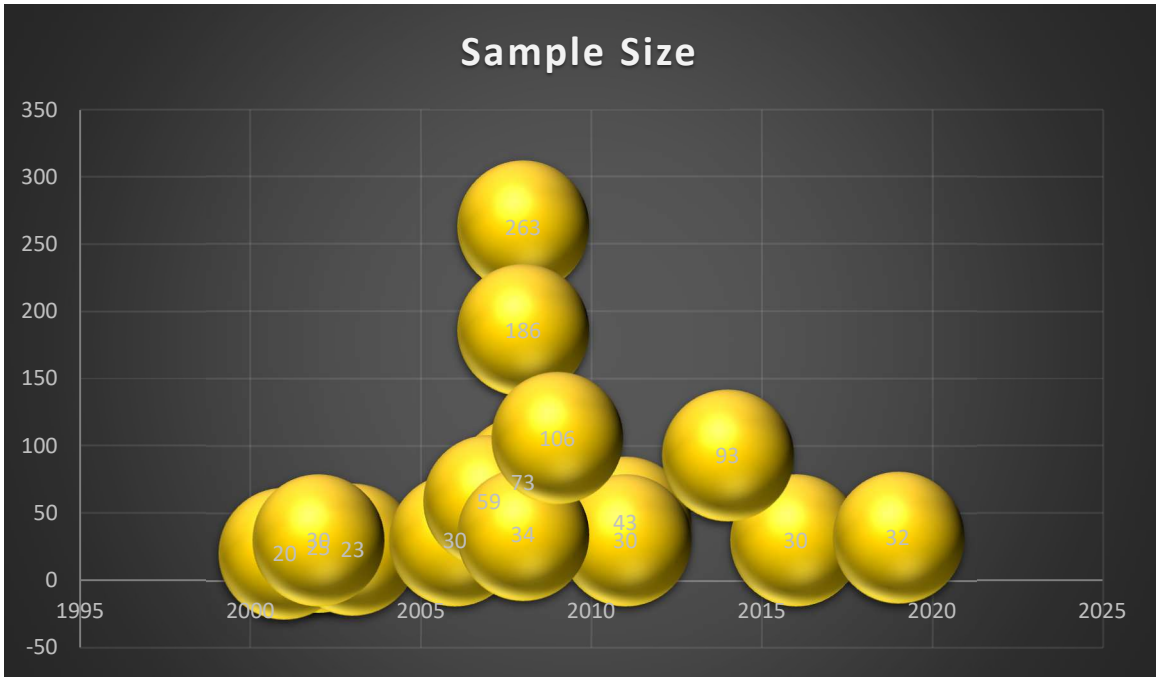
Figure 4- Gender Distribution



Sample Size:

Studies had different sample sizes with the range of 20 to 263. Pecora et al 2001 study has the smallest sample size 20 whereas study by Kim et al 2008 has the largest sample size of 263 teeth. The mean of sample size for all studies are 52. (Figure 5)

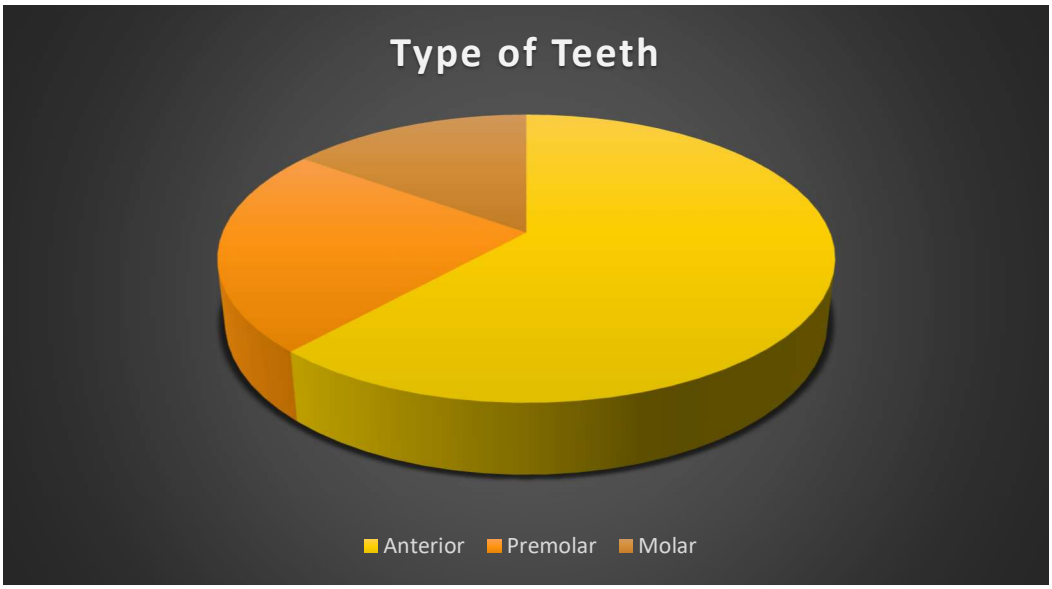
Figure 5- Sample Size



Type of Teeth:

Most of teeth included in the studies were anterior (62 %) followed by premolars (23 %) and molars (15 %). Study by Kim et al 2008 has the most anterior teeth were included 147 anterior teeth (Figure 6).

Figure 6
Type of teeth

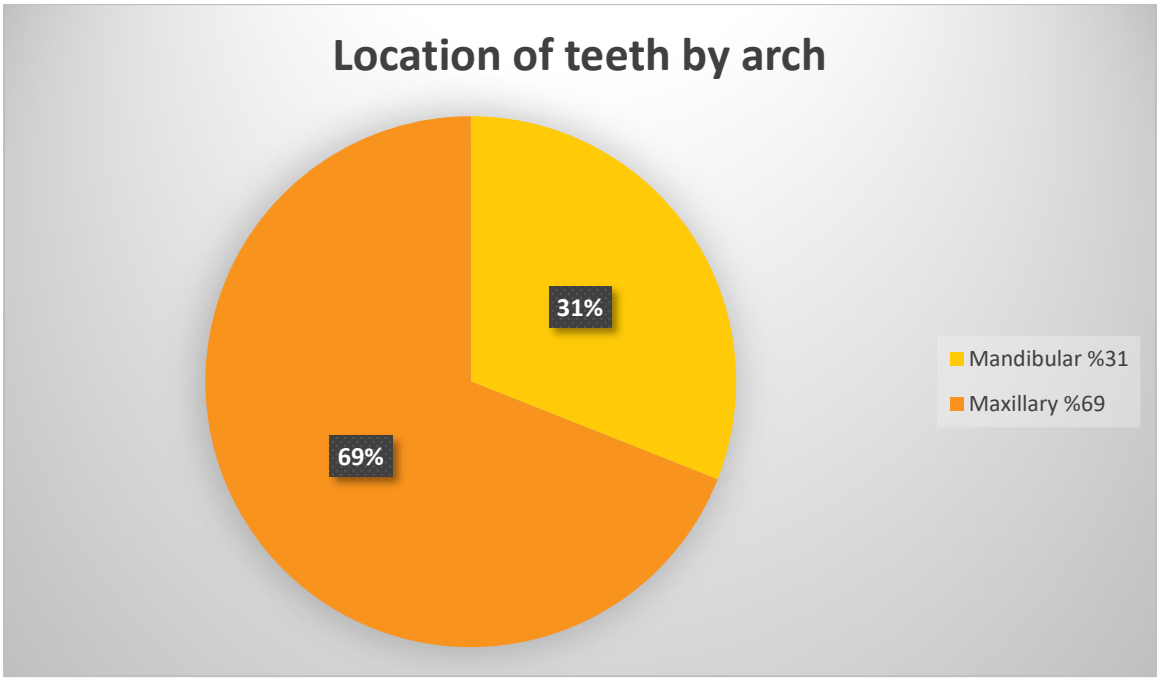


Location of teeth:

Most of the teeth evaluated in studies are maxillary teeth %69 whereas mandibular teeth are %31 of the study group. Study by Kim et al has the most number of maxillary and mandibular teeth that are 183 and 80 respectively. Study by Parmar et al. evaluated 29 maxillary teeth which is the lowest number of upper teeth. Study by Taschieri et al 2011 evaluated 17 mandibular teeth that is the lowest number of mandibular teeth among other studies. (Figure 7).

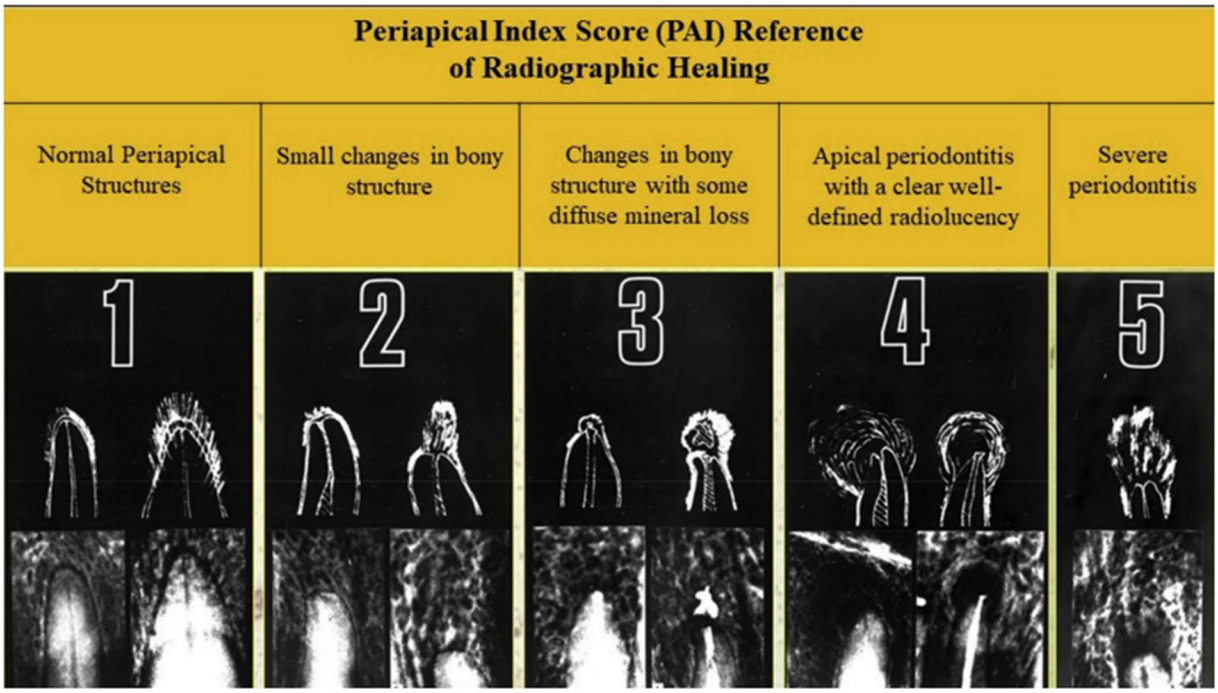
Figure 7

Location of teeth



Studies used different radiographic scale to evaluate their outcomes such as Periapical Index Score (PAI). The periapical index is a system that categorizes radiographic conditions on a scale of 1 to 5, with 1 indicating health and 5 indicating severe periodontitis with worsening symptoms. Its accuracy is established by comparing it to reference radiographs of teeth with confirmed histological diagnosis (46). Figure-8

Figure-8 (PAI)



GURE 1 – The PAI score reference by Orstavik et al [24] describing the radiographic healing status of the periapical tissues correlated to histology.

Rud & Molven classification is another radiographic scale that is being used in studies to access radiographic periapical healing (47).

Based on Rud classification, there are four different groups as follow:

(A) Complete healing

(B) Incomplete healing (scar tissue).

(C) Uncertain healing.

(D) Unsatisfactory healing (failures).

1) Complete healing after endodontic surgery

A) Re-formation of periodontal space of normal width and lamina dura to be followed around the apex (Figure-9)

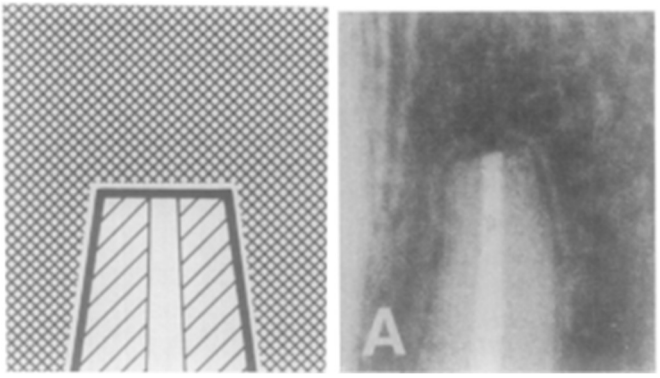


Figure-10

B) Slight increase in width of apical periodontal space, but less than twice the width of non-involved parts of the root (Figure-11)

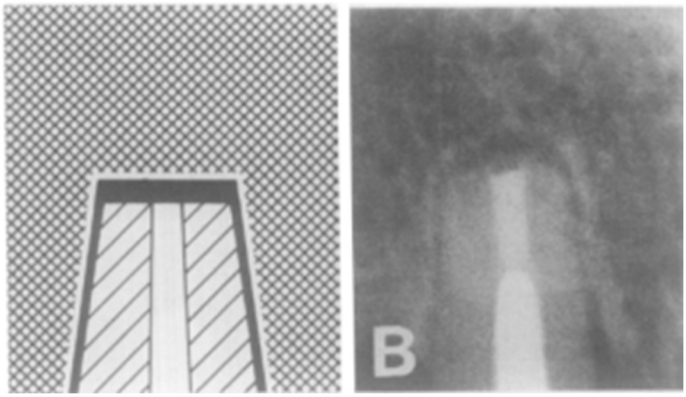


Figure-11

C) Tiny defect in the lamina dura (maximum 1 mm) adjacent to the root filling (Figure-12)

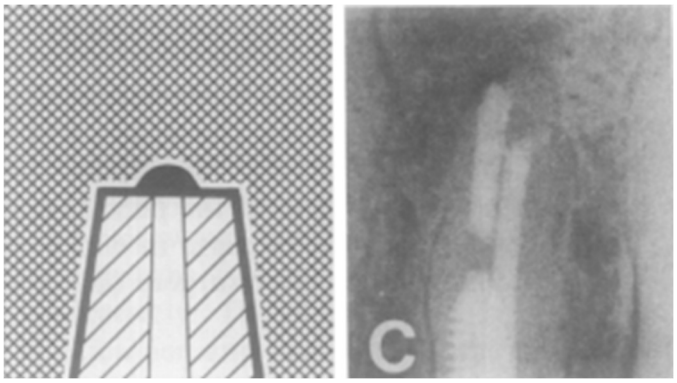


Figure-12

D) Complete bone repair, bone bordering the apical area does not have the same density as surrounding non-involved bone (Figure-13)

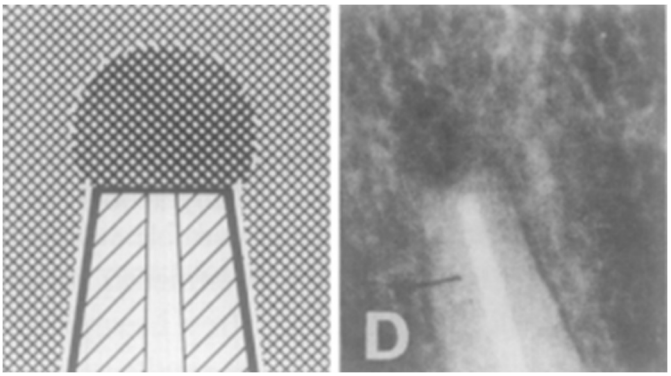
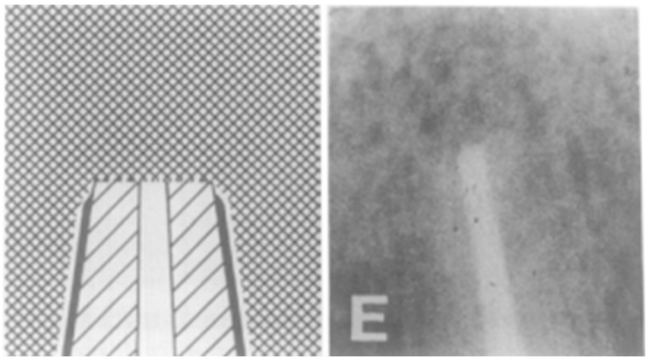


Figure-13

E) Complete bone repair; no apical periodontal space can be discerned (Figure-13)



2) Incomplete healing (scar tissue): The rarefaction has decreased in size or remained stationary and is characterized by one or more of the following findings.

A) Bone structures are recognized within the rarefaction; the periphery of the rarefaction is irregular and may be demarcated by a compact bone border; the rarefaction is located asymmetrically around the apex; the connection of the rarefaction with the periodontal space is angular (Figure-14)

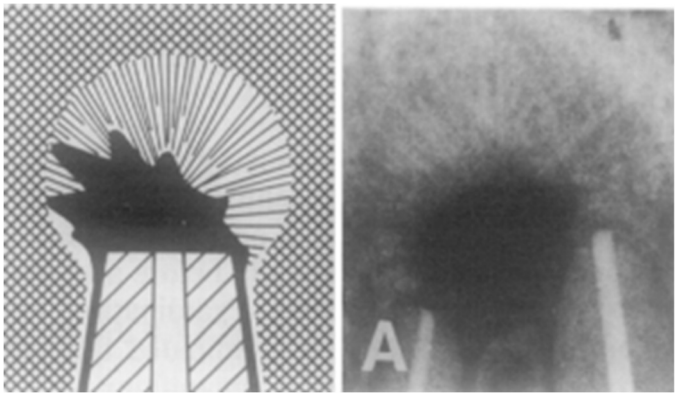


Figure-14

B) Isolated scar tissue in the bone 1 year follow up (Figure-15)

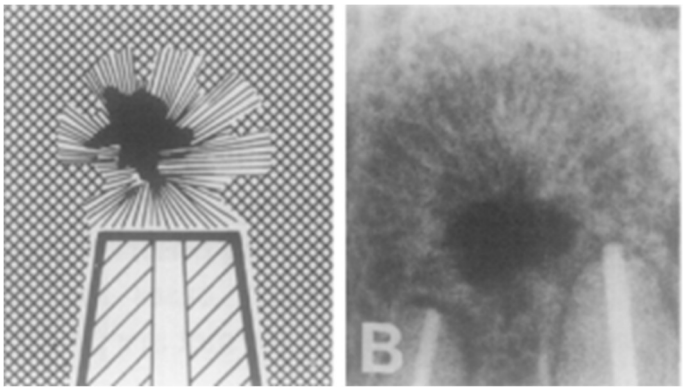


Figure-15

3) Uncertain healing after endodontic surgery. The rarefaction has decreased in size, and with one or more of the following characteristics; the radiolucency is larger than twice

the width of the periodontal space; is bordered by lamina-dura like bone structures; has a circular or semicircular periphery; is located symmetrically around the apex as a funnel-shaped extension of the periodontal space; bony structures are discernible within the bony cavity. A collar-shaped increase in width of lamina dura coronal to the radiolucency may also be found.

A) Immediately after surgery and B) One year follow up (Figure-16)

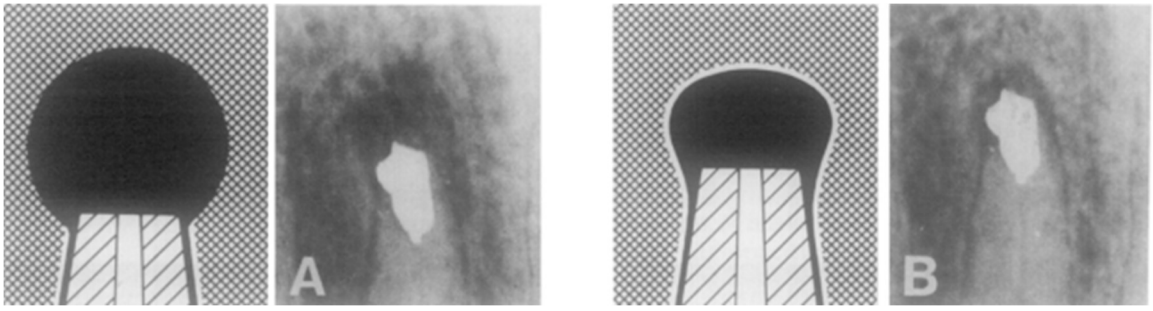


Figure-16

4) Unsatisfactory healing after endodontic surgery. The rarefaction has enlarged or is unchanged. A) after surgery B) one year follow up (Figure-17).

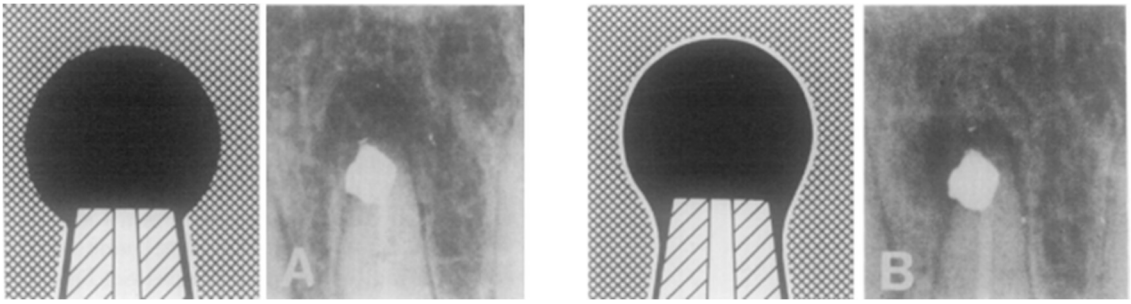


Figure-17

According to Taschieri et al, the combination of endodontic surgery and guided tissue regeneration is effective in treating periapical lesions that extend through and through, showing a favorable result for up to four years.

Pecora et al, used calcium sulphate in conjunction with their treatment protocol.
The study findings indicate that incorporating calcium sulfate as a bone graft in the traditional surgical approach for through-and-through lesions enhances the clinical results. It is advisable to perform histological analysis to assess the quality of tissues formed through both surgical procedures.

Taschieri et al, in another study(2008) proposed that employing a combination of a resorbable collagen membrane and anorganic bovine bone in the treatment of periapical through-and-through lesions could potentially contribute to positive healing outcomes one year after the operation.

Tobon et al(2002) concluded that the traditional method exhibited a less reliable healing response over the 12-month duration. Utilizing bone regeneration substances, like membrane and resorbable hydroxyapatite, enhanced the predictability of clinical, radiographic, and histological healing.

In contrast, Garrete et al, indicated that placing a guided tissue membrane over the bony opening formed in an endodontic periapical surgical procedure does not have a positive impact on the healing rate. In such cases, incurring the additional cost to the patient may not be justified.

Pecora et al. study performed examination of radiographs at 3, 6, 9, and 12 months demonstrated that lesions treated with membranes exhibited a faster healing process compared to control lesions. Additionally, the regenerated bone showed superior quality and quantity when membranes were employed. The study results suggest that the principles of guided tissue regeneration (GTR) can be successfully applied to promote healing in large periapical lesions, particularly through-and-through lesions.

Pantchev et al, researched the use of bio active PerioGlass in conjunction with periapical surgeries. This study d determined that the use of PerioGlas® as a bone substitute did not result in a significant improvement in the outcome of endodontic healing.

Dietrich et al reported that utilizing guided tissue regeneration (GTR) for apicomarginal defects with inorganic bovine bone mineral and a bioresorbable collagen membrane produces positive outcomes in periodontal healing after 12 months. This regenerative strategy should be viewed as a supplementary option for periradicular surgery when conventional endodontic therapy proves unsuccessful or impractical.

Goyal et al studied the use of PRP in conjunction with periapical surgeries. using PRP for apicomarginal defects, while showing a slight improvement compared to GTR, has emerged as an alternative treatment option to the conventional use of GTR membrane. It represents an additional approach for clinical treatment.

RESULT

Periapical surgery allows effective cleaning of periapical lesions and root surfaces, along with reshaping of the surrounding bone and root apex. To improve access to the dental apex, the bone near the lesions is sometimes removed. Healing usually occurs through local bone repair, a process some authors describe as the formation of new tissue that does not completely restore the original bone's architecture or function.

The nature of the healing process is highly influenced by the initial cell type that repopulates the wound. Epithelial cells, which migrate the fastest, usually dominate the early stages of healing. Therefore, excluding epithelial cells from the wound permits the establishment of other cell types with slower regenerative capabilities.

4-wall lesions:

This study demonstrates that the success rate for healing of 4-wall lesions using guided regeneration material bioactive resorbable hydroxyapatite (Osteogen, Impladent Ltd, Holliswood, NY, USA) ranges from 87.5% (Taschieri et al.)

to 97% (Tobon et al.) when evaluated clinical and radiographically.

Through-and-through lesions:

When using graft of bovine bone Biooss,(Geistlich Biomaterials, Wolhusen, Switzerland) in conjunction with resorbable collagen membrane Biogide, (Geistlich Biomaterials, Wolhusen, Switzerland) The success rate for healing through-and-through lesions in groups treated with GTR ranges from 75% to 88% according to Taschieri et al. The control groups exhibit a lower

success rate, ranging from 33.3% to 64%, as determined by clinical and radiographic evaluations.

Apicomarginal lesions:

According to Kim et al, the success rate for treating apicomarginal or endoperiodontal lesions is 75% when calcium sulphate was used in conjunction with Colla-tape.

The variability in the results of studies evaluating the benefits of guided tissue regeneration in surgical endodontics may stem from the lack of standardized assessment criteria. To address this heterogeneity, future studies should implement strict inclusion and exclusion criteria.

CONCLUSIONS

Failures in nonsurgical and surgical endodontic treatments can occur for various reasons. A significant factor contributing to these failures is endodontic-periodontic bone loss around the roots. The use of guided-tissue regeneration (GTR) procedures in periodontal therapy has enabled the effective treatment of certain types of periodontal bone loss. By adapting these GTR procedures for endodontic surgery, it is possible to achieve successful outcomes in cases that were previously considered to have a poor prognosis.

Incorporating bone grafts along with membranes as a supplement to surgical endodontic treatment has resulted in periapical bone healing, increased success rates, and a better prognosis for endodontic surgery in certain cases, however; there is no universal agreement whether guided tissue regeneration is significantly improves the outcome of endodontic periapical surgeries. Most authors suggest that in bigger size lesions and through-and-through defects, use of guided tissue regeneration is recommended.

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