

The following is the first study guide that encompasses only the highest level of evidence existing in the field of endodontics.

A comprehensive review was made via PubMed, BIOSIS, Cochrane, EMBASE, Web of Science and ADA Center for Evidence Based Dentistry (<http://ebd.ada.org/en/evidence/systematic-reviews/>) databases using the following keywords: endodontics, review, systematic review and meta-analysis. This search resulted in 4743 review articles. Included in this study guide are those systematic reviews, meta-analysis and narrative reviews which were published in journals with high impact factor, such as *Journal of Endodontics*, *International Journal of Endodontics*, *Australian Endodontic Journal*, *Oral Surgery*, *Oral Medicine*, *Oral Pathology*, *Oral Radiology*; *Journal of Maxillofacial Surgery*; *Journal of American Dental Association* and *Journal of Clinical Periodontology*. Abstracts were included to help candidates better understand the level of evidence of each article.

Our hope is that residents and board candidates would find this guide helpful as they prepare for board certification process.

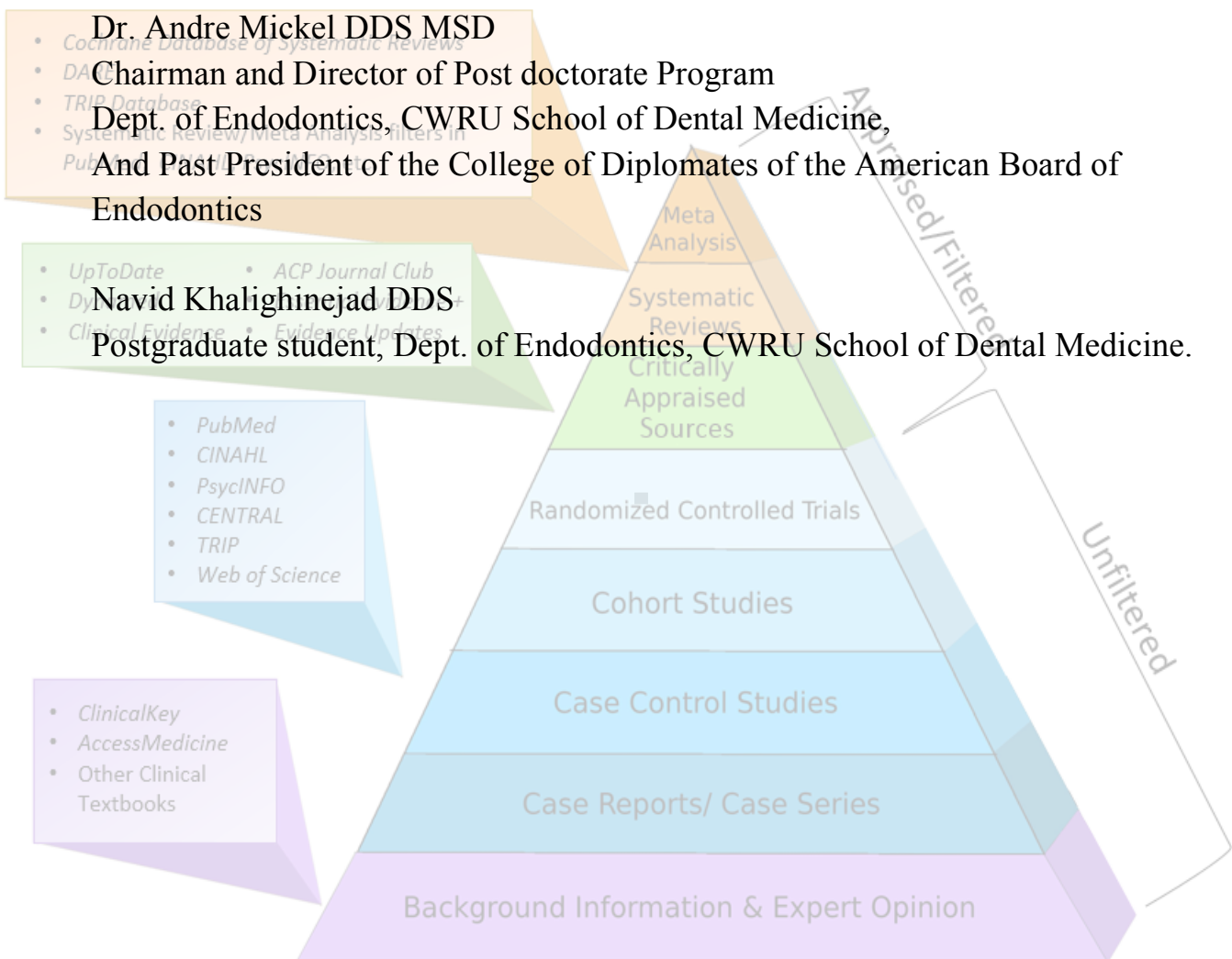


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Basics

Overlapping Protective and Destructive Regulatory Pathways in Apical Periodontitis **Ildikó J. Márton JOE, 2014**

The interaction of LPS and TLRs expressed on PDL fibroblasts (PDLFs) initiates the production of proinflammatory cytokines and chemokines IL-8/CXCL8, MCP-1/CCL2, RANTES/CCL5, pro-IL-1 β , IL-6, stromal-derived factor 1, and TNF- α as well as the immunoregulatory compounds TGF- β , IL-1Ra, and TNF- α R. Proinflammatory mediators induce vasodilation and attract PMNs and MNP to the periapical area. Invading bacteria, their byproducts, and the first wave of inflammatory mediators activate phagocytes. These cells produce a broad set of soluble mediators, which destroy pathogenic microbes, injure tooth-supporting tissues, and attract further cells of the innate and adaptive immune system. In contrast, immunoregulatory compounds attenuate the intensity of inflammatory reactions and host tissue destruction”.

Can Apical Periodontitis Modify Systemic Levels of Inflammatory Markers? A Systematic Review and Meta-analysis: Gomes JOE 2013

This systematic review and meta-analysis investigated evidence to support whether apical periodontitis (AP) can modify the systemic levels of inflammatory markers (IM) in humans. Among the 531 initially identified articles, 20 comprised the final analysis. Thirty-one different IMs were analyzed, with immunoglobulin (Ig) A, IgM, IgG, and C-reactive protein (CRP) being the most commonly investigated. CRP, interleukin (IL)-1, IL-2, IL-6, asymmetrical dimethylarginine, IgA, IgG, and IgM were shown to be increased in patients with AP compared with controls in most studies. Meta-analyses showed that serum levels of IgA ($P = .001$), IgG ($P = .04$), and IgM ($P < .00001$) were increased in humans with AP compared with healthy controls and serum levels of CRP, IgA, IgE, IgG, and IgM were not significantly different between patients with AP before and after treatment ($P > .05$). Available evidence is limited but consistent, suggesting that AP is associated with increased levels of CRP, IL-1, IL-2, IL-6, asymmetrical dimethylarginine, IgA, IgG, and IgM in humans. These findings suggest that AP may contribute to a systemic immune response not confined to the localized lesion, potentially leading to increased systemic inflammation

Pulpal Reactions to Orthodontic Force Application in Humans: A Systematic Review **Martina von Böhl JOE 2012**

Introduction Force application to a tooth during orthodontic treatment evokes a biological response of the dental pulp. The aim of this systematic literature review was to investigate the relationship between orthodontic force level and pulp reaction in humans. **Methods** Electronic search was made of publications in PubMed/old MEDLINE, Web of Science, EMBASE, CINAHL, Scopus, and the Cochrane Library (DARE, CENTRAL) until July 21, 2012. Hand search was made of publications before 1954 and the most recent ones in main dental and orthodontic journals. Additional studies were identified by hand search of reference lists of relevant articles from both the electronic and hand searches. Search terms included biomechanics, force, orthodontic*, tooth movement, dental pulp, and pulpal reaction. Two independent observers assessed eligibility for inclusion, extracted the data, applied quality

indicators, and graded level of evidence. **Results** Twenty-four studies matched the inclusion criteria. The outcomes concerned histologic and cell biological parameters after orthodontic tooth movement in 19 studies and pulpal blood flow in 5 studies. The methodologic quality of most studies was graded moderate to low. **Conclusions** Because of a lack of high-quality studies there is no conclusive scientific evidence for a relation between force level and dental pulp tissue reaction in humans. There is contradictory scientific support for a force-dependent reduction of blood flow.

The role of IL-6 on apical periodontitis: a systematic review

Azuma IEJ 2014

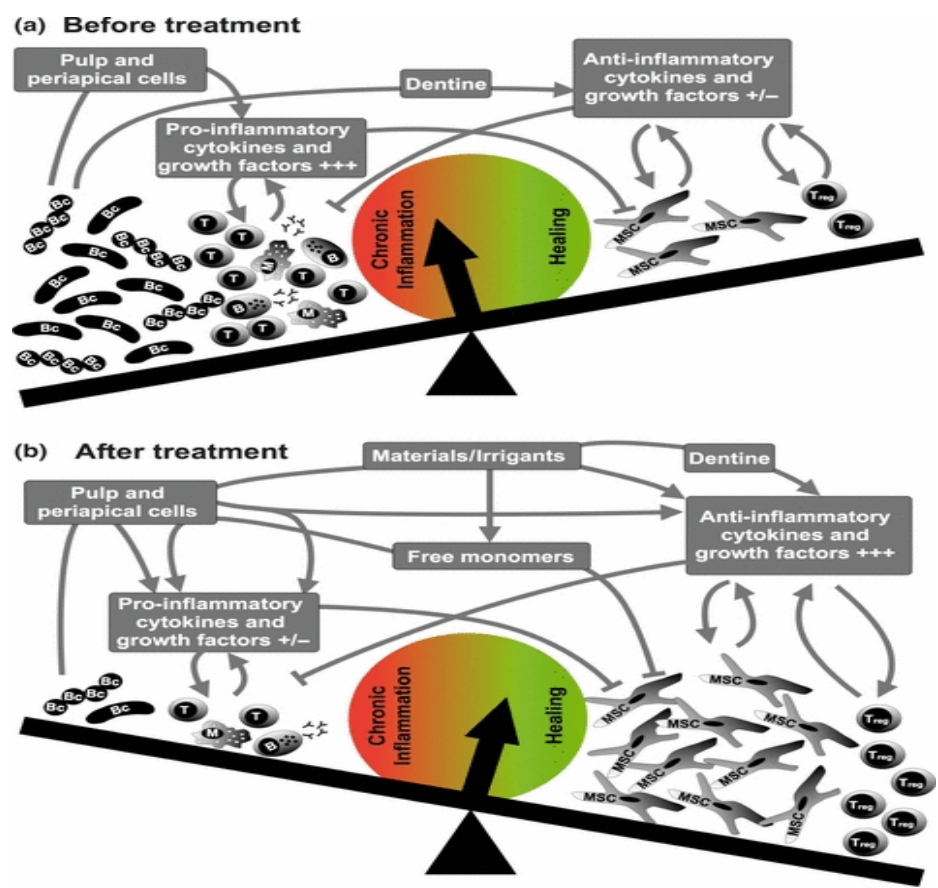
The aim of this review was to examine current knowledge of the role of interleukin-6 (IL-6) in apical periodontitis (AP) pathogenesis as an inflammatory or pro-inflammatory cytokine. It also looked at whether IL-6 could serve as a measure for differential diagnosis or as a biomarker that can further predict the progression of bone resorption. A systematic review relating to AP and IL-6 was made via PubMed, BIOSIS, Cochrane, EMBASE and Web of Science databases using keywords and controlled vocabulary. Two independent reviewers first screened titles and abstracts and then the full texts. The reference lists of the identified publications were examined for additional titles. Eighteen papers were studied in total. In vitro studies (n = 6) revealed that IL-6 is present in AP, and its levels are proportional to the size of the periapical lesions. Neutrophils and macrophages resident in these lesions can produce IL-6 in vitro after a bacterial stimulus. Animal studies (n = 5) showed that IL-6 is present in AP and that osteoblasts can produce IL-6 in vivo. On the other hand, two studies using IL-6 knockout mice revealed larger periapical lesions when compared with control groups, demonstrating IL-6's role as an anti-inflammatory cytokine. In human studies (n = 7), IL-6 was identified in AP, and its levels were higher in symptomatic, epithelialized and large lesions than in asymptomatic and small lesions. These data lead to the conclusion that IL-6 may play a **pro-inflammatory role, increasing its levels and reabsorbing bone in the presence of infections. When IL-6 is not present**, other cytokines such as IL-1 and TNF- α induce bone resorption. Further studies about the relationship between AP development and the cytokine network must be performed to establish the exact role of each cytokine in the inflammatory process.

The receptor activator of NF- κ B ligand-osteoprotegerin system in pulpal and periapical disease. G. N. Belibasakis IEJ 2013

Few human studies have attempted to investigate the role of the RANKL-OPG system in endodontic disease initiation or progression. In one investigation, periapical lesions were graded according to their inflammatory status (Fan *et al.* 2011). The authors found significantly more RANKL-positive cells in severely inflamed lesions compared to lightly inflamed counterparts. However, the RANKL/OPG ratio was statistically similar between inflammations graded as light, moderate, or intense. The RANKL/OPG ratio at the gene expression levels was also compared between granulomas and periodontal ligament of orthodontically moved teeth (Menezes *et al.* 2008). Whilst the compression sites of orthodontically moved teeth almost consistently showed RANKL mRNA levels to be higher than OPG counterparts, and tension sites the reversed ratio, i.e. OPG > RANKL, this ratio was inconsistent with granulomas. The upstream transcription of pro-inflammatory cytokine genes regulating bone resorption is modulated by a group of molecules termed suppressors of cytokine signalling (SOCS)

(Starr *et al.* 1997). In granulomas, it was shown that RANKL gene expression is negatively correlated to SOCS1 mRNA levels (Menezes *et al.* 2008). Only one human study attempted to correlate the presence of infective agents, namely cytomegalovirus and Epstein-Barr virus, to RANKL gene expression in granulomas (Yildirim *et al.* 2006). Whilst there was a higher occurrence of these viruses in the periapical lesions compared to healthy pulp tissues, no correlation was found between their presence and RANKL.

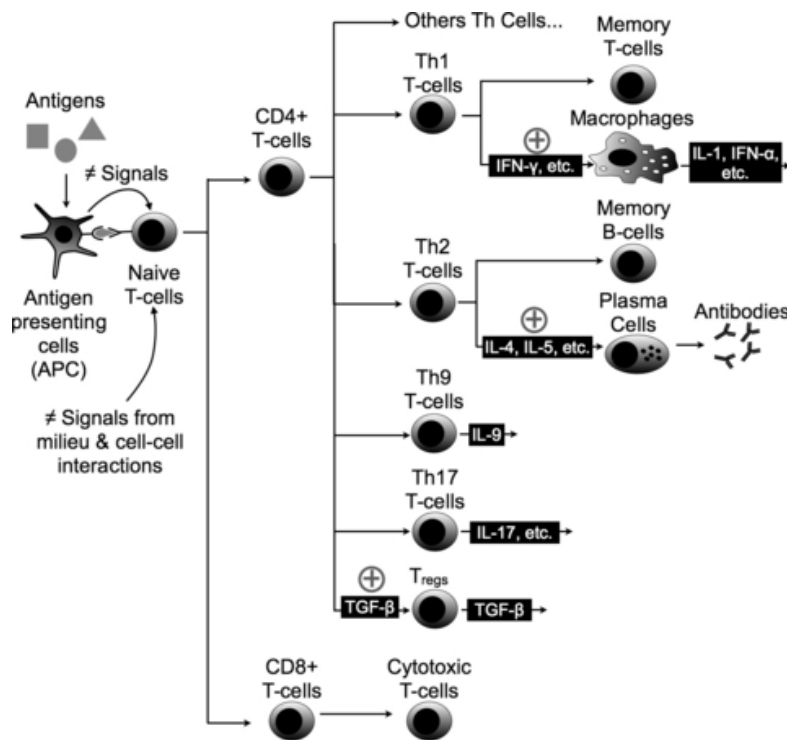
Interactions between immune system and mesenchymal stem cells in dental pulp and periapical tissues J. G. Leprince, B. D. Zeitlin, M. Tolar and O. A. Peters *IEJ* 2012



Schematic representation of a dynamic equilibrium (‘balance’) between the elements favouring the persistence of chronic inflammation on the left side, and the elements favouring progression towards healing on the right side. T, T lymphocyte; B, B lymphocyte; Treg, regulatory T cells; MSC, mesenchymal stem cell; Bc, bacteria; M, macrophage; →, stimulatory effect; ⇐, inhibitory effect. (a) Situation of an unfavourable balance before treatment: a massive bacterial load induces the release of pro-inflammatory cytokines, which maintains a chronic inflammation represented by an extensive presence of immune cells, mainly T lymphocytes. Anti-inflammatory cytokines and pro-healing growth factors are moderately produced by Tregs and MSCs and released by the dissolution of dentin during caries attack. They stimulate Tregs and MSCs and moderate the inflammatory response. (b) Situation of a favourable balance after treatment (caries removal or root canal treatment and obturation): most of the bacteria are eliminated, leading to a decrease in pro-inflammatory cytokine production and thus a reduction in the immune cell infiltrate. Anti-inflammatory cytokines and pro-healing growth

factors are produced in larger amounts (i) by MSCs and Tregs, (ii) by the dissolution of dentine or (iii) in the future, by a direct release from the applied material/irrigant. Under the action of the released mediators, more MSCs are recruited, proliferated and differentiated, which increases the anti-inflammatory effects and repairs outcome. Materials/irrigants can affect pulp and periapical cells directly inducing release of mediators that can affect either side of the balance. Finally, some substances released from the materials can also have a negative impact; specifically, free monomers released from resin-based composites can disturb MSC function, as well as stimulate the production of pro-inflammatory cytokines.

Schematic representation of adaptive immune system, including the main cell subsets and some of the cytokines involved in the immune processes of pulp and periapical disease.

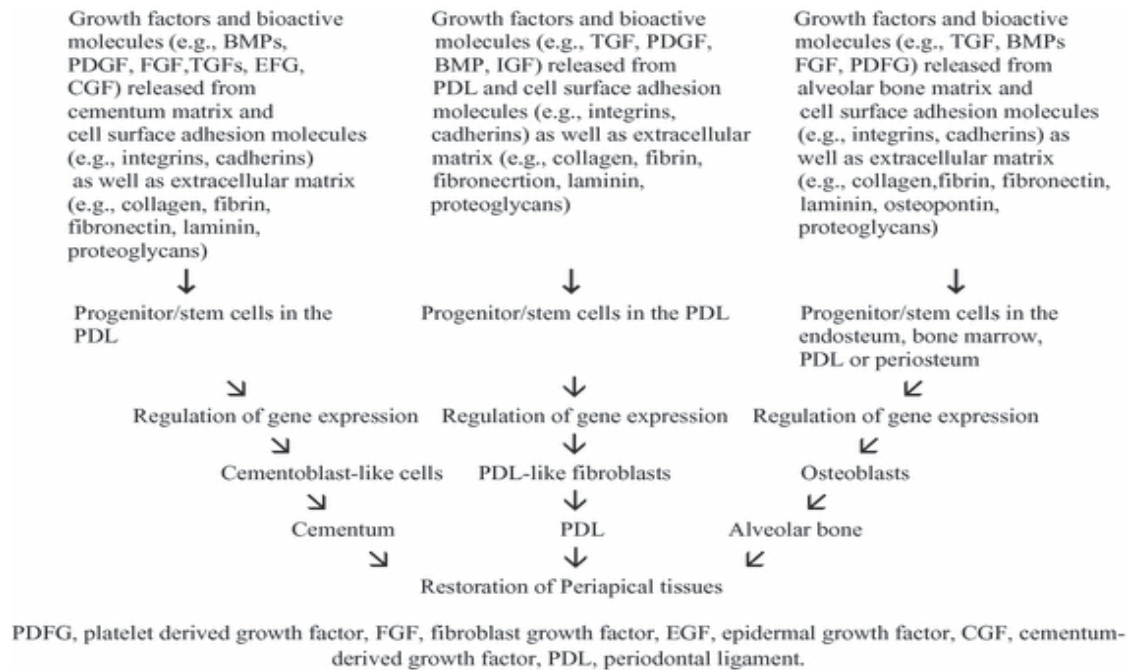


Repair and regeneration in endodontics

L. M. Lin and P. A. Rosenberg IEJ 2011

After root canal treatment, a highly orchestrated biological process enables wounded periapical tissues to be restored almost back to their original architecture radiographically. Although cell–cell and cell–matrix cross-talk and signalling between complex bioactive molecules play an important role in tissue wound healing (Clark 1996, Werner & Gross 2003, Werner *et al.* 2007), the master biological mechanism that regulates the temporal and spatial relationship between cementum, PDL and alveolar bone during periapical wound healing is not clear. Why are PDL, cementum and alveolar bone restored in such an orderly fashion without irregularity during periapical wound healing? Do newly differentiated cementoblast, PDL-like cells and osteoblasts have a position- or pattern-specific memory in the periapical area?

The wound healing process following periapical surgery is similar to that following nonsurgical root canal treatment (Lin *et al.* 2009). Both surgical and nonsurgical endodontic therapies are primarily regenerative processes with some fibrosis of the periapical tissues (Ricucci *et al.* 2009), even though radiographs may show complete restoration of the periapical structures. Periapical wound healing will never achieve complete regeneration because it is a post-natal wound, which always results in some scar formation (Bullard *et al.* 2003).

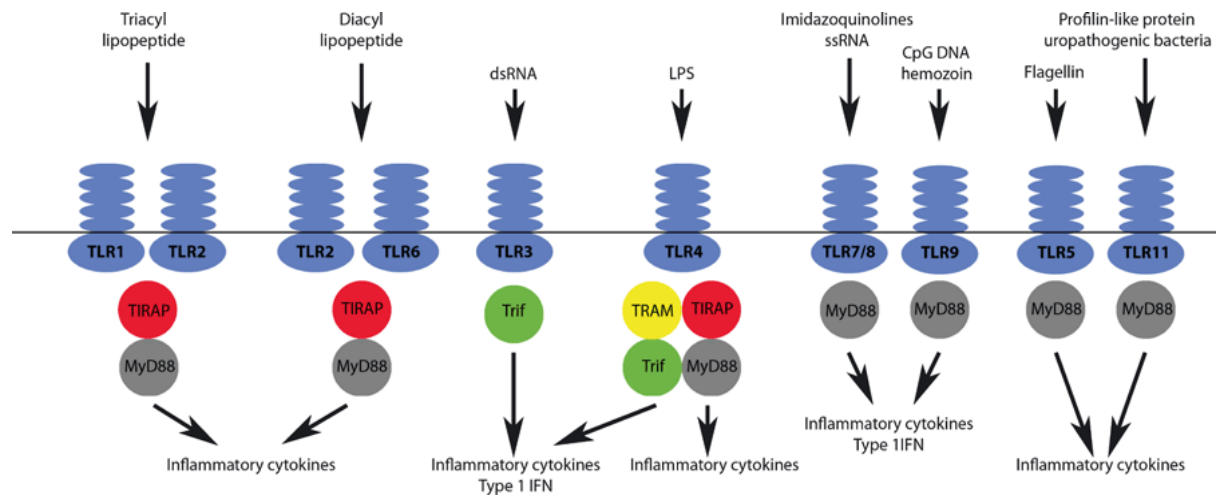


Antigen recognition and presentation in periapical tissues: a role for TLR expressing cells?

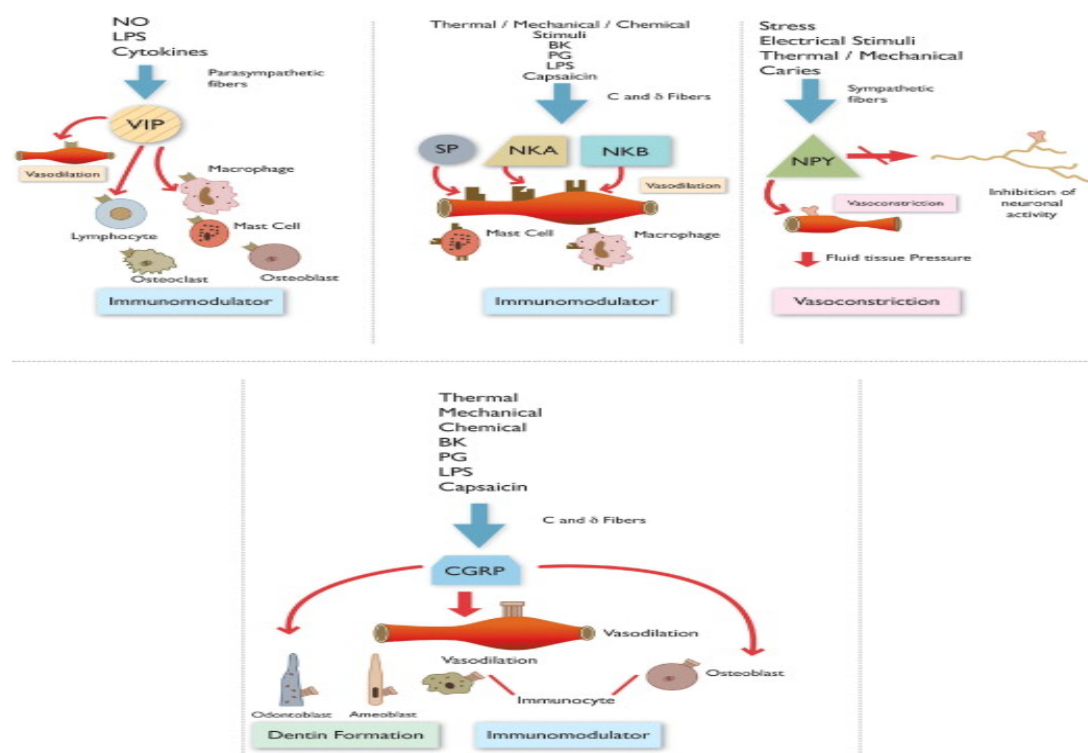
S. V. Desai IEJ 2011

TLR4 is known to be an important recognition receptor for LPS. In addition, it also modulates and co-ordinates PMN function, aids in dendritic cell maturation and various endothelial cell functions. The TLR4 ligand LPS is a Gram-negative bacterial cell wall component and is observed frequently in the infected root canal system. A study using TLR4-gene mutated mice showed reduced bone destruction in periapical tissues 3 weeks following inoculation of root canals with anaerobic bacteria compared with normal control mice. This indicates a role of TLR4 in the production of inflammatory bone-resorptive cytokines at the site of inflammation. Interestingly, TNF α production remained unaffected in these mice. However, these TLR4 deficient mice did not develop any systemic symptoms from the periapical infection suggesting that TLR4 function is unrelated to infection dissemination (Hou *et al.* 2000). A similar but milder difference in periapical bone loss was noticed in an experiment with LPS-hyporesponsive mice at 4 and 8 weeks (Fouad & Acosta 2001). Expression of TLR4 by odontoblasts (Jiang *et al.* 2006) and fibroblasts (Staquet *et al.* 2008) has been shown in response to antigen challenge. In an experimentally inflamed pulp model TLR2 and TLR4 were expressed on pulp macrophage and dendritic-like cells in a time-dependent manner, with TLR4

expression being lower and slower (Mutoh *et al.* 2007). Similarly, when TLR2+ and TLR4+ murine macrophages were stimulated by root canal pathogens in an *in vitro* experiment, higher production of nitric oxide and reactive oxygen species was observed (Marcato *et al.* 2008). Further, murine cementoblasts have shown functional expression of TLR4 in response to LPS that was associated with alteration of gene expression related to cementum formation and upregulation of osteoclastogenesis-associated molecules, such as receptor activator of NFκB ligand (RANKL) (Nemoto *et al.* 2008). Expression of TLR4 by various cell types present in human inflammatory periapical lesions awaits further research.



Neuropeptides in Dental Pulp: The Silent Protagonists, Javier Caviedes-Bucheli JOE 2008



Different stimuli that trigger neuropeptide release and their role in neurogenic inflammation. VIP is released from parasympathetic fibers stimulated by nitric oxide (NO), lipopolysaccharides (LPS), and cytokines, generating vasodilation and exerting immunomodulatory effects on different immune cells by binding on VPAC receptors. Tachykinins (substance P, neurokinin A and B) are released from C and A δ sensory fibers stimulated by thermal, mechanical, or chemical irritants. Several inflammatory mediators, such as bradykinin (BK) and prostaglandins (PG), as well as LPS and capsaicin also result in release of tachykinins, generating vasodilation and activation of some immune cells by binding to NK receptors. NPY is released from sympathetic fibers stimulated by caries, stress, and/or electrical, thermal, and mechanical irritation, generating vasoconstriction and consequently reducing fluid tissue pressure. It also inhibits neuronal activity in normal conditions. CGRP is generally co-released with SP and NKA after stimulation of the same neurons. CGRP generates vasodilation and participates in repairing processes by inducing dentin formation and modulating the action of some immune cells.

Diagnosis

Diagnosis of the condition of the dental pulp: a systematic review

Mejare, I. A., Axelsson, S., Davidson, T., Frisk, F., Hakeberg, M., Kvist, T., Norlund, A., Petersson, A., Portenier, I., Sandberg, H., Tranaeus, S., Bergenholtz, G. International Endodontic Journal. 2012;45(7):597-613

The aim of this systematic review was to appraise the diagnostic accuracy of signs/symptoms and tests used to determine the condition of the pulp in teeth affected by deep caries, trauma or other types of injury. Radiographic methods were not included. The electronic literature search included the databases PubMed, EMBASE, The Cochrane Central Register of Controlled Trials and Cochrane Reviews from January 1950 to June 2011. The complete search strategy is given in an Appendix S1 (available online as Supporting Information). In addition, hand searches were made. Two reviewers independently assessed abstracts and full-text articles. An article was read in full text if at least one of the two reviewers considered an abstract to be potentially relevant. Altogether, 155 articles were read in full text. Of these, 18 studies fulfilled pre-specified inclusion criteria. The quality of included articles was assessed using the QUADAS tool. Based on studies of high or moderate quality, the quality of evidence of each diagnostic method/test was rated in four levels according to GRADE. No study reached high quality; two were of moderate quality. The overall evidence was insufficient to assess the value of toothache or abnormal reaction to heat/cold stimulation for determining the pulp condition. The same applies to methods for establishing pulp status, including electric or thermal pulp testing, or methods for measuring pulpal blood circulation. In general, there are major shortcomings in the design, conduct and reporting of studies in this domain of dental research.

Pulp sensibility and vitality tests for diagnosing pulpal health in permanent teeth: a critical review

Alghaithy RA IEJ 2016

The aim of this review was to critically appraise the literature related to pulp vitality and sensibility testing in order to determine the diagnostic accuracy of pulp tests with reference to a gold standard or control group. Implications of the results for research and clinical practice are also explored. The MEDLINE (Ovid), MEDLINE (PubMed), Embase and Cochrane databases were searched for English-language clinical trials in humans in which in vivo studies were designed to evaluate or compare the accuracy of selected pulp sensibility and pulp vitality tests in determining the state of pulpal health in permanent teeth. Studies were included only if the results were compared to a control group or to a valid gold or reference standard. Eight studies were identified. Shortcomings in research design were found to influence the findings. The limited number of studies investigating pulp vitality tests was insufficient to answer the research question. It was concluded from this critical appraisal of the literature that laser Doppler flowmetry appeared to be the most accurate method for diagnosing the state of pulpal health and came closest to serving as a gold standard. Pulp vitality tests proved superior to pulp sensibility tests for early and accurate assessments of the pulpal health of traumatized teeth. When accurately used and interpreted, pulp sensibility tests provide valuable diagnostic information, particularly when an electric pulp test is used in combination with either CO₂ snow or Endo-Ice.

Study design	Authors and year of publication	Sensitivity										
		Laser Doppler flowmetry	Pulse oximetry	Electric pulp tester	CO ₂ snow	Endo-ice	Ethyl chloride	Ice sticks	Coolan	Heated gutta-percha	Laser Doppler flowmetry	Pulse oximetry
Cohort	Petersson <i>et al.</i> (1999)	-	-	0.72	-	-	0.83	-	-	0.86	-	-
	Evans <i>et al.</i> (1999)	1	-	0.87	-	-	0.92	-	-	-	1	-
	Kamburoğlu & Paksoy (2005)	-	-	0.83	-	-	-	-	0.93	-	-	-
	Gopikrishna <i>et al.</i> (2007)	-	1	0.71	-	0.81	-	-	-	-	-	0.95
	Weisleder <i>et al.</i> (2009) ^a	-	-	0.75	0.89	0.92	-	-	-	-	-	-
Case-control	Fuss <i>et al.</i> (1986) (adult) ^b	-	-	1	0.98	0.98	0.53	0.31	-	-	-	-
	Fuss <i>et al.</i> (1986) (youth) ^b	-	-	0.79	0.98	1.0	0.43	0.47	-	-	-	-
	Peters <i>et al.</i> (1994) ^b	-	-	0.67	0.94	-	-	-	-	-	-	-
	Karayilmaz & Kirzioğlu (2011)	1	0.81	0.92	-	-	-	-	-	-	1	0.95

Nonendodontic lesions misdiagnosed as apical periodontitis lesions: series of case reports and review of literature.

Sirotheau Corrêa Pontes F, JOE 2014

INTRODUCTION: This study aimed to analyze cases referred from a reference service in oral pathology that were initially misdiagnosed as periapical lesions of endodontic origin and to perform a review of the literature regarding lesions located in the apical area of teeth with a nonendodontic source. **METHODS:** A survey was made of clinical cases derived from the service of oral pathology from 2002 to 2012. The pertinent literature was also reviewed using ScienceDirect and PubMed databases. The lesions were grouped into benign lesions mimicking endodonticperiapical lesions (BLMEPLs), malignant lesions mimicking endodontic periapical lesions (MLMEPLs), and Stafne bone cavities. The clinical presentations were divided into lesions with swelling without pain, lesions with swelling and pain, and lesions without swelling but presenting with pain. **RESULTS:** The results showed that 66% (37/56) of cases represented benign lesions, 29% (16/56) malignant lesions, and 5% (3/56) Stafne bone cavities. The most commonly reported BLMEPLs were ameloblastomas (21%) followed by nasopalatine duct cysts (13.5%). The most frequently cited MLMEPLs were metastatic injuries (31.5%) followed by carcinomas (25%). The main clinical presentation of BLMEPLs was pain, whereas that of MLMEPLs was swelling associated with pain; Stafne bone cavities displayed particular clinical findings. **CONCLUSIONS:** Clinical and radiologic aspects as well as the analysis of the patients' medical history, pulp vitality tests, and aspiration

are essential tools for developing a correct diagnosis of periapical lesions of endodontic origin. However, if the instruments mentioned earlier indicate a lesion of nonendodontic origin, a biopsy and subsequent histopathological analysis are mandatory.

Endodontic complications in teeth with vital pulps restored with composite resins: a systematic review

Dawson, V. S., Amjad, S., Fransson, H. . Int Endod J. 2014;15(3):181-95

Composite resin is used extensively for restoration of teeth with vital pulps. Although cell culture studies have disclosed harmful effects on pulpal cells, any untoward clinical effects, manifest as adverse pulpal responses, have yet to be determined. This study comprises a systematic review, designed to address the question of whether the risk of endodontic complications is greater with composite resin restorations than with other restorative materials, such as amalgam. The study methodology involved (i) formulation of the research question, (ii) construction and conduct of an extensive literature search with (iii) interpretation and assessment of the retrieved literature. A search of the medical database PubMed was complemented with a search of the Controlled Trials Register (CENTRAL). The initial search yielded 1043 publications, the abstracts of which were read independently by the authors. After additional searches, 10 studies were included in the review. In all the included studies, the level of evidence was assessed as low. No conclusions could therefore be drawn. The included studies reported few, if any, endodontic complications. Little or no differences emerged between teeth restored with composite resins and those restored with amalgam. To determine whether composite resin restorations of teeth with vital pulps are associated with an increased risk for development of endodontic complications such as apical periodontitis, further evidence is needed, from well-constructed studies with a large number of participants.

Frequency of nonodontogenic pain after endodontic therapy: a systematic review and meta-analysis

Nixdorf, D. R., Moana-Filho, E. J., Law, A. S., McGuire, L. A., Hodges, J. S., John, M. T. . Journal of Endodontics. 2010;36(9):1494-8

INTRODUCTION: Little is known about ill-defined pain that persists after endodontic procedures, including an estimate of the problem's magnitude. We conducted a systematic review of prospective studies that reported the frequency of nonodontogenic pain in patients who had undergone endodontic procedures. Copyright 2010 American Association of Endodontists. Published by Elsevier Inc. All rights reserved. **METHODS:** Nonodontogenic pain was defined as dentoalveolar pain present for 6 months or more after endodontic treatment without evidence of dental pathology. Endodontic procedures reviewed were nonsurgical root canal treatment, retreatment, and surgical root canal treatment. Studies were searched in four databases electronically, complemented by hand searching. A summary estimate of nonodontogenic tooth pain frequency was derived using random-effects meta-analysis. Copyright 2010 American Association of Endodontists. Published by Elsevier Inc. All rights reserved. **RESULTS:** Of 770 articles retrieved and reviewed, 10 met inclusion criteria, and nine had data on both odontogenic and nonodontogenic causes of pain. A total of 3,343 teeth were enrolled within the included studies and 1,125 had follow-up information regarding pain status. We identified 48 teeth with nonodontogenic pain and estimated a 3.4% (95% confidence

interval, 1.4%-5.5%) frequency of occurrence. In nine articles containing data regarding both odontogenic and nonodontogenic causes of tooth pain, 56% (44/78) of all cases were thought to have a nonodontogenic cause. Copyright 2010 American Association of Endodontists. Published by Elsevier Inc. All rights reserved. CONCLUSIONS: Nonodontogenic pain is not an uncommon outcome after root canal therapy and may represent half of all cases of persistent tooth pain. These findings have implications for the diagnosis and treatment of painful teeth that were previously root canal treated because therapy directed at the tooth in question would not be expected to resolve nonodontogenic pain.

Identify and define all diagnostic terms for pulpal health and disease states

Levin LG, Law AS, Holland GR, Abbott PV, Roda RS Journal of Endodontics. 2009;35(12):1645-57

INTRODUCTION: Consensus Conference Subcommittee 2 was charged with the identification and definition of all diagnostic terms for pulpal health and disease states by using a systematic review of the literature. METHODS: Eight databases were searched, and numerous widely recognized endodontic texts were consulted. For each reference the level of evidence was determined, and the findings were summarized by members of the subcommittee. Highest levels of evidence were always included when available. Areas of inquiry included quantification of pulpal pain, the designation of conditions that can be identified in the dental pulp, diagnostic terms that can best represent pulpal health and disease, and metrics used to arrive at such designations. RESULTS AND CONCLUSIONS: On the basis of the findings of this inquiry, specific diagnostic terms for pulpal health and disease are suggested.

Oxygen saturation in the dental pulp of permanent teeth: a critical review

Bruno, K. F., Barletta, F. B., Felipe, W. T., Silva, J. A., Goncalves de Alencar, A. H., Estrela, C. . J Endod. 2014;40(8):1054-7

INTRODUCTION: Pulse oximetry is a noninvasive method for assessing vascular health based on oxygen saturation level. The method has recently also been used to assess dental pulp vitality, but a median oxygen saturation level suggestive of normal pulp physiology has not been determined. The objective of this study was to make a critical analysis of the published research to establish the median oxygen saturation for the diagnosis of normal dental pulps in maxillary anterior permanent teeth using pulse oximetry. METHODS: Studies reporting on the use of pulse oximeters to determine oxygen saturation in dental pulps were retrieved using the MEDLINE, Scientific Electronic Library Online, and Cochrane Central Register of Controlled Trials databases plus a manual search of relevant references cited by selected articles. Different combinations of the terms "oximetry," "oximeter," "pulp," "dental," and "dentistry" were used in the search. Statistical analysis was performed for each group of teeth (central incisors, lateral incisors, and canines) using R statistical software (US EPA ORD NHEERL, Corvallis, OR) and a random effects model ($P < .0001$) with an $I(2)$ of 99%. RESULTS: Of the 295 articles found, only 6 met the inclusion criteria (472 teeth). Of these, the number of articles included in each analysis (according to tooth group) was as follows: all 6 studies (288 teeth) for central incisors at a median oxygen saturation of 87.73%, 3 studies (90 teeth) for lateral incisors at a median oxygen saturation of 87.24%, and 4 studies (94 teeth) for canines at a median oxygen

saturation of 87.26%. CONCLUSIONS: The median oxygen saturation in normal dental pulps of permanent central incisors, lateral incisors, and canines was higher than 87%.

Prevalence of periapical radiolucency and root canal treatment: a systematic review of cross-sectional studies

Pak, Jaclyn G., Fayazi, Sara, White, Shane N. Journal of Endodontics. 2012;38(9):1170-6

INTRODUCTION: Cross-sectional studies describe the health status of a population and measure the prevalence of disease or treatment. Neither the prevalence of periapical radiolucency, a surrogate for disease, nor the prevalence of root canal treatment have been subjected to a systematic review, which is the highest level of clinical evidence. The purpose of this study was to conduct a systematic review and meta-analysis of the prevalence of periapical radiolucency and nonsurgical root canal treatment. METHODS: Inclusion/exclusion criteria were used for defined searches in MEDLINE and EMBASE. Title lists were scanned and abstracts were read to determine utility. Articles meeting the inclusion/exclusion criteria were analyzed for heterogeneity. Weighted mean percentages were calculated for the prevalence of overall periapical radiolucency, root canal treatment, and apical radiolucency in both treated and untreated teeth. RESULTS: Defined searching produced 11,491 titles. Thirty-three articles were included. Most patient samples represented modern populations from countries with high or very high human development indices. Meta-analysis was performed on 300,861 teeth. Of these, 5% had periapical radiolucencies, and 10% were endodontically treated. Of the 28,881 endodontically treated teeth, 36% had periapical radiolucencies; however, cross-sectional studies cannot distinguish between healing and failing cases. Of the 271,980 untreated teeth, 2% had periapical radiolucencies. The technical quality of root canal treatment was decried by most authors of the included studies. CONCLUSIONS: The prevalence of periapical radiolucency was very high, broadly equivalent to 1 radiolucency per patient. The prevalence of teeth with root canal treatment was very high, broadly equivalent to 2 treatments per patient. Billions of teeth are retained through root canal treatment.

Prevalence of root canal treatment and periapical radiolucency in elders: a systematic review

Hamedy, R., Shakiba, B., Pak, J. G., Barbizam, J. V., Ogawa, R. S., White, S. N. Gerodontology. 2014;28(spe):1-8

INTRODUCTION: Neither the prevalence of periapical radiolucency (PARL), a surrogate for disease, nor the prevalence of non-surgical root canal treatment (NSRCT) in elders have been subjected to systematic review. The purpose of this study was to conduct systematic review and meta-analysis of the prevalence of PARL and NSRCT in elders. METHODS: Inclusion/exclusion criteria were used for defined searches in MEDLINE and Cochrane CENTRAL. Title lists were scanned and abstracts read to determine utility; articles meeting the criteria were analyzed. Weighted mean percentages were calculated for prevalence of PARL, NSRCT, and PARL in both teeth with and without NSRCT. RESULTS: Defined searching produced 3576 titles; 29 prevalence articles were included. Patient samples mostly represented modern populations from countries with very high human development indices. Meta-analyses were performed on up to 74 000 elders' teeth. For those aged 65+, the prevalence of all teeth with NSRCT was extremely high, 21%; the prevalence of all teeth with PARL was quite high, 7%; the prevalence of PARL in NSRCT teeth was high, 25%; and the prevalence of PARL in untreated teeth was surprisingly high, 4%. In elders, the prevalence of NSRCT and

PARL separately increased with age; whereas, PARL in NSRCT teeth decreased with age.
CONCLUSIONS: In comparison to general adult populations, elders had: a much higher prevalence of NSRCT, a higher prevalence of PARL, a lower prevalence of PARL in NSRCT teeth, and a higher prevalence of PARL in untreated teeth. Teeth saved through NSRCT were preferentially retained by elders.

Discolouration potential of endodontic procedures and materials: a review H. M. A. Ahmed and P. V. Abbott IEJ 2012

Table 1. Summary of various aetiological factors causing tooth discolouration and the colours produced (Sulleman 2005, 2008)

Type of discolouration	Colour produced
I) Extrinsic	
a) <i>Direct stains</i>	
Tea, coffee and other foods	Brown to black
Cigarettes/cigars	Yellow/brown to black
Plaque/poor oral hygiene	Yellow/brown
b) <i>Indirect stains</i>	
Polyvalent metal salts and cationic antiseptics (e.g. chlorhexidine)	Black and brown
II) Intrinsic	
a) <i>Metabolic causes</i>	
e.g. congenital erythropoietic porphyria	Purple/brown
b) <i>Inherited causes</i>	
e.g. amelo/dentinogenesis	Brown or black
c) <i>Iatrogenic causes</i>	
Tetracycline	Classically yellow, brown, blue, black or grey
Fluorosis	White, yellow, grey or black
d) <i>Traumatic causes</i>	
Enamel hypoplasia	Yellow brown or white
Pulp haemorrhage products	Grey Brown to black
Root resorption	Pink spot
e) <i>Idiopathic causes</i>	Molar incisor hypo-mineralization
f) <i>Ageing causes</i>	Yellow
III) Internalized	
Caries	White spot, Orange, brown to black
Restorations	Brown, grey, black

Irrigating solutions	Type of discolouration	Author/s – year
NaOCl (undiluted and 10%)	Some discolouring effect	Gutiérrez and Guzmán (1968)
1% NaOCl + 2% chlorhexidine (CHX) gel	Dark brown precipitate (Alternative irrigation)	Vivacqua-Gomes et al. (2002)
MTAD + NaOCl (5.25–0.65%)	Brown solution (NaOCl final rinse)	Torabinejad et al. (2003)
17% EDTA + 1% CHX sol.	Pink precipitate (CHX final rinse)	González-López et al. (2006)
2% CHX sol. + 17% EDTA	White precipitate	Rasimick et al. (2008)
1.54–6.15% NaOCl + MTAD	Yellow precipitate (MTAD final rinse)	Tay et al. (2006a) (Clinical application)
1.3% NaOCl + MTAD	Red-purple (MTAD final rinse)	Tay et al. (2006a) (<i>In vitro</i> study)
NaOCl + CHX sol.	Light orange to dark brown according to conc.	Basrani et al. (2007) , Marchesan et al. (2007) , Bui et al. (2008) , Akisue et al. (2010) , Krishnamurthy & Sudhakaran (2010) , Nassar et al. (2011)
2% CHX sol. + 15% Citric acid	A white solution but returns colourless and easily removed during irrigation with CHX	Akisue et al. (2010)
2% CHX gel + 5.25% NaOCl	Discoloured enamel and dentine	Souza et al. (2011)
2% CHX sol. + 5.25% NaOCl	Discoloured dentine only	Souza et al. (2011)
2% CHX gel + 5.25% NaOCl + 17% EDTA	Discoloured enamel and dentine	Souza et al. (2011)
2% CHX sol. + 5.25% NaOCl + 17% EDTA	Discoloured dentine	Souza et al. (2011)

Anatomy:

Aetiology, incidence and morphology of the C-shaped root canal system and its impact on clinical endodontics

Kato, A., Ziegler, A., Higuchi, N., Nakata, K., Nakamura, H., Ohno, N. Int Endod J. 2014;47(11):1012-33

The C-shaped root canal constitutes an unusual root morphology that can be found primarily in mandibular second permanent molars. Due to the complexity of their structure, C-shaped root canal systems may complicate endodontic interventions. A thorough understanding of root canal morphology is therefore imperative for proper diagnosis and successful treatment. This review aims to summarize current knowledge regarding C-shaped roots and root canals, from basic morphology to advanced endodontic procedures. To this end, a systematic search was conducted using the MEDLINE, BIOSIS, Cochrane Library, EMBASE, Google Scholar, Web of Science, PLoS and BioMed Central databases, and many rarely cited articles were included. Furthermore, four interactive 3D models of extracted teeth are introduced that will allow for a better understanding of the complex C-shaped root canal morphology. In addition, the present publication includes an embedded best-practice video showing an exemplary root canal procedure on a tooth with a pronounced C-shaped root canal. The survey of this unusual structure concludes with a number of suggestions concerning future research efforts.

Clinical efficacy of electronic apex locators: systematic review

Martins, J. N., Marques, D., Mata, A., Carames, J. J Endod. 2014;40(6):759-77

INTRODUCTION: Apical constriction has been proposed as the most appropriate apical limit for the endodontic working length. Despite being the most used, some limitations are attributed to the radiographic method of working length determination. It lacks precision because it is based on the average position of the apical constriction. The electronic apex locators have been presented as an alternative to the odontometry performed by radiography. These devices detect the transition of the pulp to the periodontal tissue, which is anatomically very close to the apical constriction and may perform with improved accuracy. **METHODS:** A systematic review was performed to compare the radiographic and electronic methods. Clinical studies that compared both methods were searched for on 7 electronic databases, a manual search was performed on the bibliography of articles collected on the electronic databases, and the authors were contacted to ask for references of more research not detected on the electronic and manual search. **RESULTS:** Twenty-one articles were selected. The majority were comparative or evaluation studies, and very few clinical studies comparing both methods are available. Several methodological limitations are present on the collected articles and debated in this review. **CONCLUSIONS:** Although the available scientific evidence base is short and at considerable risk of bias, it is still possible to conclude that the apical locator reduces the patient radiation exposure and also that the electronic method may perform better on the working length determination. At least one radiographic control should be performed to detect possible errors of the electronic devices.

The Precision of Electronic Apex Locators in Working Length Determination: A Systematic Review and Meta-analysis of the Literature; Igor Tesis JOE 2015

Introduction This study aimed to evaluate the precision of electronic apex locators (EALs) in locating the apical constriction (AC) during a root canal treatment compared with a histologic evaluation of the AC as well as the effects of possible influencing factors by means of a systematic review of the literature and meta-analysis. **Methods** A systematic search of the literature was performed to identify studies that histologically evaluated the precision of EALs in human teeth. The identified studies were subject to strict inclusion criteria followed by data extraction and meta-analysis. **Results** From 247 articles, 10 articles met the inclusion criteria, with a total of 1105 EAL measurements performed by 4 types of EALs: Root ZX (J Morita, Tokyo, Japan), Justy II (Hager & Werken GmbH & Co, Duisburg, Germany), Endy 5000 (Loser Co, Leverkusen, Germany), and Endox (Lysis Co, Milan, Italy). Root ZX, Justy II, and Endy 5000 were found to be significantly more accurate than Endox in determining the distance between the file tip and the apical constriction ($P < .05$). The longest mean distance was measured by Endox (1.35 ± 0.41 mm), and the shortest mean distance was measured by Justy II (0.25 ± 0.17 mm, $P < .05$). The mean distance measured by Root ZX and Justy II in the presence of hydrogen peroxide was shorter compared with the mean distance measured by them in the presence of sodium hypochlorite ($P < .05$). The pulp status (vital or necrotic) had no significant effect on the precision of the EALs. **Conclusions** The precision of electronic working length measurement depends on the device used and the type of irrigation and is not influenced by the status of the pulp tissue.

Prevalence of C-shaped root canals in Iranian population: a systematic review

Naseri, M., Haghghi, A. K., Kharazifard, M. J., Khavid, A. Journal of Dentistry / Tehran University of Medical Sciences. 2013;10(2):186-96

OBJECTIVE: Because of the great challenges in the diagnosis and treatment of "C" configuration and lack of any systematic information about its occurrence, the purpose of the present study is to determine the prevalence of C shaped root canals in Iranian population. **METHODOLOGY:** An exhaustive search was undertaken to identify published and unpublished researches related to the C-shaped canals by using key words. The search of the MEDLINE database included all publications from 1966 to May 2012. Then selected articles were obtained and reviewed. Data evaluated and summarized in the data sheet included methodology, population, number of teeth per study (power), number of root canals, type of root canal configuration, and c-shaped canals. **RESULTS:** Six studies were included with total of 1062 teeth, all in mandibular second molars. The total incidence of C-shaped canals in Iranian population was obtained 6.96%. **CONCLUSIONS:** The incidence of C-shaped canals in Iranian population is 6.96%, which seems much less than Asian populations but nearer to Middle East countries.

Root anatomy and canal configuration of the permanent mandibular first molar: a systematic review

de Pablo, O. V., Estevez, R., Peix Sanchez, M., Heilborn, C., Cohenca, N. . Journal of Endodontics. 2010;36(12):1919-31

INTRODUCTION: The main goal of endodontic therapy is to prevent or heal apical periodontitis. However, root canal anatomy might present a clinical challenge directly related to the treatment outcome. The purpose of this study was to review published literature related to root anatomy and root canal configuration of the permanent mandibular first molar. **METHODS:** An exhaustive search was undertaken to identify published literature related to the root anatomy and root canal morphology of the permanent mandibular first molar by using key words. The search of the MEDLINE database included all publications from 1966-May 2010. Selected articles were then obtained and reviewed. Data evaluated and summarized in the data sheet included methodology, population, number of teeth per study (power), number of root canals, type of root canal configuration, and identification of number of apical foramina. **RESULTS:** Forty-one studies were identified including a total of 18,781 teeth. The incidence of a third root was 13% and was strongly correlated with the ethnicity of the studied population. Three canals were present in 61.3%, 4 canals in 35.7%, and 5 canals in approximately 1%. Root canal configuration of the mesial root revealed 2 canals in 94.4% and 3 canals in 2.3%. The most common canal system configuration was Vertucci type IV (52.3%), followed by type II (35%). Root canal configuration of the distal root revealed type I configuration in 62.7%, followed by types II (14.5%) and IV (12.4%). The presence of isthmus communications averaged 54.8% on the mesial and 20.2% on the distal root. **CONCLUSIONS:** The number of roots on the mandibular first molar is directly related to ethnicity. Root canal morphology and configuration might present the clinician with a complex anatomy requiring more diagnostic approaches, access modifications, and clinical skills to successfully localize, negotiate, disinfect, and seal the root canal system.

Root and Root Canal Morphology of Maxillary First Premolars: A Literature Review and Clinical Considerations

Ibrahim Ali Ahmad JOE 2016

Introduction Sound knowledge of the external and internal morphology of the different teeth groups is essential to ensure a successful outcome of root canal treatment. The aims of this study were to review the available literature with respect to the root and root canal morphology of maxillary first premolars and discuss the clinical considerations of this morphology on the various dental procedures. **Methods** The MEDLINE/PubMed and Scopus databases were searched for relevant literature. The identified publications were classified into anatomic studies and clinical case reports. The data extracted from anatomic studies were tabulated, and weighted averages for certain internal and external morphologic features were calculated. The anatomic and developmental variations in the clinical case reports were summarized. **Results** A total of 92 studies (45 anatomic studies and 47 case reports) including a total of 11,299 teeth were identified. The majority of maxillary first premolars had 1 root (41.7%) or 2 roots (56.6%). Regardless of the number of roots, the vast majority (86.6%) had 2 root canals, with type IV (2-2) being the most common canal configuration (64.8%). The majority of the apical foramina (66.6%) did not coincide with the apical root tip. About 38% of the teeth had lateral canals, 12.3% had apical deltas, and 16.0% had isthmi. The clinical case reports showed that the 3-rooted variant was the most common anatomic variation, and developmental anomalies were rarely reported. **Conclusions** The maxillary first premolars are predominantly 2-rooted teeth with 2 root canals. However, the clinician should be aware about the possible anatomic variations of these teeth and their relationship with the adjacent anatomic structures while planning and performing endodontic, restorative, periodontal, and surgical procedures.

Mandibular first molars with disto-lingual roots: review and clinical management

F. Abella IEJ 2012

The purpose of this review was (i) to conduct a literature review on the prevalence and morphologic classification of mandibular first molars with disto-lingual (DL) roots, and (ii) to discuss the clinical approach to diagnosis and root canal treatment of these teeth. A search was carried out on electronic (MEDLINE, PubMed and Cochrane) and hand databases, which covered all publications from 1970 to December 2011. Two reviewers independently assessed the studies and recorded type of study, origin and sample sizes, number of teeth with three roots and type of root canal configuration. Forty-five studies were identified with a total of 19 056 mandibular first molar teeth. The frequency of DL roots was 14.4% and was associated with certain ethnic populations. The most common canal configuration of mesial and distal roots was Vertucci types IV and I, respectively. No significant differences were observed in the prevalence of DL roots according to gender. Variable results related to side were observed as well as a trend in bilateral occurrence. The root length of the DL roots was in general shorter than that of the disto-buccal roots (DB). Most DL roots had a greater angle of curvature and a smaller radius of curvature in a bucco-lingual orientation. The best methods to identify DL roots are a 25° mesial parallax periapical radiograph or cone-beam computed tomography (CBCT). A trapezoidal shape access cavity is desirable to locate the orifice of the DL canal. Clinicians should be aware of the variable furcation levels during coronal pre-flaring or post-space preparation to avoid furcal/strip perforations and a weakening of DL roots.

Radiography, CBCT

Cone beam computed tomography and periapical lesions: a systematic review analysing studies on diagnostic efficacy by a hierarchical model

Kruse, C., Spin-Neto, R., Wenzel, A., Kirkevang, L. L. . Int Endod J. 2014;85(9):1203-13

AIM: To evaluate using a systematic review approach the diagnostic efficacy of CBCT for periapical lesions, focusing on the evidence level of the included studies using a six-tiered hierarchical model. METHODOLOGY: The MEDLINE bibliographic database was searched from 2000 to July 2013 for studies evaluating the potential of CBCT imaging in the diagnosis and planning of treatment for periapical lesions. The search strategy was limited to English language publications using the following combined terms in the search strategy: apical pathology or endodontic pathology or periapical or lesion or healing and CBCT or cone beam CT. The diagnostic efficacy level of the studies was assessed independently by four reviewers. RESULTS: The search identified 25 publications that qualitatively or quantitatively assessed the use of CBCT for the diagnosis of periapical lesions, in which the methodology/results comprised at least one of the following parameters: the methods, the imaging protocols or qualitative/quantitative information on how CBCT influenced the diagnosis and/or treatment plan. CONCLUSION: From the assessed studies, it can be concluded that although there is a tendency for a higher accuracy for periapical lesion detection using CBCT compared to two-dimensional imaging methods, no studies have been conducted that justify the standard use of CBCT in diagnosing periapical lesions. In addition, it should be considered that, at the present time, the efficacy of CBCT as the diagnostic imaging method for periapical lesions has been assessed merely at low diagnostic efficacy levels.

Radiological diagnosis of periapical bone tissue lesions in endodontics: a systematic review

Pettersson, A., Axelsson, S., Davidson, T., Frisk, F., Hakeberg, M., Kvist, T., Norlund, A., Mejare, I., Portenier, I., Sandberg, H., Tranaeus, S., Bergenholtz, G. . International Endodontic Journal. 2012;45(9):783-801

This systematic review evaluates the diagnostic accuracy of radiographic methods employed to indicate presence/absence and changes over time of periapical bone lesions. Also investigated were the leads radiographic images may give about the nature of the process and the condition of the pulp in nonendodontically treated teeth. Electronic literature search included the databases PubMed, Embase and CENTRAL from January 1950 to June 2011. All languages were accepted provided there was an abstract in English. The MeSH terms were 'Cone beam computed tomography (CBCT)', 'Radiography, panoramic', 'Periapical diseases', 'Dental pulp diseases', 'Sensitivity and specificity', 'receiver operating characteristics (ROC) curve', 'Cadaver', 'Endodontics' and 'Radiography dental'. Two reviewers independently assessed abstracts and full text articles. An article was read in full text if at least one of the two reviewers considered an abstract to be potentially relevant. Altogether, 181 articles were read in full text. The GRADE approach was used to assess the quality of evidence of each radiographic method based on studies of high or moderate quality. Twenty-six studies fulfilled criteria set for inclusion. None was of high quality; 11 were of moderate quality. There is

insufficient evidence that the digital intraoral radiographic technique is diagnostically as accurate as the conventional film technique. The same applies to CBCT. No conclusions can be drawn regarding the accuracy of radiological examination in identifying various forms of periapical bone tissue changes or about the pulpal condition.

The Diagnostic Efficacy of Cone-beam Computed Tomography in Endodontics: A Systematic Review and Analysis by a Hierarchical Model of Efficacy

Rosen, E., Taschieri, S., Del Fabbro, M., Beitlitum, I., Tsesis, I. . J Endod. 2015;41(7):1008-14

INTRODUCTION: The aim of this study was to evaluate the diagnostic efficacy of cone-beam computed tomographic (CBCT) imaging in endodontics based on a systematic search and analysis of the literature using an efficacy model. METHODS: A systematic search of the literature was performed to identify studies evaluating the use of CBCT imaging in endodontics. The identified studies were subjected to strict inclusion criteria followed by an analysis using a hierarchical model of efficacy (model) designed for appraisal of the literature on the levels of efficacy of a diagnostic imaging modality. RESULTS: Initially, 485 possible relevant articles were identified. After title and abstract screening and a full-text evaluation, 58 articles (12%) that met the inclusion criteria were analyzed and allocated to levels of efficacy. Most eligible articles (n = 52, 90%) evaluated technical characteristics or the accuracy of CBCT imaging, which was defined in this model as low levels of efficacy. Only 6 articles (10%) proclaimed to evaluate the efficacy of CBCT imaging to support the practitioner's decision making; treatment planning; and, ultimately, the treatment outcome, which was defined as higher levels of efficacy. CONCLUSIONS: The expected ultimate benefit of CBCT imaging to the endodontic patient as evaluated by its level of diagnostic efficacy is unclear and is mainly limited to its technical and diagnostic accuracy efficacies. Even for these low levels of efficacy, current knowledge is limited. Therefore, a cautious and rational approach is advised when considering CBCT imaging for endodontic purposes.

The Importance of Cone-beam Computed Tomography in the Management of Endodontic Problems: A Review of the Literature

Venskutonis, T., Plotino, G., Juodzbaly, G., Mickeviciene, L. J Endod. 2014;8(8):ZE05-8

INTRODUCTION: To obtain essential information in clinical endodontics, cone-beam computed tomographic (CBCT) imaging can be used in all phases of treatment including diagnosis, treatment planning, during the treatment phase, and through post-treatment assessment and follow-up. The purpose of this article was to review the use of CBCT imaging in the diagnosis, treatment planning, and assessing the outcome of endodontic complications. METHODS: Literature was selected through a search of PubMed electronic databases for the following keywords: tooth root injuries, tooth root radiography, tooth root perforation, tomography, cone-beam computed tomography, endodontic complications, tooth root internal/external resorption, root fractures, and broken instruments. The research was restricted to articles published in English. One hundred twelve articles met the inclusion criteria and were included in this review. RESULTS: Currently, intraoral radiography is the imaging technique of choice for the management of endodontic disease, but CBCT imaging appears to have a superior validity and reliability in the management of endodontic diagnosis and complications. CONCLUSIONS: Endodontic cases should be judged individually, and CBCT imaging should be considered in situations in which information from conventional imaging systems may not

yield an adequate amount of information to allow the appropriate management of endodontic problems. CBCT imaging has the potential to become the first choice for endodontic treatment planning and outcome assessment, especially when new scanners with lower radiation doses will be available.

Diagnostic Accuracy of Cone-beam Computed Tomography and Conventional Radiography on Apical Periodontitis: A Systematic Review and Meta-analysis

Kamile Leonardi Dutra JOE 2016

Introduction Endodontic diagnosis depends on accurate radiographic examination. Assessment of the location and extent of apical periodontitis (AP) can influence treatment planning and subsequent treatment outcomes. Therefore, this systematic review and meta-analysis assessed the diagnostic accuracy of conventional radiography and cone-beam computed tomographic (CBCT) imaging on the discrimination of AP from no lesion. **Methods** Eight electronic databases with no language or time limitations were searched. Articles in which the primary objective was to evaluate the accuracy (sensitivity and specificity) of any type of radiographic technique to assess AP in humans were selected. The gold standard was the histologic examination for actual AP (*in vivo*) or *in situ* visualization of bone defects for induced artificial AP (*in vitro*). Accuracy measurements described in the studies were transformed to construct receiver operating characteristic curves and forest plots with the aid of Review Manager v.5.2 (The Nordic Cochrane Centre, Copenhagen, Denmark) and MetaDisc v.1.4. software (Unit of Clinical Biostatistics Team of the Ramón y Cajal Hospital, Madrid, Spain). The methodology of the selected studies was evaluated using the Quality Assessment Tool for Diagnostic Accuracy Studies-2. **Results** Only 9 studies met the inclusion criteria and were subjected to a qualitative analysis. A meta-analysis was conducted on 6 of these articles. All of these articles studied artificial AP with induced bone defects. The accuracy values (area under the curve) were 0.96 for CBCT imaging, 0.73 for conventional periapical radiography, and 0.72 for digital periapical radiography. No evidence was found for panoramic radiography. **Conclusions** Periapical radiographs (digital and conventional) reported good diagnostic accuracy on the discrimination of artificial AP from no lesions, whereas CBCT imaging showed excellent accuracy values.

Cone-beam Computed Tomography for Detecting Vertical Root Fractures in Endodontically Treated Teeth: A Systematic Review

Edwin Chang JOE 2016

Introduction A vertical root fracture (VRF), commonly found in teeth with endodontic treatment, is challenging to diagnose and has poor treatment outcomes. Cone-beam computed tomography (CBCT) has become an increasingly popular imaging modality in endodontics, but image artifacts arising from root-filling materials may hinder VRF detection. The aim of this investigation was to conduct a systematic review to assess the diagnostic ability of CBCT for detecting VRFs in endodontically treated teeth. **Methods** A systematic review of *in vivo* clinical diagnostic literature (initial search December 2014, updated August 2015) was conducted. Assessment of methodological quality was performed by using the modified Quality Assessment of Diagnostic Accuracy Studies tool. **Results** Four studies with a total of 130 patients were included. The reported ranges of values were 40%–90% for VRF

prevalence, 84% (0.64–0.95) to 100% (0.83–1.00) for sensitivity, 64% (0.35–0.87) to 100% (0.03–1.00) for specificity, 71% (0.51–0.87) to 100% (0.63–1.00) for positive predictive value, and 50% (0.01–0.99) to 100% (0.84–1.00) for negative predictive value. All 4 studies revealed multiple items at high risk or unclear risk of bias. **Conclusions** Because of the significant imprecision in the range of reported estimates and the biases observed in the included studies, there is currently insufficient evidence to suggest that CBCT is a reliable test in detecting VRFs in endodontically treated teeth.

The Diagnostic Efficacy of Cone-beam Computed Tomography in Endodontics: A Systematic Review and Analysis by a Hierarchical Model of Efficacy

Eyal Rosen JOE 2015

Introduction The aim of this study was to evaluate the diagnostic efficacy of cone-beam computed tomographic (CBCT) imaging in endodontics based on a systematic search and analysis of the literature using an efficacy model. **Methods** A systematic search of the literature was performed to identify studies evaluating the use of CBCT imaging in endodontics. The identified studies were subjected to strict inclusion criteria followed by an analysis using a hierarchical model of efficacy (model) designed for appraisal of the literature on the levels of efficacy of a diagnostic imaging modality. **Results** Initially, 485 possible relevant articles were identified. After title and abstract screening and a full-text evaluation, 58 articles (12%) that met the inclusion criteria were analyzed and allocated to levels of efficacy. Most eligible articles ($n = 52$, 90%) evaluated technical characteristics or the accuracy of CBCT imaging, which was defined in this model as low levels of efficacy. Only 6 articles (10%) proclaimed to evaluate the efficacy of CBCT imaging to support the practitioner's decision making; treatment planning; and, ultimately, the treatment outcome, which was defined as higher levels of efficacy. **Conclusions** The expected ultimate benefit of CBCT imaging to the endodontic patient as evaluated by its level of diagnostic efficacy is unclear and is mainly limited to its technical and diagnostic accuracy efficacies. Even for these low levels of efficacy, current knowledge is limited. Therefore, a cautious and rational approach is advised when considering CBCT imaging for endodontic purposes.

Detection accuracy of root fractures in cone-beam computed tomography images: a systematic review and meta-analysis

R. H. Ma, Z. P. Ge and G. Li IEJ 2016

The aim of this review was to evaluate whether CBCT is reliable for the detection of root fractures in teeth without root fillings, and whether the voxel size has an impact on diagnostic accuracy. The studies published in PubMed, Web of Science, ScienceDirect, Cochrane Library, Embase, Scopus, CNKI and Wanfang up to May 2014 were the data source. Studies on nonroot filled teeth with the i-CAT ($n = 8$) and 3D Accuitomo CBCT ($n = 5$) units were eventually selected. In the studies on i-CAT, the pooled sensitivity was 0.83 and the pooled specificity was 0.91; in the 3D Accuitomo studies, the pooled sensitivity was 0.95 and pooled specificity was 0.96. The i-CAT group comprised 5 voxel size subgroups and the 3D Accuitomo group contained 2 subgroups. For the i-CAT group, there was a significant difference amongst the five subgroups (0.125, 0.2, 0.25, 0.3 and 0.4 mm; $P = 0.000$). Pairwise comparison revealed

that 0.125 mm voxel subgroup was significantly different from those of 0.2, 0.25 and 0.3 mm voxel subgroups, but not from the 0.4 mm voxel subgroup. There were no significant differences amongst any other two subgroups (by $\alpha' = 0.005$). No significant difference was found between 0.08 mm and 0.125 mm voxel subgroups ($P = 0.320$) for the 3D Accutomo group. The present review confirms the detection accuracy of root fractures in CBCT images, but does not support the concept that voxel size may play a role in improving the detection accuracy of root fractures in nonroot filled teeth.

Instrumentation

Hand and ultrasonic instrumentation for orthograde root canal treatment of permanent teeth

Pedrazzi V, Oliveira-Neto JM, Sequeira P, Fedorowicz Z, Nasser M. 2008;(4):CD006384

BACKGROUND: Endodontic treatment of root canals or root canal treatment is a frequently performed dental procedure and is carried out on teeth in which irreversible pulpitis has led to necrosis (death) of the dental pulp (nerve). Removal of the necrotic tissue remnants and cleaning and shaping of the root canal are important phases of root canal treatment. Treatment options include the use of hand and rotary instruments and methods using ultrasonic or sonic equipment. **OBJECTIVES:** The objectives of this review were to determine the relative clinical effectiveness of hand instrumentation versus ultrasonic instrumentation alone or in conjunction with hand instrumentation for orthograde root canal treatment of permanent teeth. **SEARCH STRATEGY:** We searched the Cochrane Oral Health Group Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE and LILACS. We searched the reference lists of relevant articles in an attempt to locate additional published and unpublished trials. No language restriction was applied. The last electronic search was conducted in December 2007. **SELECTION CRITERIA:** Randomised controlled trials involving people over 18 years of age with single and multiple permanent teeth with a completely formed apex and with no evidence of internal resorption requiring root canal treatment were included. Patients undertaking re-treatment of a tooth were excluded. **DATA COLLECTION AND ANALYSIS:** Screening of eligible studies was conducted in duplicate and independently. Results were to be expressed as fixed-effect or random-effects models using mean differences for continuous outcomes and risk ratios for dichotomous outcomes with 95% confidence intervals. Heterogeneity was to be investigated including both clinical and methodological factors. **MAIN RESULTS:** No eligible randomised controlled trials were identified. **AUTHORS' CONCLUSIONS:** This review illustrates the current lack of published or ongoing randomised controlled trials and the unavailability of high level evidence, based on clinically relevant outcomes, for the effectiveness of ultrasonic instrumentation used alone or as an adjunct to hand instrumentation for orthograde root canal treatment. Future randomised controlled trials might focus more closely on evaluating the effectiveness of combinations of these interventions with an emphasis on not only clinically relevant but also patient-centred outcomes.

Master apical file size - smaller or larger: a systematic review of microbial reduction

Aminoshariae, A., Kulild, J. . Int Endod J. 2014;88(1045):20140658

The purpose of this systematic review was to determine, in patients undergoing root canal treatment, whether apical enlargement of canals affected microbial reduction. A PICO (population, intervention, comparison and outcome) strategy was developed to identify previously published studies dealing with apical size of canal and microbial reduction. The MEDLINE, Embase, Cochrane and PubMed databases were searched. Additionally, the bibliographies of all relevant articles and textbooks were manually searched. Based on inclusion and exclusion criteria, two reviewers independently selected the relevant articles. Due to the variety of methodologies and different techniques used to measure outcome for

master apical file enlargement, it was not possible to standardize the research data and to apply a meta-analysis. Seven articles were identified that met the inclusion criteria. Five of the seven articles generally concluded that canal enlargement reduced bioburden in the root canal system. Two articles reported no difference in canals enlarged to size 25 or 40. The results of the systematic review confirmed that more evidence-based research in this area is needed. With the limited information currently available, the best current available clinical evidence suggests that contemporary chemomechanical debridement techniques with canal enlargement techniques do not eliminate bacteria during root canal treatment at any size.

Kinematic Effects of Nickel-Titanium Instruments with Reciprocating or Continuous Rotation Motion: A Systematic Review of *In Vitro* Studies

So-Yeon Ahn JOE 2016

Introduction: This review aimed to compare the kinematic effect of nickel-titanium instruments with reciprocating and continuous rotation motion for cyclic fatigue resistance, shaping ability, apical debris extrusion, and dentinal defects or cracks. **Method** Articles were selected for inclusion in this review if they fulfilled all of the following criteria: described *in vitro* studies performed on either extracted human teeth or an artificial canal model, assessed both reciprocating and rotary instruments, compared reciprocating files and rotary files for the kinematics of files, and evaluated reciprocating and rotary files regarding the aim of this study. The electronic search was undertaken in MEDLINE, Cochrane database, and manual searches, including journals, reference lists, and other reviews. **Results** Twelve studies were chosen for cyclic fatigue, 19 studies for shaping ability, 14 studies for apical debris extrusion, and 13 studies for dentinal defects or cracks. Most of the studies showed that reciprocating motion had a higher resistance to cyclic fatigue. Nine studies from the shaping studies reported less canal transportation by using the reciprocating motion than the continuous rotation. The reciprocating instruments tended to extrude more dentin debris than the continuous rotating instruments, but many of the studies showed conflicting results. In addition, 2 studies from the defects or cracks studies claimed the reciprocating motion produced more dentinal defects than the continuous rotating motion. **Conclusions** Instruments with reciprocating motion seemed to have better resistance to cyclic fatigue with less canal transportation tendency than the instruments with continuous rotating motion.

Current Assessment of Reciprocation in Endodontic Preparation: A Comprehensive Review: Properties and Effectiveness

Gianluca Plotino, JOE 2016

Introduction Many reciprocating file systems (RFs) have recently been introduced. This article reviews the properties, effectiveness, and clinical outcomes of the RFs. **Methods** A PubMed electronic search was conducted by using appropriate key words to identify investigations on RFs. After retrieving the full-text relevant articles, the cross citations were also identified. **Results** This review summarizes the mechanical properties, shaping ability, preservation of the root canal anatomy, shaping time, cleaning effectiveness, microcrack formation, bacterial reduction, extrusion of debris, and removal of root canal filling materials

of RFs. **Conclusions** The favorable results of RFs indicate their potential application as viable alternatives to rotary file systems, yet no filing system is able to entirely prepare the dentin of canals, totally eliminate sessile and planktonic microorganisms, or remove the filling material completely from the root canal system.

The influence of two reciprocating single-file and two rotary-file systems on the apical extrusion of debris and its biological relationship with symptomatic apical periodontitis. A systematic review and meta-analysis

J. Caviedes-Bucheli IEJ 2016

This systematic review and meta-analysis investigated the influence of the number of files (full-sequence rotary-file versus reciprocating single-file systems) used during root canal preparation on the apical extrusion of debris and its biological relationship with the occurrence of symptomatic apical periodontitis. An extensive literature research was carried out in the Medline, ISI Web of Science and Cochrane databases, for relevant articles with the keyword search strategy. Based on inclusion and exclusion criteria, two reviewers independently rated the quality of each study determining the level of evidence of the articles selected. The primary outcome for the meta-analysis was determined by the amount of debris extruded into the periapical tissue during root canal preparation with multiple- or single-file systems in four laboratory studies. Analysis of in vivo release of neuropeptides (SP and CGRP) after root canal preparation with single- or multiple-file systems was also carried out. Amongst the 128 articles initially found, 113 were excluded for being nonrelevant or not fulfilling the selection criteria. Another four articles were excluded after methodology evaluation. Finally, nine laboratory studies and two in vivo studies were included in the systematic review. Four of the laboratory studies were further included for meta-analysis that revealed greater debris extrusion after the use of single-file techniques when compared to multiple-file systems. Analysis of in vivo neuropeptide expression in the periodontal ligament suggests that the design of the instrument is more important than the number of files used. Both rotary and reciprocating single-file systems generate apical extrusion of debris in laboratory studies, or expression of neuropeptides in vivo. Available evidence is limited, but supports the fact that this inflammatory reaction is not influenced by the number of files but the type of movement and the instrument design.

Endodontic mishaps (perforations, broken instrument, ...)

Impact of a retained instrument on treatment outcome: a systematic review and meta-analysis

Panitvisai P, Parunnit P, Sathorn C, Messer HH . Journal of Endodontics. 2010;36(5):775-80

INTRODUCTION: Fracture of root canal instruments is one of the most troublesome incidents in endodontic therapy. This systematic review and meta-analysis aim to determine the outcome difference between retained fractured instrument cases and matched conventional treated cases. **METHODS:** The MEDLINE database, EMBASE, Web of Science, and the Cochrane Database were searched. Reference lists were scanned. A forward search was undertaken on identified articles. Papers citing these articles were identified through Science Citation Index to identify potentially relevant subsequent primary research. A systematic data extraction sheet was constructed. Data in these studies were independently extracted. Risk differences of included studies were combined by using the generic inverse variance data and fixed effects method. A 2-stage analysis was conducted. The first was limited to case-control studies, and the second included case series in which data were available for teeth with and without periradicular lesions. **RESULTS:** Two case-control studies were identified and included, covering 199 cases. Weighted mean healing for teeth with a retained instrument fragment was 91%. The 2 studies were homogeneous. Risk difference of the combined data was 0.01, indicating that a retained fragment did not significantly influence healing. Overall, 80.7% of lesions healed when a periapical lesion was present, compared with 92.4% remaining healthy when no lesion was present initially ($P < .02$). **CONCLUSIONS:** On the basis of the current best available evidence, the prognosis for endodontic treatment when a fractured instrument fragment is left within a root canal is not significantly reduced.

The Prognosis of Altered Sensation after Extrusion of Root Canal Filling Materials: A Systematic Review of the Literature

Eyal Rosen, DMD Igor Tsisis, DMD JOE 2016

Introduction The aim of this study was to systematically review and evaluate the literature regarding the prognosis of altered sensation after extrusion of root canal filling materials and the possible factors influencing it. **Methods** A systematic search of the literature was performed to identify studies that reported on altered sensation after extrusion of root canal filling materials during endodontic treatments. The articles were evaluated for their relevance based on strict inclusion criteria, and the identified suitable articles were subject to data extraction and analysis. **Results** Initially, 109 possibly relevant articles were identified. After screening and full-text evaluations, 28 articles that met the inclusion criteria were analyzed, reporting on a total of 84 patients with altered sensation after extrusion of root canal filling materials. All the included studies, except 1 case series, were case reports. Under the limited available data, the extracted data showed that 91% of the patients had fully or partially recovered over time. Most of the cases in the lower molars as well as most of the cases in which the obturation was performed using paraformaldehyde-containing sealer or cases in which an

immediate treatment was not performed did not fully recover. **Conclusions** The current scientific knowledge regarding the prognosis of nerve injuries caused by overextruded endodontic materials relies primarily on case reports. Within the limitations of the published data, it seems that the tooth locations, types of extruded materials and the obturation technique, and treatment after the injury may affect the nerve injury prognosis.

Treatment Outcome of Repaired Root Perforation: A Systematic Review and Meta-analysis

Siew. K JOE 2015

Introduction This study aimed to review systematically the reported treatment outcome of repaired root perforation and to identify any preoperative factors that may influence the outcome of such repair. **Methods** A comprehensive search was conducted by using 4 electronic databases, as well as manual search of cited references, to identify reports related to root perforation. Clinical studies published from 1950 to mid-2014 that evaluated the outcome of repaired root perforations were identified. Studies were further screened for similar characteristics for pooling of data for meta-analysis. **Results** Seventeen studies were included for systematic review and 12 suitable for meta-analysis. An overall pooled success rate of 72.5% (confidence interval, 61.9%–81.0%) was estimated for nonsurgical repair of root perforations. The use of mineral trioxide aggregate appeared to enhance the success rate to 80.9% (confidence interval, 67.1%–89.8%), but the difference was not statistically significant. The presence of pre-existing radiolucency adjacent to the perforation site fared a lower chance of success after repair ($P < .05$). Maxillary teeth demonstrated a significantly higher success rate compared with their mandibular counterpart ($P < .05$). **Conclusions** Within the limitations of this study, it may be concluded that nonsurgical repair of root perforation results in a success rate of more than 70%. Teeth in the maxillary arch and absence of preoperative radiolucency adjacent to the perforation are favorable preoperative factors for healing after perforation repair. In view of the relatively high rate of clinical success, nonsurgical repair may be considered as the preferred treatment to handle this complication that arises during root canal therapy.

Management of Intracanal Separated Instruments

Ahmad A. Madarati JOE 2013

Intracanal separation of endodontic instruments may hinder cleaning and shaping procedures within the root canal system, with a potential impact on the outcome of treatment. The purposes of this narrative review of separated instruments were to (1) review the literature regarding treatment options, influencing factors, and complications and (2) suggest a decision-making process for their management. An online search was conducted in peer-review journals listed in PubMed to retrieve clinical and experimental studies, case reports, and review articles by using the following key words: instruments, files, obstructions, fractured, separated, broken, removal, retrieval, management, bypassing, and complications with or without root canal and endodontic. There is a lack of high-level evidence on management of separated instruments. Conventional conservative management includes removal of or bypassing the fragment or filling the root canal system to the coronal level of the fragment. A surgical intervention remains an alternative approach. These approaches are influenced by a number of factors and may be associated with complications. On the basis of current clinical evidence, a

decision-making process for management is suggested. Guidelines for management of intracanal separated instruments have not been formulated. Decisions on management should consider the following: (1) the constraints of the root canal accommodating the fragment, (2) the stage of root canal preparation at which the instrument separated, (3) the expertise of the clinician, (4) the armamentaria available, (5) the potential complications of the treatment approach adopted, and (6) the strategic importance of the tooth involved and the presence/or absence of periapical pathosis. Clinical experience and understanding of these influencing factors as well as the ability to make a balanced decision are essential.

Microbial load reduction (Irrigation, Intracanal medicament)

Antibacterial efficacy of calcium hydroxide intracanal dressing: a systematic review and meta-analysis

Sathorn C, Parashos P, Messer H . Int Endod J. 2007;40(1):2-10

AIM: To determine to what extent does calcium hydroxide intracanal medication eliminate bacteria from human root canals, compared with the same canals before medication, as measured by the number of positive cultures, in patients undergoing root canal treatment for apical periodontitis (teeth with an infected root canal system). METHODOLOGY: CENTRAL, MEDLINE and EMBASE databases were searched. Reference lists from identified articles were scanned. A forward search was undertaken on the authors of the identified articles. Papers that had cited these articles were also identified through the Science Citation Index to identify potentially relevant subsequent primary research. REVIEW METHODS: The included studies were pre-/post-test clinical trials comparing the number of positive bacterial cultures from treated canals. Data in those studies were independently extracted. Risk differences of included studies were combined using the generic inverse variance and random effect method. RESULTS: Eight studies were identified and included in the review, covering 257 cases. Sample size varied from 18 to 60 cases; six studies demonstrated a statistically significant difference between pre- and post-medicated canals, whilst two did not. There was considerable heterogeneity among studies. Pooled risk difference was -21%; 95% CI: -47% to 6%. The difference between pre- and post-medication was not statistically significant ($P = 0.12$). CONCLUSIONS: Calcium hydroxide has limited effectiveness in eliminating bacteria from human root canal when assessed by culture techniques.

Antibacterial efficacy of intracanal medicaments on bacterial biofilm: a critical review

Estrela C, Sydney GB, Figueiredo JA, Estrela CR . Journal of Applied Oral Science. 2009;17(1):1-7

The purpose of this paper is to discuss critically the antibacterial efficacy of intracanal medicaments on bacterial biofilm. Longitudinal studies were evaluated by a systematic review of English-language articles retrieved from electronic biomedical journal databases (MEDLINE, EMBASE, CENTRAL) and handsearching records, using different matches of keywords for root canal biofilm, between 1966 and August 1st, 2007. The selected articles were identified from titles, abstracts and full-text articles by two independent reviewers, considering the tabulated inclusion and exclusion criteria. Disagreements were resolved by consensus. The search retrieved 91 related articles, of which 8.8% referred to in vivo studies demonstrating the lack of efficacy of endodontic therapy on bacterial biofilm. Intracanal medicaments were found to have a limited action against bacterial biofilm.

Effectiveness of single- versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis

Sathorn C, Parashos P, Messer HH . Int Endod J. 2005;38(6):347-55

AIM: The clinical question this review aimed to answer is: does single-visit root canal treatment without calcium hydroxide dressing, compared to multiple-visit treatment with calcium hydroxide dressing for 1 week or more, result in a lower healing (success) rate (as measured by clinical and radiographic interpretation)? METHODOLOGY: CENTRAL, MEDLINE, EMBASE and HEALTH STAR databases were used. Reference lists from identified articles were scanned. A forward search was undertaken on the authors of the identified articles. Papers that had cited these articles were also identified through Science Citation Index to identify potentially relevant subsequent primary research. REVIEW METHODS: The included studies were randomized controlled clinical trials (RCTs) comparing healing rate of single- and multiple-visit root canal treatment in humans. The outcome measured was healing of radiographically detectable lesions. Data in those studies were independently extracted. RESULTS: Only three RCTs were identified and included in the review, covering 146 cases. Sample size of all three studies was small; none demonstrated a statistically significant difference in healing rates. Risk differences of included studies were combined using the inverse variance-weighted method (RD(Pooled) = -6.3%; 95% CI: -20.3-7.8). CONCLUSION: Based on the current best available evidence, single-visit root canal treatment appeared to be slightly more effective than multiple visit, i.e. 6.3% higher healing rate. However, the difference in healing rate between these two treatment regimens was not statistically significant (P = 0.3809).

Efficacy of lasers as an adjunct to chemo-mechanical disinfection of infected root canals: a systematic review

Fransson, H., Larsson, K. M., Wolf, E. . International Endodontic Journal. 2013;46(4):296-307

The aim was to evaluate the efficacy of various types of lasers used as an adjunct to chemo-mechanical disinfection of infected root canals with the outcome measures 'normal periapical condition' or 'reduction of microbial load'. PubMed, CENTRAL and ISI Web of Knowledge literature searches with specific indexing terms and a subsequent hand search were made with stated limits and criteria. Relevant publications were retrieved, followed by interpretation. The quality of each included publication was assessed as high, moderate or low. The initial search process yielded 234 publications. All abstracts of these publications were read, and the reference lists of relevant publications were hand-searched. Ten articles were read in full text and interpreted according to a data extraction form. Five were included in the systematic review and were assessed. A meta-analysis was impossible to perform because the included studies were heterogeneous with regard to study design, treatment and outcome measures. Positive effects were reported; however, no concluding evidence grade could be made because each included study was judged to have low quality, primarily due to lack of a power analysis, blinding and reproducibility. The evidence grade for whether lasers can be recommended as an adjunct to chemo-mechanical disinfection of infected root canals was insufficient. This does not necessarily imply that laser should not be used as an adjunct to root canal treatment but instead underscores the need for future high-quality studies. 2012 International Endodontic Journal.

Efficacy of sodium hypochlorite and chlorhexidine against Enterococcus faecalis--a systematic review

Estrela C, Silva JA, de Alencar AH, Leles CR, Decurcio DA . Journal of Applied Oral Science. 2008;16(6):364-8

The efficacy of the sodium hypochlorite (NaOCl) and chlorhexidine (CHX) on Enterococcus faecalis was evaluated by systematic review and meta-analysis. The search strategies included search in electronic biomedical journal databases (MEDLINE, EMBASE, CENTRAL) and handsearching records, using different matches of keywords for NaOCl, CHX and Enterococcus faecalis. From 41 in vivo studies, 5 studies met the inclusion criteria. In a sample containing 159 teeth, E. faecalis was detected initially in 16 (10%) teeth by polymerase chain reaction (PCR) and 42 (26.4%) teeth by microbial culture techniques. After root canal disinfection, this species was observed in 11 (6.9%) teeth by PCR and 12 (7.5%) teeth by culture.

Irrigants for non-surgical root canal treatment in mature permanent teeth

Fedorowicz, Zbys, Nasser, Mona, Sequeira-Byron, Patrick, de Souza, Raphael Freitas, Carter, Ben, Heft, Marc . Cochrane Database of Systematic Reviews. 2012

BACKGROUND: Root canal treatment is carried out on teeth in which irreversible pulpitis has led to necrosis of the dental pulp. As a treatment option it is an alternative to dental extraction. Mechanical preparation and irrigation with antiseptic or antibacterial solutions destroys bacteria and cleans the infected root canal. Irrigants should be effective in deactivating bacteria in the entire root canal space without causing any adverse tissue reactions. Sodium hypochlorite (NaOCl) and chlorhexidine are commonly used but there is uncertainty as to which solution, concentration or combination is the most effective. **OBJECTIVES:** To assess the effects of irrigants used in the non-surgical root canal treatment of mature permanent teeth. **SEARCH METHODS:** We searched the Cochrane Oral Health Group's Trials Register (to 5 July 2012), the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library 2012, Issue 4), MEDLINE via Ovid (1950 to 5 July 2012), EMBASE via Ovid (1980 to 5 July 2012), LILACS via BIREME (1980 to 5 July 2012). There were no restrictions regarding language or date of publication. **SELECTION CRITERIA:** Randomised controlled trials in single or multi-rooted permanent teeth with pulpal or periapical pathology or both, which require root canal treatment. Irrigants either against each other or against inactive irrigant or placebo. Combinations of irrigants were allowed and if used in conjunction with EDTA (ethylenediaminetetra-acetic acid) or similar chelating agents. **DATA COLLECTION AND ANALYSIS:** Two review authors independently assessed risk of bias of included trials and extracted data. **MAIN RESULTS:** We included 11 trials involving 851 participants with 879 teeth which had undergone root canal treatment and involved the use of irrigants. Two trials were assessed as being at low risk of bias, with six unclear and three high. Four trials compared sodium hypochlorite versus chlorhexidine, however, no primary outcomes and only one secondary outcome, bacterial growth cultures, was reported for two of these trials (20% and 50% of teeth in the control group had positive bacterial culture). The meta-analysis indicated no strong evidence of a difference in the existence of bacterial growth between the interventions (risk ratio 0.73; 95% confidence interval 0.34 to 1.56; P = 0.41). The seven remaining trials each compared different interventions and only two of these trials included useable data on the primary outcomes of swelling and pain. One trial compared sodium hypochlorite 5.25% alone versus sodium hypochlorite 5.25% combined with hydrogen

peroxide 3%, and versus normal saline and reported pain at 3 to 14 days after the procedure. There was no evidence of a difference in pain between the three groups. The other trial compared sodium hypochlorite 5% versus sodium hypochlorite with 'proteolytic enzyme', and there was no evidence of a difference in swelling between the groups. Two further trials reported bacterial growth, and three trials failed to report any data which could be used in the review. None of the included trials reported any data on adverse effects nor radiological changes in periapical radiolucency. **AUTHORS' CONCLUSIONS:** Although root canal irrigants such as sodium hypochlorite and chlorhexidine appear to be effective at reducing bacterial cultures when compared to saline, most of the studies included in this review failed to adequately report these clinically important and potentially patient-relevant outcomes. There is currently insufficient reliable evidence showing the superiority of any one individual irrigant. The strength and reliability of the supporting evidence was variable and clinicians should be aware that changes in bacterial counts or pain in the early postoperative period may not be accurate indicators of long-term success. Future trials should report both clinician-relevant and patient-preferred outcomes at clearly defined perioperative, as well as long-term, time points.

The effect of photodynamic therapy in root canal disinfection: a systematic review

Chrepa, V., Kotsakis, G. A., Pagonis, T. C., Hargreaves, K. M. . J Endod. 2014;40(7):891-8

INTRODUCTION: Effective root canal disinfection is a fundamental component of successful root canal treatment. Photodynamic therapy (PDT) has been proposed as a new adjunctive method for additional disinfection of the root canal system with the possibility of improved treatment outcomes. The aim of this systematic review was to investigate the effect of PDT on bacterial load reduction during root canal disinfection. **METHODS:** Two reviewers independently conducted a comprehensive literature search using a combination of medical subject heading terms and key words to identify studies relevant to the Population Intervention Control Outcome question. The selection of articles for inclusion was performed in 2 phases based on predetermined eligibility criteria according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Inter-reviewer agreement for each phase was recorded. The effect of PDT on bacterial load reduction during root canal disinfection was evaluated as the primary outcome variable during data extraction. **RESULTS:** The literature search provided 57 titles and abstracts. Three articles met the inclusion criteria and were selected for this systematic review. The reasons for study exclusion in each phase were recorded. Because of the heterogeneity in clinical indications and PDT protocols among the included studies, a meta-analysis could not be performed. All included studies showed a positive effect of PDT in the reduction of microbial load in root canal treatment ranging from 91.3%-100%. **CONCLUSIONS:** Limited clinical information is currently available on the use of PDT in root canal disinfection. If supported by future clinical research, PDT may have efficacy for additional root canal disinfection, especially in the presence of multi-drug-resistant bacteria.

Contamination Controls for Analysis of Root Canal Samples by Molecular Methods: An Overlooked and Unsolved Problem

David Figdor JOE 2016

Introduction: It has been almost 20 years since molecular methods were first described for the analysis of root canal microbial flora. Contamination control samples are essential to establish DNA decontamination before taking root canal samples, and this review assessed

those studies. **Methods:** Using PubMed, a search was conducted for studies using molecular microbial analysis for the investigation of endodontic samples. Studies were grouped according to the cleaning protocol, acquisition methods, and processing of control samples taken to check for contamination. **Results:** Of 136 studies applying molecular analysis to root canal samples, 21 studies performed surface cleaning and checking nucleotide decontamination with contamination control samples processed by polymerase chain reaction. Only 1 study described disinfection, sampling from the access cavity, and processing by polymerase chain reaction and reported the result; that study reported that all samples contained contaminating bacterial DNA. **Conclusions:** Cleaning, disinfection, and checking for contamination are basic scientific prerequisites for this type of investigation; yet, this review identifies it as an overlooked issue. On the basis of this review, we call for improved scientific practice in this field.

The Effect of Sodium Hypochlorite and Chlorhexidine as Irrigant Solutions for Root Canal Disinfection: A Systematic Review of Clinical Trials

Lucio Souza Gonçalves JOE 2016

Introduction This systematic review aimed to compare the effectiveness of sodium hypochlorite and chlorhexidine for root canal disinfection during root canal therapy. **Methods** A literature search for clinical trials was made on the PubMed (MEDLINE), Web of Knowledge, SCOPUS, and Science Direct databases and in the reference lists of the identified articles up to January 2015. Quality assessment of the selected studies was performed according to the Consolidated Standards of Reporting Trials statement. **Results** One clinical trial and 4 randomized clinical trials were selected from the 172 articles initially identified. There was heterogeneity in the laboratory methods used to assess the root canal disinfection as well as in the concentrations of the irrigants used. Therefore, meta-analysis was not performed. Two studies reported effective and similar reductions in bacterial levels for both irrigants. Sodium hypochlorite was more effective than chlorhexidine in reducing microorganisms in 1 study, and another reported opposite findings. Both root irrigants were ineffective in eliminating endotoxins from necrotic pulp root canals in 1 study. Trial design and information regarding randomization procedures were not clearly described in the clinical trials. No study compared laboratory results with clinical outcomes. **Conclusions** The available evidence on this topic is scarce, and the findings of studies were not consistent. Additional randomized clinical trials using clinical outcomes to compare the use of sodium hypochlorite and chlorhexidine during root canal therapy are needed.

Ultrasonically Activated Irrigation to Remove Calcium Hydroxide from Apical Third of Human Root Canal System: A Systematic Review of *In Vitro* Studies

Ibrahim Ethem Yaylali JOE 2015

Introduction The aim of this systematic review was to summarize the outcomes of *in vitro* studies comparing ultrasonically activated irrigation versus other irrigation techniques for removing calcium hydroxide (Ca[OH]₂) from the apical third of root canals. **Methods** The research question was developed according to the PICO strategy. A comprehensive literature search was performed. The Medline, Embase, and TRIP electronic databases were searched. A hand search of the reference lists of identified articles was performed to isolate relevant articles. Two reviewers critically assessed the studies against our

inclusion and exclusion criteria. Evaluation of the risk of bias of the studies was performed independently by the 2 reviewers. **Results** After study selection, 62 were assessed for eligibility. Of these, 9 met the inclusion criteria and were included in the systematic review. Because considerable heterogeneity was found in the methodologies, it was not possible to combine the results of studies in a meta-analysis. Ultrasonically activated irrigation was found to be superior to syringe irrigation and apical negative pressure irrigation, but insufficient evidence was found to indicate its superiority over the other irrigation techniques such as sonically activated irrigation, the Self-Adjusting File, (ReDent-Nova, Ra'anana, Israel) and the RinsEndo, (Dürr Dental, Bietigheim, Germany). **Conclusions** On the basis of available evidence, we determined the effectiveness of ultrasonically activated irrigation compared with syringe and apical negative pressure irrigation. Because of the small sample sizes, low number of included studies, and limitations, further research is needed to confirm our results.

Antagonistic Interactions between Sodium Hypochlorite, Chlorhexidine, EDTA, and Citric Acid

Giampiero Rossi-Fedele JOE 2012

Introduction Root canal irrigants play a significant role in the elimination of microorganisms, tissue dissolution, and the removal of debris and smear layer. No single solution is able to fulfill these actions completely; therefore, their association is required. The aim of this investigation was to review the antagonistic interactions occurring when sodium hypochlorite (NaOCl), chlorhexidine (CHX), EDTA, and citric acid (CA) are used together during endodontic treatment. **Methods** A search was performed in the electronic database Medline (articles published through 2011; English language; and the following search terms or combinations: “interaction AND root canal irrigant or endodontic irrigant or sodium hypochlorite or chlorhexidine,” “sodium hypochlorite AND EDTA or ethylenediaminetetraacetic acid or citric acid or chelating agent or chlorhexidine,” and “chlorhexidine AND EDTA or ethylenediaminetetraacetic acid or citric acid or chelating agent”) to identify publications that studied unwanted chemical interactions between NaOCl, CHX, and EDTA and CA. **Results** The search identified 1,285 publications; 19 fulfilled the inclusion/exclusion criteria of the review. Their research methodology was classified as either *in vitro* or *ex vivo*. **Conclusions** Antagonistic interactions included the loss of free available chlorine for NaOCl when in contact with chelators, which consequently reduced the tissue dissolution capability and to a lesser extent antimicrobial activities. When CHX and NaOCl are mixed, a precipitate forms that can present detrimental consequences for endodontic treatment, including a risk of discoloration and potential leaching of unidentified chemicals into the periradicular tissues. CHX and EDTA mixtures cause a precipitate, whereas CHX and CA do not exhibit interaction.

Influence of pH changes on chlorine-containing endodontic irrigating solutions

G. Rossi-Fedele IEJ 2011

Chlorine-containing solutions are used for broad disinfection purposes. Water disinfection literature suggests that their disinfectant action depends on pH values as this will influence the available free chlorine forms. Hypochlorous acid (HOCl) has been suggested to have an antimicrobial effect around 80–100 times stronger than the hypochlorite ion. The aim of this paper was to review the influence of pH changes on the efficacy of chlorine-containing

endodontic irrigating solutions. An electronic and hand search (articles published through to 2010, including 'in press' articles; English language; search terms 'root canal irrigants AND sodium hypochlorite or hypochlorous acid or superoxidized water or electrochemically activated solution'; 'antimicrobial action AND sodium hypochlorite or hypochlorous acid or superoxidized water or electrochemically activated solution'; 'tissue dissolution AND sodium hypochlorite or hypochlorous acid or superoxidized water or electrochemically activated solution'; 'smear layer AND sodium hypochlorite or hypochlorous acid or superoxidized water or electrochemically activated solution') was performed to identify publications that compared chlorine water solutions with different pH. Of 1304 publications identified, 20 were considered for inclusion in the review. The search resulted in the retrieval of articles studying sodium hypochlorite (NaOCl), superoxidized waters (SOW) and sodium dichloroisocyanurate (NaDCC). Regarding antimicrobial efficacy, the literature suggested that reducing the pH value of NaOCl to between 6 and 7.5 would lead to improved action; SOW was described as having a lower antimicrobial effect. The tissue dissolution activity NaOCl decreased when the pH reached values between 6 and 7.5; NaDCC and SOW had no clinically relevant tissue dissolution capability. Chlorine solutions of different characteristics appeared to have some cleaning efficacy although they should to be used in conjunction with chelating and/or detergent agents.

Antibacterial effect of calcium hydroxide combined with chlorhexidine on *Enterococcus faecalis*: a systematic review and meta-analysis.

Saatchi M, J Appl Oral Sci. 2014

OBJECTIVE: *Enterococcus faecalis* (*E. faecalis*) is the most frequently isolated strain in failed endodontic therapy cases since it is resistant to calcium hydroxide (CH). Whether a combination of CH and chlorhexidine (CHX) is more effective than CH alone against *E. faecalis* is a matter of controversy. Thus, the aim of this study was to conduct a systematic review and meta-analysis of the literature. **MATERIAL AND METHODS:** A comprehensive search in PubMed, EMBASE, EBSCOhost, The Cochrane Library, SciELO, and BBO databases, Clinical trials registers, Open Grey, and conference proceedings from the earliest available date to February 1, 2013 was carried out and the relevant articles were identified by two independent reviewers. Backward and forward search was performed and then inclusion and exclusion criteria were applied. The included studies were divided into "comparisons" according to the depth of sampling and dressing period of each medicament. Meta-analysis was performed using Stata software 10.0. The level of significance was set at 0.05. **RESULTS:** Eighty-five studies were retrieved from databases and backward/forward searches. Forty five studies were considered as relevant (5 in vivo, 18 in vitro, 18 ex vivo, and 4 review articles). Nine studies were included for meta-analysis. Inter-observer agreement (Cohen kappa) was 0.93. The included studies were divided into 21 comparisons for meta-analysis. Chi-square test showed the comparisons were heterogeneous ($p < 0.001$). Random effect model demonstrated no significant difference between CH/CHX mixture and CH alone in their effect on *E. faecalis* ($p = 0.115$). **CONCLUSIONS:** According to the evidence available now, mixing CH with CHX does not significantly increase the antimicrobial activity of CH against *E. faecalis*. It appears that mixing CH with CHX does not improve its ex vivo antibacterial property as an intracanal medicament against *E. faecalis*. Further in vivo studies are necessary to confirm and correlate the findings of this study with the clinical outcomes.

Review of ultrasonic irrigation in endodontics: increasing action of irrigating solutions.

MOZO; Med Oral Patol Oral Cir Bucal. 2012

INTRODUCTION: Effective irrigant delivery and agitation are prerequisites for successful endodontic treatment. Ultrasonic irrigation can be performed with or without simultaneous ultrasonic instrumentation. Existing literature reveals that ultrasonic irrigation may have a very positive effect on chemical, biological and physical debridement of the root canal system as investigated in many in vitro studies. OBJECTIVE: The purpose of this review article was to summarize and discuss the available information concerning ultrasonic irrigation in endodontics. METHODS: This article presents an overview of ultrasonic irrigation methods and their debridement efficacy. In this paper the relevant literature on passive ultrasonic irrigation is reviewed. Information from original scientific papers or reviews listed in MEDLINE and Cochrane were included in the review. RESULTS: The use of ultrasound in the irrigation procedure results in improved canal cleanliness, better irrigant transfer to the canal system, soft tissue debridement, and removal of smear layers and bacteria. There are many in vitro studies, but there is a need to standardize protocols, and correlate the clinical efficacy of ultrasonic devices with improved treatment outcomes. Understanding the basis of ultrasonic irrigation is fundamental for clinicians and researchers to improve the design and use of ultrasonic irrigation.

Microbiology

Correlation between *Enterococcus faecalis* and Persistent Intraradicular Infection Compared with Primary Intraradicular Infection: A Systematic Review

Chenjiao Zhang JOE 2015

Introduction The relationship between *Enterococcus faecalis* and pulpal or periradicular diseases has been studied for many years; however, whether *E. faecalis* is correlated with persistent intraradicular infections (teeth after failed endodontic treatments) compared with primary intraradicular infections remains controversial. The objective of this systematic review was to compare the prevalence of *E. faecalis* in primary and persistent intraradicular infections. **Methods** An exhaustive literature search combined with specified inclusion criteria was performed to collect all studies comparing the prevalence of *E. faecalis* in root canals with primary and persistent intraradicular infections. Descriptive statistics were applied first because of the high heterogeneity among studies. Subgroup analysis according to different detecting methods (culture and polymerase chain reaction) and sensitivity analysis was then applied. Meta-analysis was conducted with the help of Stata/SE 12.0 (StataCorp, College Station, TX) after excluding studies with uncertain forms of pulpal and periradicular lesions in their primary infection groups. **Results** The systematic review included 10 studies covering 972 teeth. Among them, 2 studies used the culture technique, 6 studies used polymerase chain reaction, and the other 2 used both techniques. The detection rate of *E. faecalis* by both methods was higher in persistent infections compared with untreated chronic periapical periodontitis as primary infections. The difference was statistically significant (odds ratio = 7.247; 95% confidence interval, 4.039–13.002). **Conclusions** *E. faecalis* is more highly correlated with persistent intraradicular infections compared with untreated chronic periapical periodontitis.

Association of Functional Gene Polymorphism with Apical Periodontitis

Anita Aminoshariae JOE 2015

Introduction To date, only a few studies have searched for relationships between genetic polymorphism and periapical microbial infection. Thus, the purpose of this systematic review was to evaluate the relationship between host modifying factors and their association with apical periodontitis. **Methods** Two reviewers independently conducted a comprehensive literature search. The MEDLINE, Embase, Cochrane, and PubMed databases were searched. Additionally, the bibliographies of all relevant articles and textbooks were manually searched. **Results** Eight articles were identified and included in this review. The results of the present review suggest that although some authors have reported that some biologic markers may play a role in apical periodontitis, others have not supported this association. Limitations were noted in the current studies by not judiciously matching selected case/control groups, balancing or adjusting for confounders (such as smoking, diabetes, and body mass index), using the Hardy-Weinberg Equilibrium, providing power calculation for a given sample size, correcting for false-positive (type I) error, or providing odds ratios with confidence intervals. The results of this review suggest polymorphism and biological modifiers, by which some individuals, if challenged by bacterial accumulations, may exhibit a more vigorous immunoinflammatory response, leading to apical periodontitis. **Conclusions** More research in this area is warranted to determine greater specificity in these possible interactions.

Prevalence of *Treponema* Species Detected in Endodontic Infections: Systematic Review and Meta-regression Analysis

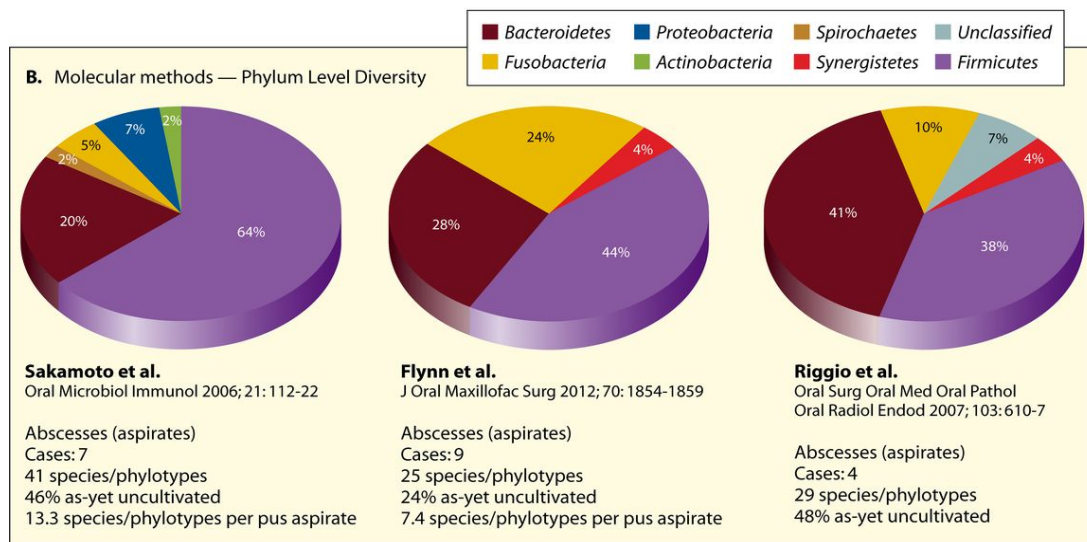
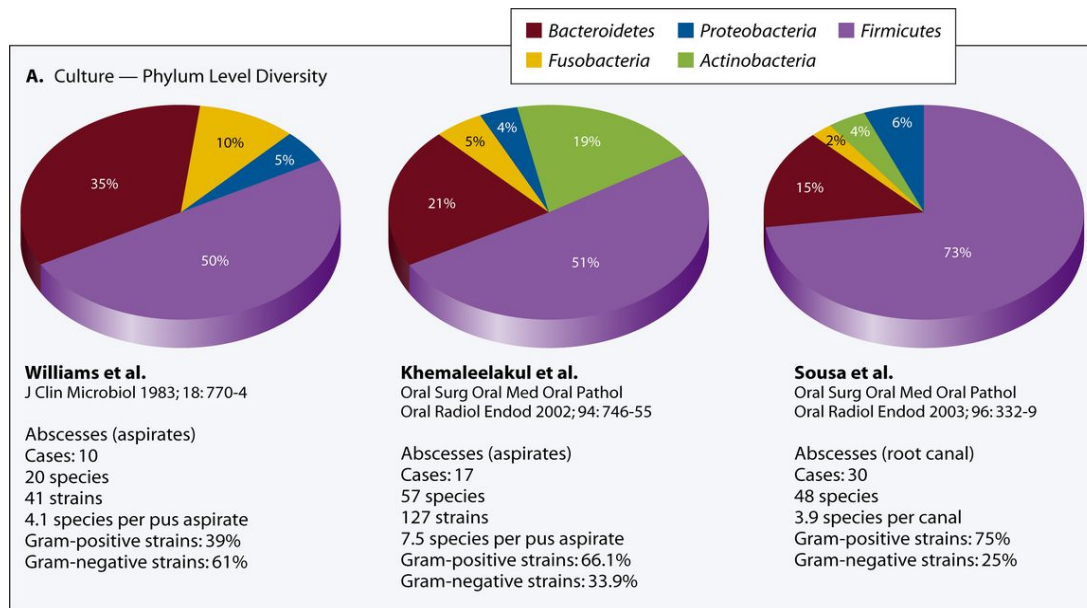
Fábio R.M. Leite JOE 2015

Introduction This systematic review and meta-regression analysis aimed to calculate a combined prevalence estimate and evaluate the prevalence of different *Treponema* species in primary and secondary endodontic infections, including symptomatic and asymptomatic cases. **Methods** The MEDLINE/PubMed, Embase, Scielo, Web of Knowledge, and Scopus databases were searched without starting date restriction up to and including March 2014. Only reports in English were included. The selected literature was reviewed by 2 authors and classified as suitable or not to be included in this review. Lists were compared, and, in case of disagreements, decisions were made after a discussion based on inclusion and exclusion criteria. A pooled prevalence of *Treponema* species in endodontic infections was estimated. Additionally, a meta-regression analysis was performed. **Results** Among the 265 articles identified in the initial search, only 51 were included in the final analysis. The studies were classified into 2 different groups according to the type of endodontic infection and whether it was an exclusively primary/secondary study ($n = 36$) or a primary/secondary comparison ($n = 15$). The pooled prevalence of *Treponema* species was 41.5% (95% confidence interval, 35.9–47.0). In the multivariate model of meta-regression analysis, primary endodontic infections ($P < .001$), acute apical abscess, symptomatic apical periodontitis ($P < .001$), and concomitant presence of 2 or more species ($P = .028$) explained the heterogeneity regarding the prevalence rates of *Treponema* species. **Conclusions** Our findings suggest that *Treponema* species are important pathogens involved in endodontic infections, particularly in cases of primary and acute infections.

Microbiology and treatment of acute apical abscesses.

Siqueira JF Jr, Rôças IN. Clin Microbiol Rev. 2013

Bacterial phyla with representatives in acute apical abscesses as revealed by studies using either culture (A) or molecular (B) open-ended methods. Data refer to the number of different taxa found in each phylum. Note that regardless of the study and method, the majority of species detected belong to the phyla Firmicutes and Bacteroidetes. Representatives of the phyla Synergistetes and Spirochaetes were revealed only by molecular methods.



The smear layer in endodontics – a review

D. R. Violich IEJ 2010

In support of smear layer removal:

* It contains bacteria, their by-products and necrotic tissue (McComb & Smith 1975, Goldberg & Abramovich 1977, Wayman et al. 1979, Cunningham & Martin 1982, Yamada et al. 1983). Bacteria may survive and multiply (Brännström & Nyborg 1973) and can proliferate into the dentinal tubules (Olgart et al. 1974, Akpata & Blechman 1982, Williams & Goldman 1985, Meryon et al. 1986, Meryon & Brook 1990), which may serve as a reservoir of microbial irritants (Pashley 1984).

* It may act as a substrate for bacteria, allowing their deeper penetration in the dentinal tubules (George et al. 2005).

* It may limit the optimum penetration of disinfecting agents (McComb & Smith 1975, Outhwaite et al. 1976, Goldberg & Abramovich 1977, Wayman et al. 1979, Yamada et al. 1983). Bacteria may be found deep within dentinal tubules (Byström & Sundqvist 1981, 1983, 1985) and smear layer may block the effects of disinfectants in them (Goldberg & Abramovich 1977, Wayman et al. 1979, Yamada et al. 1983, Baumgartner & Mader 1987). Haapasalo & Ørstavik (1987) found that in the absence of smear layer, liquid camphorated monochlorophenol disinfected the dentinal tubules rapidly and completely, but calcium hydroxide failed to eliminate *Enterococcus faecalis* even after 7 days of incubation. A subsequent study concluded that the smear layer delayed but did not abolish the action of the disinfectant (Ørstavik & Haapasalo 1990). Brännström (1984) had previously stated that following the removal of the smear layer, bacteria in the dentinal tubules can easily be destroyed.

It can act as a barrier between filling materials and the canal wall and therefore compromise the formation of a satisfactory seal (Lester & Boyde 1977, White et al. 1984, Cergneux et al. 1987, Czonstkowsky et al. 1990, Foster et al. 1993, Yang & Bae 2002). Lester & Boyde (1977) found that zinc oxide – eugenol based root canal sealers failed to enter dentinal tubules in the presence of smear. In two consecutive studies, White et al. observed that plastic filling materials and sealers penetrated dentinal tubules after removal of smear layer (White et al. 1984, 1987). Okşan et al. (1993) also found that smear prevented the penetration of sealers into dentinal tubules, whilst no penetration of sealer was observed in control groups. Penetration in their smear-free groups ranged from 40 to 60 µm. It may be concluded that such tubular penetration increases the interface between the filling and the dentinal structures, which may improve the ability of a filling material to prevent leakage (White et al. 1984). If the aim is maximum penetration into the dentinal tubules to prevent microleakage, root canal filling materials should be applied to a surface free of smear and either a low surface activity or, alternatively, an adequate surface-active reagent must be added to them (Aktener et al. 1989). However, there are no reports of a correlation between microleakage and penetration of filling materials into dentinal tubules, whilst the basis of leakage studies remains questionable. Pashley et al. (1989) observed an extensive network of microchannels around restorations that had been placed in cavities with smear layer. The thickness of these channels was 1–10 µm. Smear layer may thus present a passage for substances to leak around or through its particles at the interface between the filling material and the tooth structure. Pashley & Depew (1986) reported that, when experimenting with class 1 cavities, microleakage decreased after the removal of smear layer, but dentinal permeability increased. Saunders & Saunders (1992) concluded that coronal leakage of root canal fillings was less in smear-free groups than those with a smear layer.

* It is a loosely adherent structure and a potential avenue for leakage and bacterial contaminant passage between the root canal filling and the dentinal walls (Mader et al. 1984, Cameron 1987b, Meryon & Brook 1990). Its removal would facilitate canal filling (McComb & Smith 1975, Goldman et al. 1981, Cameron 1983).

Obturation

Determining the optimal obturation length: a meta-analysis of literature

Schaeffer MA, White RR, Walton RE . J Endod. 2005;31(4):271-4

The purpose was to aid in determining termination of instrumentation and obturation. A meta-analysis was conducted as to success/failure of different obturation lengths. Inclusion criteria were (a) minimum follow-up of 2 yr, (b) data on obturation length, (c) definition of success/failure, (d) available data on success/failure, (e) radiographic evaluation. Correlations were made as to success/failure as related to length of obturation from the apex. When comparing group A (obtured 0-1 mm from apex) versus group C (obtured past apex) using the DerSimonian and Laird estimates, group A showed a marginally better ($p < 0.10$) success rate than group C by 28.8%. Group A had better success than group B (obtured >1 mm short); the difference was insignificant. The results were similar after controlling for study quality using a single random effects regression model. In conclusion, the meta-analysis indicated that a better success rate is achieved when treatment includes obturation short of the apex.

Effect of smear layer on sealing ability of canal obturation: a systematic review and meta-analysis

Shahravan A, Haghdoost AA, Adl A, Rahimi H, Shadifar F . J Endod. 2007;33(2):96-105

The purpose of this systematic review was to determine whether smear layer removal reduces leakage of obturated human teeth in vitro. PubMed was searched for articles published between 1975 and 2005, and results were categorized based on the method of leakage test. Among 26 eligible papers with 65 comparisons, 53.8% of the comparisons reported no significant difference, 41.5% reported a difference in favor of removing the smear layer, and 4.7% reported a difference in favor of keeping it; differences were significant ($p=0.034$).

Emergency, Pain medication, antibiotic, anesthesia:

Evidence-based recommendations for antibiotic usage to treat endodontic infections and pain: A systematic review of randomized controlled trials.

Aminoshariae, J Am Dent Assoc. 2016

BACKGROUND: The purpose of this investigation was to identify evidence-based scientific methodologies to aid dental clinicians in establishing the indications for prescribing antibiotics for endodontic infection or pain. **METHODS:** The authors prepared and registered a protocol on PROSPERO. They conducted electronic searches in MEDLINE, Scopus, Cochrane Library, and ClinicalTrials.gov. In addition, the authors hand searched the bibliographies of all relevant articles, the gray literature, and textbooks for randomized controlled clinical studies. The authors independently selected the relevant articles. **RESULTS:** The overall quality of the studies was fair with a low risk of bias, but 2 studies had a moderate risk of bias. **CONCLUSIONS:** The best available clinical evidence signals no indications for prescribing antibiotics preoperatively or postoperatively to prevent endodontic infection or pain unless the spread of infection is systemic, the patient is febrile, or both. Generally, an accurate diagnosis coupled with effective endodontic treatment will decrease microbial flora enough for healing to occur.

A Cochrane systematic review finds no evidence to support the use of antibiotics for pain relief in irreversible pulpitis

Keenan JV, Farman AG, Fedorowicz Z, Newton JT . J Endod. 2006;32(2):87-92

The Cochrane Systematic Review promotes evidence-based outcomes studies. The review summarized here was conducted in an attempt to achieve reliable evidence concerning the effectiveness, or otherwise, of prescribing antibiotics for patients having irreversible pulpitis. A competent search strategy was developed and used across several databases including MEDLINE to identify randomized controlled trials for inclusion. Assessment of methodological quality was based on criteria defined by The Cochrane Collaboration. Clinical outcome, expressed in terms of pain relief, was examined. There was a relative dearth of research providing a high level of evidence. Only one methodologically sound trial was found that compared pain relief with systemic antibiotic/analgesic treatment against a placebo/analgesic combination during the acute preoperative phase of irreversible pulpitis. Although the selected study used a relatively small, low-powered sample, it did provide some evidence that there is no significant difference in pain relief for patients with untreated irreversible pulpitis who received antibiotics versus those who did not. These findings increase the rationale to investigate the teaching of safe and effective antibiotic prescribing in endodontics and to advance the development of appropriate evidence-based clinical guidelines.

Antibiotic use for irreversible pulpitis

Keenan JV, Farman AG, Fedorowicz Z, Newton JT. Cochrane Database Syst Rev. 2005;(2):CD004969

BACKGROUND: Irreversible pulpitis, which is characterised by acute and intense pain, is one of the most frequent reasons that patients attend for emergency dental care. Apart from removal of the tooth the customary way of relieving the pain of irreversible pulpitis is by drilling into the tooth, removing the inflamed pulp (nerve) and cleaning the root canal. However, a significant minority of dentists continue to prescribe antibiotics to stop the pain of irreversible pulpitis. **OBJECTIVES:** The objective of this review was to provide reliable evidence regarding the effectiveness of prescribing systemic antibiotics for irreversible pulpitis by comparing clinical outcomes expressed as pain relief. **SEARCH STRATEGY:** We searched the following databases: Cochrane Oral Health Group Trials Register and Pain, Palliative Care and Supportive (PaPaS) Care Group Trials Register to 6th September 2004; the Cochrane Central Register of Controlled Trials (CENTRAL) The Cochrane Library Issue 3 2004; MEDLINE (1966 to 6th September 2004); EMBASE (1980 to week 36 2004). **SELECTION CRITERIA:** This review includes one randomised controlled trial which compared pain relief with systemic antibiotics and analgesics, against placebo and analgesics in the acute preoperative phase of irreversible pulpitis. **DATA COLLECTION AND ANALYSIS:** Only one trial is included in this review, therefore pooling of data from studies was not possible and a descriptive summary is presented. **MAIN RESULTS:** One trial involving 40 participants was included in this review. There was a close parallel distribution of the pain ratings in both the intervention and placebo groups over the 7 day study period. The between-group differences in sum pain intensity differences (SPID) for the penicillin group were (6.0+/-10.5), and for placebo (6.0+/-9.5) P = 0.776. The sum pain percussion intensity differences (SPPID) for the penicillin group were (3.5+/-7.5) and placebo (2.0+/-7.0) P = 0.290, with differences as assessed by the Mann-Whitney-Wilcoxon test considered to be statistically significant at P < 0.05. There was no significant difference in the mean total number of ibuprofen tablets (P = 0.839) and Tylenol tablets (P = 0.325), in either group over the study period. The administration of penicillin over placebo did not appear to significantly reduce the quantity of analgesic medication taken (P > 0.05) for irreversible pulpitis. **AUTHORS' CONCLUSIONS:** This review which was based on one methodologically sound but low powered small sample trial provided some evidence that there is no significant difference in pain relief for patients with untreated irreversible pulpitis who did or did not receive antibiotics in addition to analgesics.

Emergency management of acute apical abscesses in the permanent dentition: a systematic review of the literature

Matthews DC, Sutherland S, Basrani B. J Can Dent Assoc. 2003;69(10):660

OBJECTIVE: To perform a systematic literature review and meta-analysis on the effectiveness of interventions used in the management of acute apical abscess in the permanent dentition. **METHODS:** Electronic databases were searched from their inception to March 2002. These searches, combined with manual searching, yielded 85 citations, of which 35 were relevant. Independent application of inclusion criteria by 3 reviewers yielded 8 eligible randomized controlled studies. Data on population, interventions, outcomes (reduction of pain or swelling or both, as reported by patients or clinicians) and methodological quality were determined by independent triplicate review. Disagreements were resolved by consensus. **RESULTS:** All papers included in the meta-analysis compared an antibiotic with an active control, a placebo

or no pharmacotherapy as an adjunct for patients who had received concomitant therapy (i.e., incision and drainage, endodontic therapy or extraction). The 8 trials were randomized; in 3 of these, the method of randomization was described and appropriate. Five studies were double-blinded, and 2 of these described the method of blinding. Four trials described withdrawals, but none included an intention-to-treat analysis. Six studies compared 2 antibiotics. For the outcomes "absence of infection" and "absence of pain" the pooled odds ratios (ORs) were not statistically significant; for the outcome "absence of pain and infection," 3 studies showed an equivalent treatment effect in both treatment and control groups. One open-label study (with a quality score of 2) showed a result favouring azithromycin over co-amoxiclav (OR 0.58, 95% confidence interval 0.35-0.96). Two studies compared adjunctive antibiotic therapy with placebo; no benefit to patients was demonstrated with this intervention. **CONCLUSIONS:** In the management of localized acute apical abscess in the permanent dentition, the abscess should be drained through a pulpectomy or incision and drainage. This analysis indicated that antibiotics are of no additional benefit. In the event of systemic complications (e.g., fever, lymphadenopathy or cellulitis), or for an immunocompromised patient, antibiotics may be prescribed in addition to drainage of the tooth.

Emergency management of acute apical periodontitis in the permanent dentition: a systematic review of the literature

Sutherland S, Matthews DC . J Can Dent Assoc. 2003;69(3):160

OBJECTIVE: To perform a systematic literature review and meta-analysis on the effectiveness of interventions used in the emergency management of acute apical periodontitis in the permanent dentition. **METHODS:** Electronic databases were searched from their inception to 2001. These searches, combined with manual searching, yielded 1,097 citations, of which 92 were relevant. Independent application of inclusion criteria by 2 teams of reviewers yielded 15 eligible randomized controlled trials. Data on population, interventions, outcomes (pain relief or change in intensity of pain as reported by patients or clinicians) and methodological quality were determined by independent duplicate review. Disagreements were resolved by consensus. **RESULTS:** Meta-analysis showed that pre-emptive analgesics (nonsteroidal anti-inflammatory drugs [NSAIDs]) in conjunction with pulpectomy provided a significant benefit (weighted mean difference -11.70, 95% confidence interval -22.84 to -0.56). Three interventions did not show significant benefit: systemic antibiotics, intracanal treatment with a steroid-antibiotic combination, and trephination through attached gingiva. **CONCLUSIONS:** In the management of pain associated with acute apical periodontitis, there is strong evidence to support the use of systemic NSAIDs in conjunction with nonsurgical endodontics. The use of antibiotics is not recommended.

Flare-ups after endodontic treatment: a meta-analysis of literature

Tsesis I, Faivishevsky V, Fuss Z, Zukerman O . Journal of Endodontics. 2008;34(10):1177-81

The purpose of this study was to determine the frequency of flare-ups and to evaluate factors that affect it by using meta-analysis of results of previous studies. MEDLINE database was searched by using Entrez PubMed search engine and Medical Subject Headings (MeSH) search with EviDents Search Engine to identify the studies dealing with endodontic flare-up phenomenon. The search covered all articles published in dental journals in English from 1966-May 2007, and the relevancy of 119 selected articles was evaluated by reading their titles and abstracts, from which 54 were rejected as irrelevant and 65 were subjected to a suitability test.

Six studies that met all the above mentioned criteria were included in the study. Average percentage of incidence of flare-ups for 982 patients was 8.4 (standard deviation +/-57). There were insufficient data to investigate the effect of the influencing factors.

Frequency of persistent tooth pain after root canal therapy: a systematic review and meta-analysis

Nixdorf DR, Moana-Filho EJ, Law AS, McGuire LA, Hodges JS, John MT . Journal of Endodontics. 2010;36(2):224-30

INTRODUCTION: Little is known about the frequency of persistent pain after endodontic procedures even though pain is a core patient-oriented outcome. We estimated the frequency of persistent pain, regardless of etiology, after endodontic treatment. **METHODS:** Persistent tooth pain was defined as pain present \geq 6 months after endodontic treatment. Endodontic procedures included in the review were pulpectomy, nonsurgical root canal treatment, surgical root canal treatment, and retreatment. Four databases were searched electronically complemented by hand searching. Two independent reviewers determined eligibility, abstracted data, and assessed study quality. A summary estimate of persistent all-cause tooth pain frequency was established by using a random-effects meta-analysis. Using subgroup analyses, we explored the influence of treatment approach (surgical/nonsurgical), longitudinal study design (prospective/retrospective), follow-up rate, follow-up duration, initial treatment versus retreatment, and quality of reporting (Strengthening the Reporting of Observational Studies in Epidemiology rankings) on the pain frequency estimate. **RESULTS:** Of 770 articles retrieved and reviewed, 26 met inclusion criteria. A total of 5,777 teeth were enrolled, and 2,996 had follow-up information regarding pain status. We identified 168 teeth with pain and derived a frequency of 5.3% (95% confidence interval, 3.5%-7.2%, $p < 0.001$) for persistent all-cause tooth pain. High and statistically significant heterogeneity among studies ($I^2 = 80\%$) was present. In subgroup analysis, prospective studies had a higher pain frequency (7.6%) than retrospective studies did (0.9%). Quality of study reporting was identified as the most influential reason for study heterogeneity. **CONCLUSIONS:** The frequency of all-cause persistent tooth pain after endodontic procedures was estimated to be 5.3%, with higher report quality studies suggesting $>7\%$.

Pain prevalence and severity before, during, and after root canal treatment: a systematic review

Pak, J. G., White, S. N. . Journal of Endodontics. 2011;37(4):429-38

INTRODUCTION: Anticipation and experience of root canal associated pain is a major source of fear for patients and a very important concern of dentists. Pretreatment, treatment, and posttreatment pain is anticipated, experienced, remembered, and shared by patients. The purpose was to determine the influence of root canal treatment on pain prevalence and severity and estimate the prevalence and severity of pretreatment, treatment, and posttreatment pain in patients receiving root canal treatment. **METHODS:** Defined searching of MEDLINE, Embase, Cochrane, and PsycINFO databases identified 5,517 articles. Systematic review, including title scanning, abstract scanning, full-text review, and quality rating, provided 72 studies for meta-analysis. L'Abbe plots were used to evaluate the influence of root canal treatment on pain prevalence and severity. Pretreatment, treatment, and posttreatment pain

prevalence and severity data were analyzed. RESULTS: L'Abbe plots revealed that pain prevalence and severity decreased substantially after treatment. Mean pretreatment, 24-hour posttreatment, and 1-week posttreatment pain prevalences with associated standard deviations were 81 (28%), 40 (24%), and 11 (14%), respectively. Pretreatment, 24-hour posttreatment, and 1-week posttreatment pain severities, on a 100-point scale, were 54 (24%), 24 (12%), and 5 (5%), respectively. Supplemental injections were frequently required (60 [24%]). CONCLUSIONS: Pretreatment root canal-associated pain prevalence was high but dropped moderately within 1 day and substantially to minimal levels in 7 days. Pretreatment root canal-associated pain severity was moderate, dropped substantially within 1 day of treatment, and continued to drop to minimal levels in 7[**NON-BREAKING SPACE**]days. Supplemental anesthesia was often required.

The prevalence of postoperative pain and flare-up in single- and multiple-visit endodontic treatment: a systematic review

Sathorn C, Parashos P, Messer H . Int Endod J. 2008;41(2):91-9

AIM: The aim of this systematic review was to assess the evidence regarding postoperative pain and flare-up of single- or multiple-visit root canal treatment. METHODOLOGY: CENTRAL, MEDLINE and EMBASE databases were searched. Reference lists from identified articles were scanned. A forward search was undertaken on the authors of the identified articles. Papers that had cited these articles were also identified through Science Citation Index to identify potentially relevant subsequent primary research. REVIEW METHODS: The included clinical studies compared the prevalence/severity of postoperative pain or flare-up in single- and multiple-visit root canal treatment. Data in those studies were extracted independently. RESULTS: Sixteen studies fitted the inclusion criteria in the review, with sample size varying from 60 to 1012 cases. The prevalence of postoperative pain ranged from 3% to 58%. The heterogeneity amongst included studies was far too great to conduct meta-analysis and yield meaningful results. CONCLUSION: Compelling evidence indicating a significantly different prevalence of postoperative pain/flare-up of either single- or multiple-visit root canal treatment is lacking.

A systematic review of cardiovascular effects of epinephrine on hypertensive dental patients

Bader JD, Bonito AJ, Shugars DA . Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;93(6):647-53

OBJECTIVE: A systematic review was conducted to identify any additional risks of adverse cardiovascular outcomes to hypertensive individuals represented by use of epinephrine-containing anesthetic solutions and epinephrine-impregnated retraction cords. STUDY DESIGN: Two searches identified 373 local anesthetic and 33 retraction cord reports; 6 local anesthetic reports met inclusion criteria. RESULTS: Use of epinephrine in uncontrolled hypertensive patients was associated with small, nonsignificant increases in systolic and diastolic blood pressure. No adverse outcomes were reported. Only one study examined effects of epinephrine on controlled hypertensive patients, in whom additional risks due to interactions with antihypertensive medication are possible. Available studies did not address effects of gingival retraction cord on hypertensive patients. CONCLUSIONS: Although the increased risk for adverse events among uncontrolled hypertensive patients was found to be low and the

reported occurrence of adverse events in hypertensive patients associated with the use of epinephrine in local anesthetics was minimal, the quantity and quality of the pertinent literature is problematic.

The effectiveness of an additional lingual infiltration in the pulpal anesthesia of mandibular teeth: a systematic review

Dou, L., Luo, J., Yang, D., Wang, Y. Quintessence Int. 2013;44(5):457-64

OBJECTIVES: The aim of this systematic review is to investigate the effect of an additional lingual infiltration on the pulpal anesthesia of mandibular teeth. **METHOD AND MATERIALS:** Prospective clinical trials were searched from Medline, EMBASE, Cochrane Library, Pubmed, SCI, and the China National Knowledge Infrastructure. Papers that met the inclusion criteria were accepted. Data was extracted by two investigators using a designed extraction form. The anesthetic efficacy of an additional lingual infiltration on the pulpal anesthesia of mandibular teeth was analyzed. **RESULTS:** Seven prospective randomized controlled trials were included. All subjects of these studies were volunteers with healthy pulps, without patients with pulpitis. Compared to buccal infiltration alone, an additional lingual infiltration following buccal infiltration is more likely to achieve a successful pulpal anesthesia in the mandibular incisor area, with a relative risk for success of 2.00 [1.08, 3.72] for 2% lidocaine and 1.32 [1.15, 1.51] for 4% articaine. For mandibular canines and premolars, the additional lingual infiltration following inferior alveolar nerve block did not enhance the anesthetic efficacy. In the mandibular molar area, no significant difference was found after an additional lingual infiltration with either 2% lidocaine or 4% articaine. **CONCLUSION:** An additional lingual infiltration following buccal infiltration can enhance the anesthetic efficacy compared with buccal infiltration alone in the mandibular incisor area. For mandibular canines, premolars, and molars, an additional lingual infiltration is not recommended, since no data exist to support such usage. Lingual infiltration of articaine in the mandibular teeth with pulpitis should be studied further.

Combining paracetamol (acetaminophen) with nonsteroidal antiinflammatory drugs: a qualitative systematic review of analgesic efficacy for acute postoperative pain

Ong CK, Seymour RA, Lirk P, Merry AF. Anesth Analg. 2010;110(4):1170-9

BACKGROUND: There has been a trend over recent years for combining a nonsteroidal antiinflammatory drug (NSAID) with paracetamol (acetaminophen) for pain management. However, therapeutic superiority of the combination of paracetamol and an NSAID over either drug alone remains controversial. We evaluated the efficacy of the combination of paracetamol and an NSAID versus either drug alone in various acute pain models. **METHODS:** A systematic literature search of Medline, Embase, Cumulative Index to Nursing and Allied Health Literature, and PubMed covering the period from January 1988 to June 2009 was performed to identify randomized controlled trials in humans that specifically compared combinations of paracetamol with various NSAIDs versus at least 1 of these constituent drugs. Identified studies were stratified into 2 groups: paracetamol/NSAID combinations versus paracetamol or NSAIDs. We analyzed pain intensity scores and supplemental analgesic requirements as primary outcome measures. In addition, each study was graded for quality using a validated scale. **RESULTS:** Twenty-one human studies enrolling 1909 patients were analyzed. The NSAIDs used were ibuprofen (n = 6), diclofenac (n = 8), ketoprofen (n = 3),

ketorolac (n = 1), aspirin (n = 1), tenoxicam (n = 1), and rofecoxib (n = 1). The combination of paracetamol and NSAID was more effective than paracetamol or NSAID alone in 85% and 64% of relevant studies, respectively. The pain intensity and analgesic supplementation was 35.0% +/- 10.9% and 38.8% +/- 13.1% lesser, respectively, in the positive studies for the combination versus paracetamol group, and 37.7% +/- 26.6% and 31.3% +/- 13.4% lesser, respectively, in the positive studies for the combination versus the NSAID group. No statistical difference in median quality scores was found between experimental groups. **CONCLUSION:** Current evidence suggests that a combination of paracetamol and an NSAID may offer superior analgesia compared with either drug alone.

Does Articaine Provide an Advantage over Lidocaine in Patients with Symptomatic Irreversible Pulpitis? A Systematic Review and Meta-analysis

Jason Kung JOE 2016

Introduction Achieving profound pulpal anesthesia can be difficult in patients with symptomatic irreversible pulpitis. This study provides a systematic review and meta-analysis to address the population, intervention, comparison, outcome (PICO) question: in adults with symptomatic irreversible pulpitis who are undergoing endodontic treatment, what is the comparative efficacy of articaine compared with lidocaine in reducing pain and incidence of adverse events? **Methods** A protocol was prepared and registered on PROSPERO. Electronic searches were conducted in MEDLINE, Scopus, Cochrane Library, and ClinicalTrials.gov by using strict inclusion and exclusion criteria. Two independent reviewers assessed eligibility for inclusion and quality. Weighted anesthesia success rates and 95% confidence intervals (CIs) were estimated and compared by using a random-effects model. **Results** Two hundred seventy-five studies were initially identified from the search; 10 double-blind, randomized clinical trials met the inclusion criteria. For combined studies, articaine was more likely than lidocaine to achieve successful anesthesia (odds ratio [OR], 2.21; 95% CI, 1.41–3.47; $P = .0006$; $I^2 = 40\%$). Maxillary infiltration subgroup analysis showed no significant difference between articaine and lidocaine (OR, 3.99; 95% CI, 0.50–31.62; $P = .19$; $I^2 = 59\%$). For combined mandibular anesthesia studies articaine was superior to lidocaine (OR, 2.20; 95% CI, 1.40–3.44; $P = .0006$; $I^2 = 30\%$), with further subgroup analysis showing no difference for mandibular block anesthesia (OR, 1.44; 95% CI, 0.87–2.38; $P = .16$; $I^2 = 0\%$). When used for supplemental infiltration after successful mandibular block anesthesia, articaine was significantly more effective than lidocaine (OR, 3.55; 95% CI, 1.97–6.39; $P < .0001$; $I^2 = 9\%$). There were no reports of adverse events. **Conclusions** This systematic review of double-blind, randomized clinical trials provides level 1 evidence to support the use of articaine for patients with symptomatic irreversible pulpitis. There is a significant advantage to using articaine over lidocaine for supplementary infiltration after mandibular block anesthesia but no advantage when used for mandibular block anesthesia alone or for maxillary infiltration.

Efficacy and safety of articaine versus lidocaine for irreversible pulpitis treatment: A systematic review and meta-analysis of randomised controlled trials

Naichuan Su Aus End Journal 2016

The aim was to assess the efficacy and safety of articaine compared with lidocaine for irreversible pulpitis (IP) treatment. Databases were explored electronically and relevant journals as well as the references of the included studies were hand-searched for randomised clinical trials comparing the efficacy and safety of articaine with lidocaine in treatment of IP. Twenty studies were included, of which eight had low risk of bias, 10 had moderate risk of bias and two had high risk of bias. In comparison with 2% lidocaine with 1:100 000 epinephrine, 4% articaine with 1:100 000 epinephrine showed a higher success rate in anaesthesia of IP at either person (risk ratio (RR) 1.15; 95% confidence intervals (CI) 1.10 1.20; $P < 0.00001$) or tooth unit (RR 1.10; 95% CI 1.10 1.19, $P < 0.00001$), lower VAS scores during injection phase (mean difference (MD) -0.67 ; 95% CI $-1.26 -0.08$, $P = 0.02$) and treatment phase (MD -3.35 ; 95% CI $-3.78 -2.91$, $P < 0.00001$), shorter onset time of pulpal anaesthesia (MD -0.94 ; 95% CI $-1.13 -0.74$, $P < 0.00001$) and lower percentage of patients undergoing adverse events (RR 0.17; 95% CI 0.03 0.92, $P = 0.04$). Given the efficacy and safety of the two solutions, 4% articaine with 1:100 000 epinephrine was superior to 2% lidocaine with 1:100 000 epinephrine in dental treatments in IP.

Effectiveness of Antimicrobial Prophylaxis in Preventing the Spread of Infection as a Result of Oral Procedures: A Systematic Review and Meta-Analysis.

Moreno-Drada JA J Oral Maxillofac Surg. 2016

PURPOSE: To determine the effectiveness of prophylactic antibiotics for preventing localized infections of the oral cavity, neck, and thoracic cavity in patients undergoing oral procedures. **MATERIALS AND METHODS:** A systematic review and meta-analysis was performed. A search strategy was applied to the Medline database through Ovid, EMBASE, LILACS, the Cochrane Central Register of Controlled Trials, and OpenGrey. Clinical trials were included, and studies in which patients underwent procedures outside the oral cavity were excluded. Statistical analysis was performed using Stata 13 and RevMan 5.3. A risk of bias assessment was performed according to Cochrane recommendations. **RESULTS:** For the primary results of oral cavity infection with antibiotic intervention versus placebo, 6 studies with a risk difference (RD) of -0.025 were included (95% confidence interval [CI], -0.043 to -0.007). For bacteremia with antibiotic intervention versus placebo, 7 studies with an RD of -0.278 were included (95% CI, -0.380 to -0.176); when an analysis of antibiotic versus antibiotic was performed, 6 studies with an RD -0.072 were included (95% CI, -0.255 to -0.112), favoring antibiotic prophylaxis. There was no evidence of neck and thoracic cavity infection. For type of treatment, implant surgery with placebo showed an RD of -0.021 (95% CI, -0.043 to 0.001), whereas an RD -0.245 was observed when performing tooth extraction (95% CI, -0.337 to -0.154). **CONCLUSION:** The incidence of infections in the oral cavity decreased with the use of antibiotic prophylaxis in patients undergoing tooth extraction. However, for implant surgery and endodontic surgery, prophylactic antibiotic showed no differences compared with placebo. No infections in the neck or thoracic cavity were reported. It is necessary to evaluate antibiotic prophylaxis in high-risk patient.

Effect of premedication to provide analgesia as a supplement to inferior alveolar nerve block in patients with irreversible pulpitis

J Am Dent Assoc. 2016

BACKGROUND: The authors' objective was to determine whether scientific evidence supports the use of oral premedication to increase the efficacy of inferior alveolar nerve block (IANB) and to decrease endodontic treatment pain in patients with diagnosed irreversible pulpitis. **TYPES OF STUDIES REVIEWED:** The authors included randomized controlled trials that involved enteral premedication and 2% lidocaine IANB for adults with irreversible pulpitis compared with placebo. In particular, the authors reviewed studies comparing nonsteroidal anti-inflammatory drugs (NSAIDs), benzodiazepines, acetaminophen, and corticosteroids with placebo. The authors searched the following electronic databases: the Cochrane Library, MEDLINE, and Web of Science. **RESULTS:** The authors analyzed 9 randomized controlled clinical trials. Patients who took the NSAIDs under study, including ibuprofen, ketorolac, diclofenac, indomethacin, and lornoxicam, 1 hour before endodontic treatment showed statistically significant improvement in the outcome of having "little or no pain" during endodontic treatment compared with patients who took a placebo 1 hour before endodontic treatment (risk ratio [RR], 1.989; 95% confidence interval [CI], 1.495-2.646; $P < .001$). Benzodiazepines were not as well represented in the literature, but the 2 included studies did not show a significant improvement in patients' having "little or no pain" during endodontic treatment over placebo (RR, 0.989; 95% CI, 0.677-1.444; $P = .954$). **CONCLUSIONS AND PRACTICAL IMPLICATIONS:** There is moderate evidence to support the use of oral NSAIDs—in particular, ibuprofen (600 milligrams)—1 hour before the administration of IANB local anesthetic (1.8-3.6 milliliters of 2% lidocaine) to provide additional analgesia to the patient.

Restoration of endodontically treated teeth

A review of failure modes in teeth restored with adhesively luted endodontic dowels

Rasimick, B. J., Wan, J., Musikant, B. L., Deutsch, A. S. Journal of Prosthodontics. 2010;19(8):639-46

PURPOSE: Previous clinical studies indicated loss of retention between dowel and tooth was a major cause of failure for passive endodontic dowels. Advances in luting cement technology may have improved the retention of dowels. The purpose of this systematic review was to determine the clinical failure modes for dowel/core/crown restorations luted using resin-based cements that are either self-etching or used in conjunction with a bonding agent. **MATERIALS AND METHODS:** PubMed was searched for English language, peer-reviewed clinical research following restorations for 2 years or longer. For inclusion, a study group must have followed more than 50 permanent teeth restored using a dowel luted with resin cement and a bonding agent. Furthermore, more than 80% of the restorations must have received a nonresin crown. **RESULTS:** Fifteen studies met the inclusion criteria and reported a total of 187 failures from 3046 restorations. The commonly reported causes of failure were dowel debonding (37% of all failures and primary cause in 8 of the 17 reporting study groups) and endodontic lesions (37% of all failures and primary cause in 6 of the 11 reporting study groups). **CONCLUSIONS:** Loss of retention remains a major mode of failure even for passive, nonmetal dowels luted by resin cements with a bonding agent. The exact nature and underlying causes of debonding have not been adequately investigated.

A systematic review of single crowns on endodontically treated teeth

Stavropoulou AF, Koidis PT . J Dent. 2007;35(10):761-7

OBJECTIVES: To test the hypothesis that the placement of a crown is associated with improved (long term) survival of root canal treated teeth, using a systematic review process of clinical studies. **DATA SOURCES:** Papers referring to single crowns on endodontically treated teeth were located by a MEDLINE search and hand searching. One thousand six hundred and nine references were found, and they were subjected to a systematic review procedure. **STUDY SELECTION:** A three-step inclusion-exclusion procedure was applied to identify papers that represented; good scientific practice (GSP), reported results of all patients, restorations on root canal treated teeth (RCT) for more than 2 years and had sufficient data to generate life table analyses. The outcomes were 'survival of RCT restored with crowns' and 'survival of RCT with direct restorations'. Ten studies survived. These data showed an overall mean GSP of 0.605 with a 10-year survival of 81% for crowned RCT and a 10-year survival of 63% for RCT with direct restorations (resin composites, amalgam, cements). **CONCLUSION:** RCTs restored with crowns show an acceptable long-term survival of 10 years, while direct restorations have a satisfactory survival only for a short period.

Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies)

Dietschi D, Duc O, Krejci I, Sadan A . Quintessence Int. 2008;39(2):117-29

OBJECTIVE: The restoration of endodontically treated teeth has long been guided by empirical rather than biomechanical concepts. Part I of this literature review presented up-to-date knowledge about changes in tissue structure and properties following endodontic therapy, as well as the behavior of restored teeth in monotonic mechanical tests or finite element analysis. The aim of the second part is to review current knowledge about the various interfaces of restored, nonvital teeth and their behavior in fatigue and clinical studies. **REVIEW METHOD:** The basic search process included a systematic review of articles contained in the PubMed/Medline database, dating between 1990 and 2005, using single or combined key words to obtain the most comprehensive list of references; a perusal of the references of the references completed the review. **RELEVANT INFORMATION AND CONCLUSIONS:** Nonvital teeth restored with composite resin or composite resin combined with fiber posts resisted fatigue tests and currently represent the best treatment option. In comparison to rigid metal and/or ceramic posts, when composite resin or composite resin/fiber posts fail, the occurrence of interfacial defects or severe tooth breakdown is less likely. Adhesion into the root, however, remains a challenge because of the unfavorable ovoid canal configuration, as well as critical dentin microstructure in the deepest parts of the canal. Thus, specific combinations of adhesives and cements are recommended. The clinical performance of post-and-core restorations proved satisfactory overall, in particular with a contemporary restorative approach using composite resin and fiber posts. However, the clinical literature does not clearly isolate or identify exact parameters critical to success. This, in turn, emphasizes the importance and relevance of in vitro studies to further improve the quality and long-term stability of prosthetic foundation

Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature--Part 1. Composition and micro- and macrostructure alterations

Dietschi D, Duc O, Krejci I, Sadan A . Quintessence Int. 2007;38(9):733-43

The specific biomechanical alterations related to vitality loss or endodontic procedures are confusing issues for the practitioner and have been controversially approached from a clinical standpoint. The aim of part 1 of this literature review is to present an overview of the current knowledge about composition changes, structural alterations, and status following endodontic therapy and restorative procedures. The basic search process included a systematic review of the PubMed/Medline database between 1990 and 2005, using single or combined key words to obtain the most comprehensive list of references; a perusal of the references of the relevant sources completed the review. Only negligible alterations in tissue moisture and composition attributable to vitality loss or endodontic therapy were reported. Loss of vitality followed by proper endodontic therapy proved to affect tooth biomechanical behavior only to a limited extent. Conversely, tooth strength is reduced in proportion to coronal tissue loss, due to either caries lesion or restorative procedures. Therefore, the best current approach for restoring endodontically treated teeth seems to (1) minimize tissue sacrifice, especially in the cervical area so that a ferrule effect can be created, (2) use adhesive procedures at both radicular and coronal levels to strengthen remaining tooth structure and optimize restoration stability and retention, and (3) use post and core materials with physical properties close to those of natural dentin, because of the limitations of current adhesive procedures.

Clinical studies of fiber posts: a literature review

Cagidiaco MC, Goracci C, Garcia-Godoy F, Ferrari M . Int J Prosthodont. 2008;21(4):328-36

PURPOSE: This literature review aimed to find answers to relevant questions regarding the clinical outcome of endodontically treated teeth restored with fiber posts. **MATERIALS AND METHODS:** All clinical studies published since 1990 in journals indexed in MEDLINE were retrieved by searching PubMed with the query terms "fiber posts and clinical studies." The reference list of the collected articles was also screened for further relevant citations. The strength of the evidence provided by the reviewed papers was assessed according to the criteria of evidence-based dentistry. **RESULTS:** Five randomized controlled trials (RCTs) on fiber posts have been published in peer-reviewed journals. A meta-analysis is not applicable to these studies since they do not address the same specific clinical question. Retrospective and prospective trials without controls are also available. **CONCLUSIONS:** Two RCTs indicate that fiber-reinforced composite posts outperform metal posts in the restoration of endodontically treated teeth. However, this evidence cannot be considered as conclusive. Longer-term RCTs would be desirable. The placement of a fiber-reinforced composite post protects against failure, especially under conditions of extensive coronal destruction. The most common type of failure with fiber-reinforced composite posts is debonding.

Comparison of fracture resistance between cast posts and fiber posts: a meta-analysis of literature

Zhou, L., Wang, Q. . Journal of Endodontics. 2013;39(1):11-5

INTRODUCTION: The aim of this study was to compare the fracture resistance of cast posts versus the fracture resistance of fiber posts by means of meta-analysis when they were used in the restoration of endodontically treated teeth. **METHODS:** MEDLINE, Cochrane Controlled Trials Register, China National Knowledge Infrastructure, and China Biology Medicine disc were used in the literature search. Two independent reviewers assessed the titles and abstracts of all articles that were found according to the predefined inclusion criteria. Relevant articles were acquired in full-text form. Data in these studies were independently extracted. Standardized mean differences of included studies were combined and analyzed by using meta-analysis. **RESULTS:** Thirteen studies met the inclusion criteria. There was considerable heterogeneity among these studies. The standardized mean difference of the combined data was 0.64 (95% confidence interval, 0.08-1.20; $P < .001$), indicating that the cast post group displayed significantly higher fracture resistance than the fiber post group. **CONCLUSIONS:** On the basis of the current best available evidence, we concluded that cast posts had higher fracture resistance than fiber posts.

Do Metal Post-retained Restorations Result in More Root Fractures than Fiber Post-retained Restorations? A Systematic Review and Meta-analysis

Figueiredo, F. E., Martins-Filho, P. R., Faria, E. Silva A. L. J Endod. 2014;51(1):62-74

INTRODUCTION: Teeth requiring endodontic treatment commonly have compromised a coronal tooth structure that often requires the use of an intraradicular post to retain the coronal restoration. Although usually successful, catastrophic failures requiring extraction have been

reported in the literature. The aim of this systematic review was to analyze clinical trials and cohort studies that evaluated the incidence rate of root fractures in post-retained restorations. The hypothesis was that the incidence rate related to the use of metal posts was higher than that of fiber posts. METHODS: A MEDLINE search for clinical studies reporting the incidence of root fractures of restorations retained with fiber posts or metal posts of endodontically treated teeth with a more than 5-year follow-up was conducted from inception to January 2014. Seven randomized clinical trials and 7 cohort studies were included. RESULTS: The pooled survival rate was 90% (95% confidence interval, 85.5-93.3) for metal-based posts and 83.9% (95% confidence interval, 67.6-92.8) for fiber-reinforced posts. The overall incidence rate of root fractures (catastrophic failures) was similar between metal and fiber posts. Prefabricated metal posts and carbon fiber posts had a 2-fold increase in the incidence rate of root fractures compared with cast metal posts and glass fiber posts, respectively. CONCLUSIONS: The results of this study did not show significant differences for root fracture incidence between metal- and fiber posts. However, the studies included in this review presented a high risk of bias, and further well-designed clinical studies are required to confirm these findings.

Fiber-based post systems: a review

Bateman G, Ricketts DN, Saunders WP . Br Dent J. 2003;195(1):43-8;

OBJECTIVES: This article presents a review of published literature examining fibre-based endodontic post systems. DATA SOURCES: A MEDLINE search was carried out for any articles in dental journals pertaining to fibre-based post systems. Wherever possible articles cited were obtained from the journals and where this was not possible abstracts were obtained. Where no abstract was available the article was not considered for evaluation. DATA EXTRACTION: Articles were reviewed by a single observer and subject to meeting inclusion criteria were included in the review. Fifty-nine articles were considered suitable for inclusion. DATA SYNTHESIS: Articles were divided into categories and a subjective description of the articles was made. CONCLUSIONS: Review indicated that (1) most published literature on fibre-based posts took the form of laboratory analyses; (2) evidence for carbon-fibre posts far exceeds that for quartz-fibre posts; (3) laboratory evidence was contradictory and could not be used to inform practice reliably; (4) few clinical studies have been carried out though these have suggested fibre based posts may be clinically appropriate for restoration of the endodontically treated tooth; and (5) controlled prospective clinical trials evaluating fibre-based posts should be undertaken to inform use for clinical practice.

Root canal posts for the restoration of root filled teeth

Bolla M, Muller-Bolla M, Borg C, Lupi-Pegurier L, Laplanche O, Leforestier E . Cochrane Database Syst Rev. 2007;(1)

BACKGROUND: The foundation for the reconstruction of endodontically-treated teeth can be provided by a metal or a non-metal post and core system but no guidelines exist for choosing one or the other in particular clinical cases. OBJECTIVES: To assess the effectiveness of different post and core systems for the restoration of endodontically-treated teeth. The primary objective of this review was to compare the clinical failure rates of the different types of posts. SEARCH STRATEGY: We searched the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library 2005, Issue 3), MEDLINE (from 1966 to September

2005), Scopus (from January 1985 to December 2004) and EMBASE (until December 2004). We looked through reference lists of articles and dental conference proceedings. We contacted researchers in the field and manufacturers. **SELECTION CRITERIA:** Randomised or quasi-randomised clinical trials (RCTs) comparing failures on endodontically-treated permanent teeth with different types of post. The outcomes were loss of retention, post fracture and root fracture. **DATA COLLECTION AND ANALYSIS:** Two review authors (Michele Muller-Bolla (MMB) and Cybele Borg (CB)) independently assessed the quality of trials and extracted data. Study authors were contacted for additional information. **MAIN RESULTS:** Two trials involving 317 participants were included but only one of them, involving 200 participants, compared metal to non-metal posts. The other answered to the secondary objective. The risk of failure was greater with metal-cast posts (9/98) compared to carbon fibre posts (0/97) (risk ratio (RR) = 0.05 (95% confidence interval (CI) 0.00 to 0.90)) but the study was at high risk of bias. Thus fewer failures occurred when using non-metal posts but the evidence is unreliable. **AUTHORS' CONCLUSIONS:** Our systematic review could not specify which type of post and core system should be used when two or three dentine walls remain. More RCTs are needed to confirm whether fibre-reinforced post and core systems are superior and to clarify the influence of the remaining tooth structure on the treatment outcome of the different post and core systems available. Well-defined inclusion criteria focusing on the number of dentine walls (two or three) should be used.

Single crowns versus conventional fillings for the restoration of root filled teeth

Fedorowicz, Z., Carter, B., de Souza, R. F., Chaves, C. A., Nasser, M., Sequeira-Byron, P. The Cochrane database of systematic reviews. 2012;5(2):CD009109

BACKGROUND: Endodontic treatment, involves removal of the dental pulp and its replacement by a root canal filling. Restoration of root filled teeth can be challenging due to structural differences between vital and non-vital root filled teeth. Direct restoration involves placement of a restorative material e.g. amalgam or composite directly into the tooth. Indirect restorations consist of cast metal or ceramic (porcelain) crowns. The choice of restoration depends on the amount of remaining tooth which may influence long term survival and cost. The comparative in service clinical performance of crowns or conventional fillings used to restore root filled teeth is unclear. **OBJECTIVES:** To assess the effects of restoration of endodontically treated teeth (with or without post and core) by crowns versus conventional filling materials. **SEARCH METHODS:** We searched the following databases: the Cochrane Oral Health Group's Trials Register, CENTRAL, MEDLINE via OVID, EMBASE via OVID, CINAHL via EBSCO, LILACS via BIREME and the reference lists of articles as well as ongoing trials registries. There were no restrictions regarding language or date of publication. Date of last search was 13 February 2012. **SELECTION CRITERIA:** Randomized controlled trials (RCTs) or quasi-randomized controlled trials in participants with permanent teeth which have undergone endodontic treatment. Single full coverage crowns compared with any type of filling materials for direct restoration, as well as indirect partial restorations (e.g. inlays and onlays). Comparisons considered the type of post and core used (cast or prefabricated post), if any. **DATA COLLECTION AND ANALYSIS:** Two review authors independently assessed trial quality and extracted data. **MAIN RESULTS:** One trial judged to be at high risk of bias due to missing outcome data, was included. 117 participants with a root filled premolar tooth restored with a carbon fiber post, were randomized to either a full coverage metal-ceramic crown or direct adhesive composite restoration. At 3 years there was no reported difference

between the non-catastrophic failure rates in both groups. Documentation of the post and marginal gap formation occurred in a small number of teeth. **AUTHORS' CONCLUSIONS:** There is insufficient evidence to support or refute the effectiveness of conventional fillings over crowns for the restoration of root filled teeth. Until more evidence becomes available clinicians should continue to base decisions on how to restore root filled teeth on their own clinical experience, whilst taking into consideration the individual circumstances and preferences of their patients.

The restoration of endodontically treated, single-rooted teeth with cast or direct posts and cores: a systematic review

Heydecke G, Peters MC . J Prosthet Dent. 2002;87(4):380-6

Direct post-and-core restorations with prefabricated posts are becoming increasingly popular. A literature review was conducted to compare the clinical and in vitro performance of cast posts and cores to that of direct cores with prefabricated posts in single-rooted teeth. Research on the restoration of endodontically treated teeth was identified through a search of electronic databases. The search yielded a total of 1773 references. After these references were subjected to strict inclusion criteria, 10 in vitro and 6 in vivo studies remained and critically reviewed. A comparison of fracture loads in the in vitro studies revealed no significant difference between cast and direct posts and cores. Meta-analysis of the data suggested that there is no difference in fracture behavior associated with the 2 treatment modalities. An overall survival analysis was not possible for the in vivo studies. The survival for cast posts and cores in 2 studies ranged from 87.2% to 88.1% and in a third study reached 86.4% for direct cores after 72 months. Randomized clinical trials on this topic were not available but should be conducted to verify published findings

Do Metal Post-retained Restorations Result in More Root Fractures than Fiber Post-retained Restorations? A Systematic Review and Meta-analysis

Fabrcio Eneas Diniz Figueiredo JOE 2015

Introduction Teeth requiring endodontic treatment commonly have compromised a coronal tooth structure that often requires the use of an intraradicular post to retain the coronal restoration. Although usually successful, catastrophic failures requiring extraction have been reported in the literature. The aim of this systematic review was to analyze clinical trials and cohort studies that evaluated the incidence rate of root fractures in post-retained restorations. The hypothesis was that the incidence rate related to the use of metal posts was higher than that of fiber posts. **Methods** A MEDLINE search for clinical studies reporting the incidence of root fractures of restorations retained with fiber posts or metal posts of endodontically treated teeth with a more than 5-year follow-up was conducted from inception to January 2014. Seven randomized clinical trials and 7 cohort studies were included. **Results** The pooled survival rate was 90% (95% confidence interval, 85.5–93.3) for metal-based posts and 83.9% (95% confidence interval, 67.6–92.8) for fiber-reinforced posts. The overall incidence rate of root fractures (catastrophic failures) was similar between metal and fiber posts. Prefabricated metal posts and carbon fiber posts had a 2-fold increase in the incidence rate of root fractures compared with cast metal posts and glass fiber posts, respectively. **Conclusions** The results of

this study did not show significant differences for root fracture incidence between metal- and fiber posts. However, the studies included in this review presented a high risk of bias, and further well-designed clinical studies are required to confirm these findings.

Ferrule Effect: A Literature Review

Juloski JOE 2012

Introduction Preserving intact coronal and radicular tooth structure, especially maintaining cervical tissue to create a ferrule effect, is considered to be crucial for the optimal biomechanical behavior of restored teeth. The ferrule effect has been extensively studied and still remains controversial from many perspectives. The purpose of this study was to summarize the results of research conducted on different issues related to the ferrule effect and published in peer-reviewed journals listed in PubMed. **Methods** The search was conducted using the following key words: “ferrule” and “ferrule effect” alone or in combination with “literature review,” “fracture resistance,” “fatigue,” “finite element analysis,” and “clinical trials.” **Results** The findings from reviewed articles were categorized into three main categories: laboratory studies, computer simulation, and clinical trials. Laboratory studies were further classified into subchapters based on the main aspect investigated in relation to the ferrule effect. **Conclusions** The presence of a 1.5- to 2-mm ferrule has a positive effect on fracture resistance of endodontically treated teeth. If the clinical situation does not permit a circumferential ferrule, an incomplete ferrule is considered a better option than a complete lack of ferrule. Including a ferrule in preparation design could lead to more favorable fracture patterns. Providing an adequate ferrule lowers the impact of the post and core system, luting agents, and the final restoration on tooth performance. In teeth with no coronal structure, in order to provide a ferrule, orthodontic extrusion should be considered rather than surgical crown lengthening. If neither of the alternative methods for providing a ferrule can be performed, available evidence suggests that a poor clinical outcome is very likely.

Outcome assessment

A systematic review on the outcome of surgical vs non-surgical procedure for the retreatment of periapical lesions

Del Fabbro M, Taschieri S . Minerva Stomatol. 2007;56(11-12):621-32

The most common therapeutical options for the retreatment of teeth with periapical pathosis are orthograde treatment and periapical surgery. The aim of this review was to evaluate the outcomes of surgical versus non-surgical retreatment, in order to provide clinicians with evidence-based information for decision making process. Articles were retrieved by electronic search strategy and traditional searching. Articles were selected based on strict inclusion criteria. The first criterion was the success of retreatment, as determined by clinical and radiographic criteria. The outcomes were further dichotomized according to functionality criteria. Two randomized trials (RCTs) were found. One hundred and twenty-six teeth were followed up after one year, and 82 after 4 years. The success rate for surgical treatment after one year was slightly better than non-surgical: 90.7% vs 80.6%, respectively, according to functional criteria. At the four-year evaluation (40 surgically treated and 42 non-surgically treated cases from 1 RCT) the outcomes were similar. A higher early post-operative discomfort was reported for surgically treated cases. There is no apparent advantage of using a surgical or non-surgical approach for the retreatment of periapical lesions in terms of long-term outcome. The choice between the two procedures should rely upon factors other than the mere treatment outcome, such as patient's initial clinical situation, patient's preference, operator's experience and skill, complication risk, technical feasibility, and overall treatment cost. More well-designed RCTs should be performed with a large sample size and at least 4 years follow-up, using modern instrumentation and materials, to detect a true difference in the long term between the outcomes of the two alternative treatments, if any exists.

An introduction to meta-analysis within the framework of multilevel modelling using the probability of success of root canal treatment as an illustration

Lewsey JD, Gilthorpe MS, Gulabivala K . Community Dent Health. 2001;18(3):131-7

OBJECTIVE: To introduce the statistical methodology of meta-analysis within the framework of multilevel modelling (MLM) using an illustrative example. **BASIC RESEARCH DESIGN:** In meta-analysis it is important that the quantitative pooling of study results should be carried out in conjunction with careful consideration of the variation apparent between studies. If statistical heterogeneity is found to be significant, it is due, at least in part, to clinical heterogeneity. It is possible to account for clinical heterogeneity by including covariates that are thought to be responsible, using meta-regression. **CLINICAL SETTING:** A total of 38 studies of root canal treatment outcome were identified as being suitable for introducing the meta-analysis methodology. Two covariates were considered for modelling: a 'loose' or 'strict' (loose--incomplete radiographic healing; strict--complete radiographic healing) criterion for judging outcome of treatment and the year in which the study was performed. **RESULTS:** There was considerable statistical heterogeneity between the study results. The effect of employing loose criteria for judging success significantly increased the probability of success when compared to employing strict criteria. Furthermore, the variance between studies was significantly reduced when this covariate was included in the modelling process when

compared to the variation estimated in the model which did not consider covariates.
CONCLUSION: MLM is a good facilitator for meta-analysis and meta-regression.

Endodontic therapy using magnification devices: a systematic review

Del Fabbro M, Taschieri S . Journal of Dentistry. 2010;38(4):269-75

OBJECTIVES: The purpose of this systematic review was to investigate if the use of magnification devices in endodontics is associated with the improvement of clinical and radiographic outcomes. DATA: The treatment success as determined by clinical and radiographic evaluation after 1-year follow-up was the main outcome. The main search terms used alone or in combination were: endodontic treatment, endodontic therapy, endodontic surgery, apicoectomy, periapical surgery, microscope, endoscope, loupes, magnification devices. SOURCES: The authors searched MEDLINE, Embase, Cochrane Oral Health Specialized Register, Cochrane Central Register of Controlled Trials for articles published up to September 2009 plus hand-searching of relevant journals and reference list of pertinent reviews and included studies. STUDY SELECTION: Prospective clinical trials comparing endodontic therapy performed with or without using magnification devices, as well as trials comparing two or more magnification devices for endodontic therapy were considered. CONCLUSIONS: Three prospective studies were included, all dealing with endodontic surgery. No significant difference in outcomes was found among patients treated using magnifying loupes, surgical microscope or endoscope. Similarly, no difference was found with or without using the endoscope. No comparative study on magnification devices was found regarding orthograde endodontic treatment. The type of magnification device per se can only minimally affect the treatment outcome. Well-designed randomized trials should be performed to determine the true difference in treatment outcomes when using a magnification device in both orthograde and surgical endodontic treatment, if any exist.

Endosseous implants versus nonsurgical root canal therapy: a systematic review of the literature

Blicher B, Baker D, Lin J . General Dentistry. 2008;56(6):576-80; 581-2

For this article, the authors identified and reviewed the current literature, addressing two treatment options for endodontically involved teeth: root canal therapy and restoration versus extraction and the placement of a dental implant. The literature was evaluated as a basis for making treatment decisions. PubMed was queried for all studies that compared nonsurgical root canal therapy (NSRCT) and restoration with the extraction of teeth and placement of a dental implant. This search was supplemented by searching the bibliographies of these studies to ensure that all relevant studies were included. A total of 38 studies were found that directly compared NSRCT and restoration with extraction and placement of a dental implant. The literature is discussed in terms of outcomes for both treatment options, considerations in treatment plan decision-making, or the opinions of the authors

Factors influencing the long-term results of endodontic treatment: a review of the literature

Basmadjian-Charles CL, Farge P, Bourgeois DM, Lebrun T . Int Dent J. 2002;52(2):81-6

The purpose of this review of the literature is to examine the factors and their influence on the outcome of endodontic treatments, and also to attempt to have an authors' consensus concerning the impact of these factors on long-term results. The documentary research was conducted using the meta-analysis principles of critical reading of the literature. Two groups of factors can be identified regarding the outcome of endodontic treatments: those which influence the success of the procedure and those which do not significantly affect the success rate. Agreement is obtained in all studies on two major factors, the preoperative periapical status and the apical limit of the obturation, which appear to strongly influence the success of endodontic therapy. This review highlights the methodological problems of retrospective studies and points out the need for consensus regarding the evaluation criteria of root canal therapy.

For teeth requiring endodontic treatment, what are the differences in outcomes of restored endodontically treated teeth compared to implant-supported restorations?

Iqbal MK, Kim S . Int J Oral Maxillofac Implants. 2007;22 Supp:96-116

PURPOSE: The clinical question this systematic review aimed to answer was "What are the differences in outcomes of restored endodontically treated teeth compared to implant-supported restorations? Therefore, the aim of this study was to use systematic review to compare the survival of compromised teeth restored with either root canal therapy followed by a crown, or placement of a single-tooth implant. **MATERIALS AND METHODS:** MEDLINE, EMBASE, and PubMed databases were searched for studies dealing with survival of single-tooth implants and restored endodontically treated teeth. A 2-step screening procedure was used to identify articles that met the inclusion/exclusion criteria. Fifty-five studies related to single-tooth implants and 13 studies related to restored root canal-treated teeth were included. The endpoint analyzed in these studies was the survival rate of the treated tooth or implant. **RESULTS:** The 95% confidence intervals for the pooled estimates for the single-tooth implants and restored endodontically treated teeth were found overlapping in forest plots for all follow-up periods. This indicated no significant differences in survival between restored root canal-treated teeth and single-tooth implants. **CONCLUSIONS:** The results of this systematic review indicate that the decision to treat a tooth endodontically or replace it with an implant must be based on factors other than the treatment outcomes of the procedures themselves. Both nonsurgical root canal therapy followed by an appropriate restoration and single-tooth implants are excellent treatment modalities for the treatment of compromised teeth.

Healing rate and post-obturation pain of single- versus multiple-visit endodontic treatment for infected root canals: a systematic review

Su, Y., Wang, C., Ye, L. . Journal of Endodontics. 2011;37(2):125-32

INTRODUCTION: The choice of single- versus multiple-visit root canal treatment for infected teeth is in dispute. The purpose of this systematic review was to compare the healing rate and post-obturation pain of single- versus multiple-visit root canal treatment for teeth with infected root canals. **METHODS:** An exhaustive literature search combined with specified inclusion criteria was performed to identify randomized or quasi-randomized controlled trials (RCTs or

quasi-RCTs), comparing root canal treatment in single and multiple appointments (2 or more visits) in patients with infected root canals. RESULTS: Ten RCTs were identified and included in this review. Of these, 6 compared the healing rate and 5 compared the prevalence of post-obturation pain in single- and multiple-visit root canal treatment on teeth with infected root canals. No significant difference was observed in the healing rate between single- versus multiple-visit root canal treatment, as well as the incidence of medium-term post-obturation pain. As to the short-term follow up, the prevalence of post-obturation pain was significantly lower in single-visit than in multiple-visit group. CONCLUSIONS: On the basis of current studies, the healing rate of single- and multiple-visit root canal treatment is similar for infected teeth. Patients experience less frequency of short-term post-obturation pain after single-visit than those having multiple-visit root canal treatment.

Single versus multiple visits for endodontic treatment of permanent teeth

Figini L, Lodi G, Gorni F, Gagliani M . Cochrane Database Syst Rev. 2007;(4):CD005296

BACKGROUND: Root canal treatment (RCT), or endodontic treatment, is a common procedure in dentistry. The main indications for RCT are irreversible pulpitis and necrosis of the dental pulp caused by carious processes, tooth cracks or chips, or dental trauma. Successful RCT is characterized by an absence of symptoms and clinical signs in teeth without radiographic evidence of periodontal involvement. The success of RCT depends on a series of variables related to the preoperative condition of the tooth, as well as the endodontic procedures. OBJECTIVES: To compare the effectiveness of single- and multiple-visit RCT, measured as tooth extraction due to endodontic problems and radiological success. To assess the difference in short- and long-term complications between single- and multiple-visit RCT. SEARCH STRATEGY: The following databases were searched for relevant trials: Cochrane Oral Health Group's Trials Register, CENTRAL, MEDLINE, and EMBASE. Hand searching was performed for the major oral medicine journals. References of included studies and reviews were checked. Endodontics experts were contacted through e-mail. No language limitations were imposed. Date of last search was 6th March 2007. SELECTION CRITERIA: Randomized and quasi-randomized controlled trials of patients needing RCT were included. Surgical endodontic treatment was excluded. The outcomes considered were the number of teeth extracted for endodontic problems; radiological success after at least 1 year, that is, absence of any periapical radiolucency; postoperative pain; painkiller use; swelling; or sinus track formation. DATA COLLECTION AND ANALYSIS: Data were collected using a specific extraction form. The validity of included studies was assessed on the basis of allocation concealment, blindness of the study, and loss of participants. Data were analyzed by calculating risk ratios. When valid and relevant data were collected, a meta-analysis of the data was undertaken. MAIN RESULTS: Twelve randomized controlled trials were included in the review. Four studies had a low risk of bias, four a moderate risk, and another four had a high risk of bias. The frequency of radiological success and immediate postoperative pain were not significantly different between single- and multiple-visit RCT. Patients undergoing single-visit RoCT reported a higher frequency of painkiller use and swelling, but the results for swelling were not significantly different between the two groups. We found no study that included tooth loss and sinus track formation among its primary outcomes. AUTHORS' CONCLUSIONS: No difference exists in the effectiveness of RCT, in terms of radiological success, between single- and multiple-visit RCT. Most short- and long-term complications are also similar in terms of frequency, although patients undergoing a single visit may experience a slightly higher frequency of swelling and are initiatively more likely to take painkillers.

Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis

Gillen, B. M., Looney, S. W., Gu, L. S., Loushine, B. A., Weller, R. N., Loushine, R. J., Pashley, D. H., Tay, F. R. . Journal of Endodontics. 2011;37(7):895-902

INTRODUCTION: Thorough cleaning and shaping of root canals are essential for periapical healing. Restoration of endodontically treated teeth is also required for them to function and prevent coronal leakage. This study compared the impact of the quality of root canal treatment versus the quality of coronal restoration in treatment outcomes. METHODS: Literature search was conducted using the search terms "coronal restoration," "root canal," "periapical status," and "quality." Articles that evaluated the effect of the quality of root filling and coronal restoration or both on the success of root canal treatment were selected. Nine articles were identified and were reviewed by 3 investigators. Data were collected based on predetermined criteria. Percentages of teeth without apical periodontitis were recorded for each category: adequate root canal treatment (AE), inadequate root canal treatment (IE), adequate restoration (AR), and inadequate restoration (IR). Data were analyzed using meta-analysis for odds ratios (ORs). RESULTS: After adjusting for significant covariates to reduce heterogeneity, the results were combined to obtain pooled estimates of the common OR for the comparison of AR/AE versus AR/IE (OR = 2.734; 95% confidence interval [CI], 2.61-2.88; P < .001) and AR/AE versus IR/AE (OR = 2.808; 95% CI, 2.64-2.97; P < .001). CONCLUSIONS: On the basis of the current best available evidence, the odds for[NON-BREAKING SPACE]healing of apical periodontitis increase with both adequate root canal treatment and adequate restorative treatment. Although poorer clinical outcomes may be expected with adequate root filling-inadequate coronal restoration and inadequate root filling-adequate coronal restoration, there is no significant difference in the odds of healing between these 2 combinations.

Outcome of endodontic surgery: a meta-analysis of the literature--part 1: Comparison of traditional root-end surgery and endodontic microsurgery

Setzer, F. C., Shah, S. B., Kohli, M. R., Karabucak, B., Kim, S. . Journal of Endodontics. 2010;36(11):1757-65

INTRODUCTION: The aim of this study was to investigate the outcome of root-end surgery. The specific outcome of traditional root-end surgery (TRS) versus endodontic microsurgery (EMS) and the probability of success for comparison of the 2 techniques were determined by means of meta-analysis and systematic review of the literature. METHODS: An intensive search of the literature was conducted to identify longitudinal studies evaluating the outcome of root-end surgery. Three electronic databases (Medline, Embase, and PubMed) were searched to identify human studies from 1966 to October 2009 in 5 different languages (English, French, German, Italian, and Spanish). Relevant articles and review papers were searched for cross-references. Five pertinent journals (Journal of Endodontics, International Endodontic Journal, Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics, Journal of Oral and Maxillofacial Surgery, International Journal of Oral and Maxillofacial Surgery) were individually searched back to 1975. Three independent reviewers (S.S., M.K., and F.S.) assessed the abstracts of all articles that were found according to predefined inclusion and exclusion criteria. Relevant articles were acquired in full-text form, and raw data were extracted independently by each reviewer. Qualifying papers were assigned to group TRS or group EMS. Weighted pooled success rates and relative risk assessment between TRS and EMS were calculated. A comparison between the groups was made by using a random effects model. RESULTS: Ninety-eight articles were identified and obtained for final analysis. In total,

21 studies qualified (12 for TRS [n = 925] and 9 for EMS [n = 699]) according to the inclusion and exclusion criteria. Weighted pooled success rates calculated from extracted raw data showed 59% positive outcome for TRS (95% confidence interval, 0.55-0.6308) and 94% for EMS (95% confidence interval, 0.8889-0.9816). This difference was statistically significant ($P < .0005$). The relative risk ratio showed that the probability of success for EMS was 1.58 times the probability of success for TRS. **CONCLUSIONS:** The use of microsurgical techniques is superior in achieving predictably high success rates for root-end surgery when compared with traditional techniques

Outcome of primary root canal treatment: systematic review of the literature - part 1. Effects of study characteristics on probability of success

Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Int Endod J. 2007;40(12):921-39

AIMS: The aims of this study were (i) to conduct a comprehensive systematic review of the literature on the outcome of primary (initial or first time) root canal treatment; (ii) to investigate the influence of some study characteristics on the estimated pooled success rates. **METHODOLOGY:** Longitudinal clinical studies investigating outcome of primary root canal treatment, published up to the end of 2002, were identified electronically (MEDLINE and Cochrane database 1966-2002 December, week 4). Four journals (International Endodontic Journal, Journal of Endodontics, Oral Surgery Oral Medicine Oral Pathology Endodontics Radiology and Dental Traumatology & Endodontics), bibliographies of all relevant papers and review articles were hand-searched. Three reviewers (Y-LN, SR and KG) independently assessed, selected the studies based on specified inclusion criteria, and extracted the data onto a pre-designed proforma. The study inclusion criteria were: longitudinal clinical studies investigating root canal treatment outcome; only primary root canal treatment carried out on the teeth studied; sample size given; at least 6-month postoperative review; success based on clinical and/or radiographic criteria (strict, absence of apical radiolucency; loose, reduction in size of radiolucency); overall success rate given or could be calculated from the raw data. The findings by individual study were summarized and the pooled success rates by each potential influencing factor were calculated for this part of the study. **RESULTS:** Of the 119 articles identified, 63 studies published from 1922 to 2002, fulfilling the inclusion criteria were selected for the review: six were randomized trials, seven were cohort studies and 48 were retrospective studies. The reported mean success rates ranged from 31% to 96% based on strict criteria or from 60% to 100% based on loose criteria, with substantial heterogeneity in the estimates of pooled success rates. Apart from the radiographic criteria of success, none of the other study characteristics could explain this heterogeneity. Twenty-four factors (patient and operative) had been investigated in various combinations in the studies reviewed. The influence of preoperative pulpal and periapical status of the teeth on treatment outcome were most frequently explored, but the influence of treatment technique was poorly investigated. **CONCLUSIONS:** The estimated weighted pooled success rates of treatments completed at least 1 year prior to review, ranged between 68% and 85% when strict criteria were used. The reported success rates had not improved over the last four (or five) decades. The quality of evidence for treatment factors affecting primary root canal treatment outcome is sub-optimal; there was substantial variation in the study-designs. It would be desirable to standardize aspects of study-design, data recording and presentation format of outcome data in the much needed future outcome studies.

Outcome of primary root canal treatment: systematic review of the literature -- Part 2.
Influence of clinical factors

Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K . Int Endod J. 2008;41(1):6-31

AIMS: (i) To carry out meta-analyses to quantify the influence of the clinical factors on the efficacy of primary root canal treatment and (ii) to identify the best treatment protocol based on the current evidence. METHODOLOGY: The evidence for the effect of each clinical factor on the success rate (SR) of primary root canal treatment was gathered in three different ways: (i) intuitive synthesis of reported findings from individual studies; (ii) weighted pooled SR by each factor under investigation was estimated using random-effect meta-analysis; (iii) weighted effect of the factor under investigation on SR were estimated and expressed as odds ratio for the dichotomous outcomes (success or failure) using fixed- and random-effects meta-analysis. Statistical heterogeneity amongst the studies was assessed by Cochran's (Q) test. Potential sources of statistical heterogeneity were investigated by exploring clinical heterogeneity using meta-regression models which included study characteristics in the regression models. RESULTS: Out of the clinical factors investigated, pre-operative pulpal and periapical status were most frequently investigated, whilst the intra-operative factors were poorly studied in the 63 studies. Four factors were found to have a significant effect on the primary root canal treatment outcome, although the data heterogeneity was substantial, some of which could be explained by some of the study characteristics. CONCLUSIONS: Four conditions (pre-operative absence of periapical radiolucency, root filling with no voids, root filling extending to 2 mm within the radiographic apex and satisfactory coronal restoration) were found to improve the outcome of primary root canal treatment significantly. Root canal treatment should therefore aim at achieving and maintaining access to apical anatomy during chemo-mechanical debridement, obturating the canal with densely compacted material to the apical terminus without extrusion into the apical tissues and preventing re-infection with a good quality coronal restoration.

Outcome of root canal obturation by warm gutta-percha versus cold lateral condensation: a meta-analysis

Peng L, Ye L, Tan H, Zhou X . J Endod. 2007;33(2):106-9

The purpose of this study was to evaluate clinical outcome differences of root canal obturation by warm gutta-percha (GP) or cold lateral condensation (CLC) through a systematic review and meta-analysis. There were 10 clinical studies evaluated. Postoperative pain, long-term outcomes, obturation quality, and overextension were the characteristics investigated. The results suggest that the two obturation techniques are not significantly different except in overextension. The relative risk (RR) value of warm GP versus CLC and 95% confidence interval (CI) of the first three criteria were 1.10 (0.71, 1.71), 0.78 (0.58, 1.05), and 1.31 (0.98, 1.76), respectively. Overextension was more likely to occur in the warm GP obturation group in comparison with the CLC group. The RR value and 95% CI were 1.98 (1.33, 2.93). In conclusion, warm GP obturation demonstrated a higher rate of overextension than CLC. Postoperative pain prevalence, long-term outcomes, and obturation quality were similar between the two groups.

Outcome of secondary root canal treatment: a systematic review of the literature

Ng YL, Mann V, Gulabivala K . Int Endod J. 2008;41(12):1026-46

AIMS (I): To investigate the effects of study characteristics on the reported success rates of secondary root canal treatment (2 degrees RCT or root canal retreatment); and (ii) to investigate the effects of clinical factors on the success of 2 degrees RCT. METHODOLOGY: Longitudinal human clinical studies investigating outcome of 2 degrees RCT which were published up to the end of 2006 were identified electronically (MEDLINE and Cochrane database 1966-2006 Dec, week 4). Four journals (Dental Traumatology, International Endodontic Journal, Journal of Endodontics, Oral Surgery Oral Medicine Oral Pathology Endodontics Radiology), bibliographies of all relevant papers and review articles were hand-searched. Two reviewers (Y-LN, KG) independently assessed and selected the studies based on specified inclusion criteria and extracted the data onto a pre-designed preform, independently. The criteria were: (i) Clinical studies on 2 degrees RCT; (ii) Stratified analyses available for 2 degrees RCT where 1 degrees RCT data included; (iii) Sample size given and larger than 10; (iv) At least 6-month post-operative review; (v) Success based on clinical and/or radiographic criteria (strict = absence of apical radiolucency; loose = reduction in size of radiolucency); and (vi) Overall success rate given or could be calculated from the raw data. Three strands of evidence or analyses were used to triangulate a consensus view. The reported findings from individual studies, including those excluded for quantitative analysis, were utilized for the intuitive synthesis which constituted the first strand of evidence. Secondly, the pooled weighted success rates by each study characteristic and potential prognostic factor were estimated using the random effect model. Thirdly, the effects of study characteristics and prognostic factors (expressed as odds ratios) on success rates were estimated using fixed and random effects meta-analysis with DerSimonian and Laird's methods. Meta-regression models were used to explore potential sources of statistical heterogeneity. Study characteristics considered in the meta-regression analyses were: decade of publication, study-specific criteria for success (radiographic, combined radiographic & clinical), unit of outcome measure (tooth, root), duration after treatment when assessing success.

Outcome of surgical endodontic treatment performed by a modern technique: a meta-analysis of literature

Tsesis I, Faivishevsky V, Kfir A, Rosen E . Journal of Endodontics. 2009;35(11):1505-11

INTRODUCTION: Numerous studies dealing with the outcome of surgical endodontic treatment have been published. However, study design, treatment protocols, follow-up periods, and inclusion and exclusion criteria are extremely variable. Thus, variable and confusing results have been reported. The aim of the present study was to assess the outcome of surgical endodontic treatment performed with a modern technique and to evaluate factors influencing the outcome by means of a meta-analysis. METHODS: An exhaustive literature search combined with strict inclusion and exclusion criteria was undertaken to identify prospective case series or randomized clinical trials that deal with surgical endodontic treatment. RESULTS: A successful outcome in a follow-up of more than 1 year postoperatively was 91.6%. Age, gender, tooth type, root-end filling material, and magnification type had no significant effect on the proportion of success. CONCLUSIONS: Surgical endodontic treatment done by using a modern technique is a predictable treatment. Additional large-scale prospective clinical studies are needed to evaluate possible predictors of success and failure.

Outcomes of MTA as root-end filling in endodontic surgery: a systematic review

Tang, Y., Li, X., Yin, S. . Quintessence International. 2010;41(7):557-66

OBJECTIVE: To compare the clinical outcomes of mineral trioxide aggregate (MTA) used as root-end filling with other materials in endodontic surgery to determine which modality offers more favorable outcomes. **METHOD AND MATERIALS:** A computerized literature search was performed in the Cochrane Library (1993-2009), MEDLINE (1993-2009), EMBASE (1993-2009), Science Citation Index (SCI) (1993-2009), Chinese Biomedicine Database (1993-2009), and China National Knowledge Infrastructure (CNKI) (1993-2009) to collect randomized controlled trials and quasi-controlled trials comparing MTA with other materials or placebo. The Cochrane Collaboration's RevMan5 software was used for data analysis. **RESULTS:** Five studies involving MTA and three other materials were included. No statistically significant difference was found in the clinical effectiveness of MTA and intermediate restorative material (IRM), with relative risk (RR) 0.62 and 95% CI 0.34 to 1.16. A statistically significant difference exists between MTA and amalgam in terms of outcome, with RR 0.35 and 95% CI 0.13 to 0.94. The difference between the gutta-percha and the MTA groups was statistically significant, with RR 0.08 and 95% CI 0.01 to 0.57. **CONCLUSION:** MTA as root-end filling is better than amalgam and purely gutta-percha but similar to IRM. There is a limited number of well-designed clinical trials within this research area. Further high-quality, large-scale, and long-term follow-up randomized controlled trials are still required to confirm the long-term outcomes of MTA as root-end filling in endodontic surgery.

Outcomes of nonsurgical retreatment and endodontic surgery: a systematic review

Torabinejad M, Corr R, Handysides R, Shabahang S . Journal of Endodontics. 2009

INTRODUCTION: The purpose of this systematic review was to compare the clinical and radiographic outcomes of nonsurgical retreatment with those of endodontic surgery to determine which modality offers more favorable outcomes. **METHODS:** The study began with targeted electronic searches of MEDLINE, PubMed, and Cochrane databases, followed with exhaustive hand searching and citation mining for all articles reporting clinical and/or radiographic outcomes for at least a mean follow-up of 2 years for these procedures. Pooled and weighted success rates were determined from a meta-analysis of the data abstracted from the articles. **RESULTS:** A significantly higher success rate was found for endodontic surgery at 2-4 years (77.8%) compared with nonsurgical retreatment for the same follow-up period (70.9%; $P < .05$). At 4-6 years, however, this relationship was reversed, with nonsurgical retreatment showing a higher success rate of 83.0% compared with 71.8% for endodontic surgery ($P < .05$). Insufficient numbers of articles were available to make comparisons after 6 years of follow-up period. Endodontic surgery studies showed a statistically significant decrease in success with each increasing follow-up interval ($P < .05$). The weighted success for 2-4 years was 77.8%, which declined at 4-6 years to 71.8% and further declined at 6+ years to 62.9% ($P < .05$). Conversely, the nonsurgical retreatment success rates demonstrated a statistically significant increase in weighted success from 2-4 years (70.9%) to 4-6 years (83.0%; $P < .05$). **CONCLUSIONS:** On the basis of these results it appears that endodontic surgery offers more favorable initial success, but nonsurgical retreatment offers a more favorable long-term outcome

Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: a systematic review

Torabinejad M, Anderson P, Bader J, Brown LJ, Chen LH, Goodacre CJ, Kattadiyil MT, Kutsenko D, Lozada J, Patel R, Petersen F, Puterman I, White SN . J Prosthet Dent. 2007;98(4):285-311

STATEMENT OF PROBLEM: Dentists and patients are regularly confronted by a difficult treatment question: should a tooth be saved through root canal treatment and restoration (RCT), be extracted without any tooth replacement, be replaced with a fixed partial denture (FPD) or an implant-supported single crown (ISC)? PURPOSE: The purpose of this systematic review was to compare the outcomes, benefits, and harms of endodontic care and restoration compared to extraction and placement of ISCs, FPDs, or extraction without tooth replacement. MATERIAL AND METHODS: Searches performed in MEDLINE, Cochrane, and EMBASE databases were enriched by hand searches, citation mining, and expert recommendation. Evidence tables were developed following quality and inclusion criteria assessment. Pooled and weighted mean success and survival rates, with associated confidence intervals, were calculated for single implant crowns, fixed partial dentures, and initial nonsurgical root canal treatments. Data related to extraction without tooth replacement and psychosocial outcomes were evaluated by a narrative review due to literature limitations. RESULTS: The 143 selected studies varied considerably in design, success definition, assessment methods, operator type, and sample size. Direct comparison of treatment types was extremely rare. Limited psychosocial data revealed the traumatic effect of loss of visible teeth. Economic data were largely absent. Success rates for ISCs were higher than for RCTs and FPDs, respectively; however, success criteria differed greatly among treatment types, rendering direct comparison of success rates futile. Long-term survival rates for ISCs and RCTs were similar and superior to those for FPDs. CONCLUSIONS: Lack of comparative studies with similar outcomes criteria with comparable time intervals limited comparison of these treatments. ISC and RCT treatments resulted in superior long-term survival, compared to FPDs. Limited data suggested that extraction without replacement resulted in inferior psychosocial outcomes compared to alternatives. Long-term, prospective clinical trials with large sample sizes and clearly defined outcomes criteria are needed.

Reasons for failures of oral implants

Chrcanovic, B. R., Albrektsson, T., Wennerberg, A. . J Oral Rehabil. 2014;41(6):443-76

This study reviews the literature regarding the factors contributing to failures of dental implants. An electronic search was undertaken including papers from 2004 onwards. The titles and abstracts from these results were read to identify studies within the selection criteria. All reference lists of the selected studies were then hand-searched, this time without time restrictions. A narrative review discussed some findings from the first two parts where separate data from non-comparative studies may have indicated conclusions different from those possible to draw in the systematic analysis. It may be suggested that the following situations are correlated to increase the implant failure rate: a low insertion torque of implants that are planned to be immediately or early loaded, inexperienced surgeons inserting the implants, implant insertion in the maxilla, implant insertion in the posterior region of the jaws, implants in heavy smokers, implant insertion in bone qualities type III and IV, implant insertion in places with small bone volumes, use of shorter length implants, greater number of implants placed per patient, lack of initial implant stability, use of cylindrical (non-threaded) implants and prosthetic rehabilitation with implant-supported overdentures. Moreover, it may be suggested

that the following situations may be correlated with an increase in the implant failure rate: use of the non-submerged technique, immediate loading, implant insertion in fresh extraction sockets, smaller diameter implants. Some recently published studies suggest that modern, moderately rough implants may present with similar results irrespective if placed in maxillas, in smoking patients or using only short implants.

Relationship between quality of root canal obturation and periapical lesion in elderly patients: a systematic review

Rutz da Silva, F., Padilha, E. Z., Candido, V. S., Cavassim, R., Pereira, A. C., Hebling, E. . Gerodontology. 2014;41(9):700-8

OBJECTIVE: The aim of this study was to investigate the relationship between quality of root canal obturations and the presence/absence of periapical lesion in elderly patients. **METHODOLOGY:** This was a systematic conducted by means analysing studies on the quality of root canal obturations and their relationship with periapical health in elderly patients. The methodological procedures were based on Cochrane. The inclusion criteria for selection of the titles were the following: (i) studies in humans; (ii) sample consisting of individuals aged 60 years or older; (iii) intending criteria defined for the evaluation of quality of root canal obturations; (iv) intending criteria defined for the evaluation of periapical health; (v) determination of the relationship between quality of endodontic treatment and presence of periapical lesions; and (vi) articles published between 1st March 2003 and 1st March 2013. **RESULTS:** A total of 3161 potentially relevant studies were found in three databases chosen for the literature review, with 1669 being repeated and 395 duplicated. Therefore, the abstracts of 1097 studies were read. A total of 1022 studies were excluded, resulting in 75 articles for full analysis. However, no study could be included in the present literature review. **CONCLUSION:** There is no consensus on the relationship between the quality of root canal obturations and periapical health in older patients.

Root-filled teeth with adequate restorations and root canal treatment have better treatment outcomes

Balto, K. Evidence-Based Dentistry. 2011;12(3):72-3

DATA SOURCES: Medline, Embase, the Cochrane Library, the Wiley online database, four journals (Journal of Endodontics, International Endodontic Journal, Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology and Endodontics and Dental Traumatology) and the references of identified articles were searched manually. There was no language restriction. **STUDY SELECTION:** Clinical studies that provided sample size, and where success was based on radiographic and/or clinical criteria that evaluated quality of root filling, the quality of coronal restoration and periapical status at least one year after root canal treatment that provided an overall success rate or sufficient data to allow it to be calculated from the raw data were included. **DATA EXTRACTION AND SYNTHESIS:** Data were collected based on predetermined criteria. Percentages of teeth without apical periodontitis were recorded for each category: adequate root canal treatment (AE); inadequate root canal treatment (IE); adequate restoration (AR); and inadequate restoration (IR). Data were analysed using meta-analysis for odds ratios (ORs). **RESULTS:** Nine article were included . After adjusting for significant covariates to reduce heterogeneity, the results were combined to obtain pooled estimates of the common OR for the comparison of AR/AE versus AR/IE:-AR/AE versus AR/IE (OR = 2.734; 95%CI, 2.61-2.88; P < .001)AR/AE versus IR/AE (OR = 2.808;

95% CI, 2.64-2.97; $P < .001$). CONCLUSIONS: On the basis of the current best available evidence, the odds for healing of apical periodontitis increase with both adequate root canal treatment and adequate restorative treatment. Although poorer clinical outcomes may be expected with adequate root filling-inadequate coronal restoration and inadequate root filling-inadequate coronal restoration, there is no significant difference in the odds of healing between these two combinations.

Success rate of endodontic treatment of teeth with vital and nonvital pulps. A meta-analysis

Kojima K, Inamoto K, Nagamatsu K, Hara A, Nakata K, Morita I, Nakagaki H, Nakamura H. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;97(1):95-9

OBJECTIVE: The purpose of this study was to use meta-analysis statistics to determine the influence of factors such as apical limit (short vs. overextension), status of the pulp (vital vs. nonvital), and periapical status (presence or absence of radiolucency) on endodontic prognosis. Study design The study-list was obtained by using a MEDLINE search and Japana Centra Revuo Medicina search. Only those papers in which the criteria for success or failure was exactly described were accepted. RESULTS: The cumulative success rate of 82.8 +/- 1.19% (average +/-95% confidence interval) was obtained for vital pulp; and 78.9 +/- 1.05%, for nonvital ones. There was a significant difference between the 2 groups. The cumulative success rates with overextension, flush, and underextension in vital teeth were 70.8 +/- 1.44, 86.5 +/- 0.88, and 85.5 +/- 0.98% respectively. There was a significant difference between flush and overextension and between flush and underextension. The rates for nonvital pulp were similar to those for vital ones. CONCLUSION: The root canal should be filled to within 2 mm of the radiographic apex.

Survival of Intentionally Replanted Teeth and Implant-supported Single Crowns: A Systematic Review

Torabinejad, M., Dinsbach, N. A., Turman, M., Handysides, R., Bahjri, K., White, S. N. J Endod. 2015;41(7):992-8

INTRODUCTION: Although nonsurgical initial root canal treatment and retreatment have high success rates, periapical disease can remain. The survival rates of 2 surgical procedures, intentionally replanted (IR) teeth and implant-supported single crowns (ISCs), have yet to be compared. The purpose of this systematic review and meta-analysis was to examine the literature and quantify the survival of IR teeth and compare it with that of ISCs. METHODS: Systematic searches were enriched by citation mining. Weighted survival means and 95% confidence intervals (CI) were estimated using a random-effects model and compared. RESULTS: The quality of the IR and ISC articles was only moderate. Data for ISCs were much more plentiful than for IR teeth. Meta-analysis revealed a weighted mean survival of 88% (95% CI, 81%-94%) for IR teeth. Root resorption was reported with a mean prevalence of 11%. The weighted mean survival of ISCs was 97% (95% CI, 96%-98%). The mean survival of ISCs was significantly higher than that of IR teeth ($P < .001$). A recent study on IR teeth indicated that orthodontic extrusion before intentional replantation improved survival rates. CONCLUSIONS: A systematic review and meta-analysis found that the mean survival of ISCs was significantly higher than IR teeth. However, treatment decisions must be based on a wide variety of treatment and patient-specific parameters. Intentional replantation may have a role when ISC is not practicable. Studies using contemporary treatment and analytic methods should be used to identify and measure intentional replant prognostic and treatment variables.

The outcome of endodontic resurgery: a systematic review

Peterson J, Gutmann JL . Int Endod J. 2001;34(3):169-75

AIM: The aim of this paper is to establish an outcome standard for the assessment of healing radiographically after resurgery of persistent periradicular lesions by systematically reviewing the results from published studies. METHODOLOGY: The systematic review process requires the definition of predetermined criteria delineating the inclusion parameters of studies reviewed. Of 42 papers that were reviewed, eight qualified for inclusion. A weighted-average was calculated from the results taken from the eight eligible, peer-reviewed studies, published between 1970 and 1997. RESULTS: Three hundred and thirty patients out of 2375 (14%) from the included studies underwent resurgery for failure of healing as determined radiographically. Of this population, 35.7% healed successfully after resurgery, 26.3% healed with uncertain results and 38% did not heal at the one-year follow-up. CONCLUSIONS: Although there is nearly equal distribution of results between all categories, a 35.7% rate of healing as assessed radiographically is essentially equivalent to the 38% failure rate. This paper will allow an evaluation of current research results to establish an outcome standard and enable techniques and filling materials to be evaluated and compared. Furthermore, the outcome standard can assist in defining demographic and aetiological factors that contribute to the potential outcome of resurgery cases.

Tooth Retention through Endodontic Microsurgery or Tooth Replacement Using Single Implants: A Systematic Review of Treatment Outcomes

Torabinejad, M., Landaez, M., Milan, M., Sun, C. X., Henkin, J., Al-Ardah, A., Kattadiyil, M., Bahjri, K., Dehom, S., Cortez, E., White, S. N. . J Endod. 2014;225(4):419-35

INTRODUCTION: Clinicians are regularly confronted with difficult choices. Should a tooth that has not healed through nonsurgical root canal treatment be treated through endodontic microsurgery or be replaced using a single implant? Acquiring complete, unbiased information to help clinicians and their patients make these choices requires a systematic review of the literature on treatment outcomes. The purpose of this systematic review was to compare the outcomes of tooth retention through endodontic microsurgery to tooth replacement using an implant supported single crown. METHODS: Searches performed in PubMed, Cochrane Library, Web of Science, and EMBASE databases were enriched by citation mining. Inclusion criteria were defined. Sentinel articles were identified and included in the final selection of studies. Weighted survival and success rates for single implants and endodontic microsurgery were calculated. RESULTS: The quality of the articles reporting on single implants and endodontic microsurgery was moderate. Data for single implants were much more plentiful than for endodontic microsurgery, but the endodontic microsurgery studies had a slightly higher quality rating. Single implants and endodontic microsurgery were not directly compared in the literature. Outcomes criteria were often unclear. At 4-6 years, single implants had higher survival rates than teeth treated with endodontic microsurgery. Qualitatively different success criteria precluded valid comparison of success rates. CONCLUSIONS: Survival rates for single implants and endodontic microsurgery were both high (higher for single implants). Appraisal was limited by a lack of direct treatment comparisons. Long-term studies with a broad range of carefully defined outcomes criteria are needed.

Tooth survival following non-surgical root canal treatment: a systematic review of the literature

Ng YL, Mann V, Gulabivala K . International Endodontic Journal. 2010;43(3):171-89

AIMS: To investigate (i) the effect of study characteristics on reported tooth survival after root canal treatment (RCTx) and (ii) the effect of clinical factors on the proportion of root filled teeth surviving after RCTx. METHODOLOGY: Longitudinal human clinical studies investigating tooth survival after RCTx which were published up to the end of 2007 were identified electronically (MEDLINE and Cochrane database 1966-2007 December, week 4). In addition, four journals (Dental Traumatology, International Endodontic Journal, Journal of Endodontics, Oral Surgery Oral Medicine Oral Pathology Oral Radiology & Endodontics), bibliographies of all relevant articles and review articles were hand searched. Two reviewers (Y-LN, KG) assessed and selected the studies based on specified inclusion criteria and extracted the data onto a pre-designed proforma, independently. The criteria were as follows: (i) clinical study on RCTx; (ii) stratified analysis of primary and secondary RCTx available; (iii) sample size given and larger than 10; (iv) at least 6-month postoperative review; (v) success based on survival of tooth; and (vi) proportion of teeth surviving after treatment given or could be calculated from the raw data. Three strands of evidence or analyses were used to triangulate a consensus view. The reported findings from individual studies, including those excluded for quantitative analysis, were utilized for the intuitive synthesis, which constituted the first strand of evidence. Secondly, the pooled weighted proportion of teeth surviving and thirdly the combined effects of potential prognostic factors were estimated using the fixed and random effects meta-analyses on studies fulfilling all the inclusion criteria. RESULTS: Of the 31 articles identified, 14 studies published between 1993 and 2007 were included. The majority of studies were retrospective (n = 10) and only four prospective. The pooled percentages of reported tooth survival over 2-3, 4-5 and 8-10 years following RCTx were 86% (95% CI: 75%, 98%), 93% (95% CI: 92%, 94%) and 87% (95% CI: 82%, 92%), respectively. Substantial differences in study characteristics were found to hinder effective direct comparison of findings. Evidence for the effect of prognostic factors on tooth survival was weak. Based on the data available for meta-analyses, four conditions were found to significantly improve tooth survival. In descending order of influence, the conditions increasing observed proportion of survival were as follows: (i) a crown restoration after RCTx; (ii) tooth having both mesial and distal proximal contacts; (iii) tooth not functioning as an abutment for removable or fixed prosthesis; and (iv) tooth type or specifically non-molar teeth. Statistical heterogeneity was substantial in some cases but its source could not be investigated because of insufficient available information. CONCLUSIONS: The pooled proportion of teeth surviving over 2-10 years following RCTx ranged between 86% and 93%. Four factors (listed above) were identified as significant prognostic factors with concurrence between all three strands of evidence.

Treatment of periodontal-endodontic lesions--a systematic review

Schmidt, J. C., Walter, C., Amato, M., Weiger, R. . J Clin Periodontol. 2014;41(8):779-90

BACKGROUND: The treatment of periodontal-endodontic lesions is challenging due to the involvement of both periodontal and endodontic tissues. OBJECTIVE: To evaluate the treatment options and outcomes of periodontal-endodontic lesions. MATERIAL AND METHODS: A systematic literature search was performed for articles published by 12 May 2013 using electronic databases and hand search. Two reviewers conducted the study selection,

data collection and validity assessment. The PRISMA criteria were applied. From 1087 titles identified by the search strategy, five studies and 18 case reports were included. RESULTS: Clinical studies and case reports were published from the years 1981 to 2012. A pronounced heterogeneity exists among studies regarding applied treatment protocols and quality of reporting. In all clinical studies, comprising 111 teeth, a non-surgical root canal treatment (RCT) was performed as initial treatment step. Non-surgical and/or a surgical periodontal therapy was applied in some studies without re-evaluation of the endodontic healing. Probing pocket depth reductions were reported in all included studies, comprising the data from 80 teeth at follow-up. CONCLUSIONS: A sequential treatment with root canal treatment as a first treatment step appears to be reasonable. An adequate time for tissue healing is suggested prior to re-evaluation.

Comparison of nonsurgical root canal treatment and single-tooth implants.

Morris MF, Kirkpatrick TC, Rutledge RE, Schindler WG. J Endod. 2009 Oct;35(10):1325-30

INTRODUCTION: The aim of this review was to compare the differences between nonsurgical root canal treatment and single-tooth implants. With the emerging field of implant dentistry gaining acceptance, the choice to retain a diseased tooth through the use of root canal therapy or extract it and replace the tooth with an implant-supported crown has become controversial. Many practitioners consider the single-tooth implant as a reasonable alternative to the preservation of a diseased tooth. METHODS: An extensive search of the dental literature was accomplished to identify publications related to the differences in root canal therapy and dental implants. Several comparative studies were also considered. RESULTS: The treatment modalities were reviewed with respect to outcome measures and study design, success/failure, functional rehabilitation and psychological differences, complications related to treatment, cost differences, and factors influencing treatment planning considerations. CONCLUSIONS: With the reviewed information in hand, the practitioner should be better prepared to determine which treatment option is most appropriate for each individual patient.

Survival of Intentionally Replanted Teeth and Implant-supported Single Crowns: A Systematic Review

Torabinejad JOE 2015

Introduction Although nonsurgical initial root canal treatment and retreatment have high success rates, periapical disease can remain. The survival rates of 2 surgical procedures, intentionally replanted (IR) teeth and implant-supported single crowns (ISCs), have yet to be compared. The purpose of this systematic review and meta-analysis was to examine the literature and quantify the survival of IR teeth and compare it with that of ISCs. **Methods** Systematic searches were enriched by citation mining. Weighted survival means and 95% confidence intervals (CI) were estimated using a random-effects model and compared. **Results** The quality of the IR and ISC articles was only moderate. Data for ISCs were much more plentiful than for IR teeth. Meta-analysis revealed a weighted mean survival of 88% (95% CI, 81%–94%) for IR teeth. Root resorption was reported with a mean prevalence of 11%. The weighted mean survival of ISCs was 97% (95% CI, 96%–98%). The mean survival of ISCs was significantly higher than that of IR teeth ($P < .001$). A recent study on IR teeth indicated that orthodontic extrusion before intentional replantation improved survival rates. **Conclusions** A systematic review and meta-analysis found that the mean survival of ISCs was significantly higher than IR teeth. However, treatment decisions must be based on a wide variety of

treatment and patient-specific parameters. Intentional replantation may have a role when ISC is not practicable. Studies using contemporary treatment and analytic methods should be used to identify and measure intentional replant prognostic and treatment variables.

Tooth Retention through Endodontic Microsurgery or Tooth Replacement Using Single Implants: A Systematic Review of Treatment Outcomes

Torabinejad JOE 2015

Introduction Clinicians are regularly confronted with difficult choices. Should a tooth that has not healed through nonsurgical root canal treatment be treated through endodontic microsurgery or be replaced using a single implant? Acquiring complete, unbiased information to help clinicians and their patients make these choices requires a systematic review of the literature on treatment outcomes. The purpose of this systematic review was to compare the outcomes of tooth retention through endodontic microsurgery to tooth replacement using an implant supported single crown. **Methods** Searches performed in PubMed, Cochrane Library, Web of Science, and EMBASE databases were enriched by citation mining. Inclusion criteria were defined. Sentinel articles were identified and included in the final selection of studies. Weighted survival and success rates for single implants and endodontic microsurgery were calculated. **Results** The quality of the articles reporting on single implants and endodontic microsurgery was moderate. Data for single implants were much more plentiful than for endodontic microsurgery, but the endodontic microsurgery studies had a slightly higher quality rating. Single implants and endodontic microsurgery were not directly compared in the literature. Outcomes criteria were often unclear. At 4–6 years, single implants had higher survival rates than teeth treated with endodontic microsurgery. Qualitatively different success criteria precluded valid comparison of success rates. **Conclusions** Survival rates for single implants and endodontic microsurgery were both high (higher for single implants). Appraisal was limited by a lack of direct treatment comparisons. Long-term studies with a broad range of carefully defined outcomes criteria are needed.

Is endodontic re-treatment mandatory for every relatively old temporary restoration? A narrative review.

Keinan D JADA 2011

OBJECTIVES AND BACKGROUND: In this review, the authors examine whether there is any decisive evidence to support the revision of root fillings that have been exposed to the oral environment for more than three months, undertaken solely because of suspicions of microleakage. Researchers in numerous endodontic studies have addressed the evaluation of coronal microleakage by using different tracers and techniques. The need to achieve a tight, permanent coronal seal as soon as possible after the completion of endodontic treatment is obvious. However, the clinical importance of microleakage studies recently has been questioned because of their wide range and even contradictory results, and findings from only a few clinical investigations have demonstrated a clear relationship between the endodontic success rate and failure rate owed to coronal microleakage in cases involving high-quality endodontic therapy. **METHODS:** The authors analyzed commonly cited articles regarding the clinical relevance of microleakage studies and the success rate of teeth with compromised restorations. **CONCLUSIONS:** In a review of the literature, the authors found

no clear evidence to support immediate replacement of well-obtured endodontic treatment that has lasted more than three months solely because of suspicions of microleakage. It may be prudent in such cases to make a new coronal restoration immediately and to observe the tooth for at least three months before placing the permanent crown.

Surgery

The Effect of Regeneration Techniques on Periapical Surgery With Different Protocols for Different Lesion Types: A Meta-Analysis

Deng Y, J Oral Maxillofac Surg 2016

PURPOSE: To evaluate the effect of regeneration techniques (RTs) on the outcome of periapical surgery with different protocols for different lesion types. **MATERIALS AND METHODS:** PubMed, the Cochrane Library, and Embase were searched from the beginning of time until December 30, 2014. Studies that met the inclusion criteria were systematically evaluated, and a meta-analysis was performed. **RESULTS:** Eight randomized controlled trials met the inclusion criteria. A significantly better outcome was found in the combination group (membranes plus bone replacement analogues) (risk ratio [RR], 0.41; 95% confidence interval [CI], 0.22 to 0.77; $P = .005$) and bone replacement analogue-only group (RR, 0.48; 95% CI, 0.23 to 0.98; $P = .04$), whereas no significant beneficial effect was found in the membrane-only group (RR, 0.59; 95% CI, 0.29 to 1.17; $P = .13$). The use of RTs favorably affected the outcome of periapical through-and-through lesions (RR, 0.38; 95% CI, 0.18 to 0.84; $P = .02$) and large lesions (≥ 10 mm) (RR, 0.52; 95% CI, 0.28 to 0.97; $P = .04$), whereas there was no significant benefit of using RTs for 4-wall lesions (RR, 0.54; 95% CI, 0.27 to 1.07; $P = .08$). **CONCLUSIONS:** Both the isolated use of bone replacement analogues and the combination of membranes and bone replacement analogues can improve the outcome of periapical surgery, whereas using membranes alone does not have significantly favorable effects. The use of RTs for through-and-through and large lesions should be recommended.

A systematic review of in vitro retrograde obturation materials

Theodosopoulou JN, Niederman R. J Endod. 2005;31(5):341-9

The purpose of this review was two-fold: (a) to determine which retrograde obturation material(s) best prevents dye/ink penetration in vitro; and (b) to determine whether in vitro results agree with in vivo results. A MEDLINE search was conducted to identify in vitro studies published between January 1966 and October, week 4, 2003, conducted on human teeth, and published in English, German, or French language, testing the resistance to retrograde penetration of retrograde filling materials. The MEDLINE search identified 278 published articles. Of those, 115 studies examined the resistance to penetration of various retrograde filling materials, in vitro. Thirty-four studies met all the inclusion and validity criteria. The results indicate that, beyond 10 days in vitro, the most effective retrofilling materials, when measured by dye/ink penetration are: composites>glass ionomer cement>amalgam>orthograde gutta-percha>EBA. The results of these in vitro studies are not congruent with in vivo study results, suggesting a need to re-evaluate the clinical validity and importance of in vitro studies.

Effect of guided tissue regeneration on the outcome of surgical endodontic treatment: a systematic review and meta-analysis

Tsesis, I., Rosen, E., Tamse, A., Taschieri, S., Del Fabbro, M. . Journal of Endodontics. 2011;37(8):1039-45

INTRODUCTION: The use of guided tissue regeneration (GTR) techniques has been proposed as an adjunct to endodontic surgery in order to promote bone healing. Studies assessing the added benefits of GTR for the outcome of endodontic surgery are significantly variable in their treatment protocols, follow-up periods, and inclusion criteria, thus generating inconsistent and confusing results. The aim of this study was to evaluate the influence of GTR on the outcome of surgical endodontic treatment by means of a systematic review of the literature and meta-analysis. METHODS: An exhaustive literature search combined with strict inclusion and exclusion criteria was undertaken to identify clinical studies that assessed the added benefit of GTR in endodontic surgery. RESULTS: A trend of better outcome was found when GTR was used compared to control cases, but the results were not statistically significant. Lesion size, lesion type, and membrane type were identified as factors significantly affecting the outcome of GTR versus control cases. GTR techniques favorably affected the outcome of surgical endodontic treatments in cases of large periapical lesions and through-and-through lesions. A favorable outcome was found when using a resorbable membrane over using a nonresorbable membrane or graft alone. CONCLUSIONS: GTR techniques may improve the outcome of bone regeneration after surgical endodontic treatments of teeth with certain lesions. Additional large-scale prospective clinical studies are needed to further evaluate possible benefits of GTR techniques in endodontic surgery.

Materials and prognostic factors of bone regeneration in periapical surgery: a systematic review

Sanchez-Torres, A., Sanchez-Garces, M. A., Gay-Escoda, C. . Med Oral Patol Oral Cir Bucal. 2014;19(4):419-25

OBJECTIVES: Analyse the effectiveness of different materials and techniques used in guided tissue regeneration (GTR) applied in periapical surgery, comparing the success rate obtained in 4-wall defects and in through-and-through bone lesions as well as to establish prognostic factors. MATERIAL AND METHODS: A Cochrane, PubMed-MEDLINE and Scopus database search (October 2012 to March 2013) was conducted with the search terms "periapical surgery", "surgical endodontic treatment", "guided tissue regeneration", "bone regeneration", "bone grafts", "barrier membranes" and "periapical lesions" individually and next, using the Boolean operator "AND". The inclusion criteria were the use of GTR (bone graft and/or membrane barrier), clinical studies including at least 10 patients, 10 years aged articles published in English or French. The exclusion criteria were case reports and nonhuman studies. RESULTS: 34 publications were selected from a total of 483. 9 of the 34 were excluded. Finally, the systematic review included 25 articles: 2 meta-analysis, 8 reviews, 13 prospective studies and 2 retrospective studies. They were stratified according to their level of scientific evidence using the SORT criteria. The 4-wall periapical and through-and-through lesions improve more their prognosis by combining bone grafts and barrier membranes than using these materials exclusively, respect to the control groups. The results show lower failure rates in 4-wall lesions than in through-and-through lesions using GTR. CONCLUSIONS: The combined GTR technique (filling material and membranes) obtains a greater success rate both in 4-wall lesions and in through-and-through lesions, respect to the control groups. The use of regeneration materials seems to be more necessary in through-and-through lesions, > 5mm

lesions, lower teeth and apicomarginal lesions as they have the worst healing prognosis. In function of the articles scientific quality, a type B recommendation is given in favor to the use of GTR in association of periapical surgery in case of 4-wall and through-and-through lesions.

Meta-analysis of filler materials in periapical surgery

Fernandez-Yanez Sanchez A, Leco-Berrocal MI, Martinez-Gonzalez JM . Med Oral Patol Oral Cir Bucal. 2008;13(3):180-5

OBJECTIVE: To evaluate the success and failure, apical sealing and biocompatibility of silver amalgam, IRM, SuperEBA and MTA as retrograde filler materials. Study design: A metaanalysis is made of filler materials in periapical surgery, evaluating a total of 30 articles published in recent years. **RESULTS:** Percentage success with silver amalgam was 76.5% and slightly inferior to that afforded by IRM. Performance in turn increased considerably when the materials used were SuperEBA or MTA. As regards marginal leakage, MTA with a mean leakage time of 65.5 days afforded the best results, followed by SuperEBA, IRM and silver amalgam. MTA was the most biocompatible of the materials studied, with practically no inflammatory response, while inflammation proved mild or moderate with SuperEBA, mild with IRM, and moderate to severe in the case of silver amalgam. Tissue regeneration was only observed with MTA, in the same way as cement appositioning. Bone neoformation was observed with all four filler materials. **CONCLUSIONS:** MTA appears to be an ideal material, though the results obtained require confirmation by in vivo studies.

Prognostic factors in apical surgery with root-end filling: a meta-analysis

von Arx, T., Penarrocha, M., Jensen, S. . Journal of Endodontics. 2010;36(6):957-73

INTRODUCTION: Apical surgery has seen continuous development with regard to equipment and surgical technique. However, there is still a shortage of evidence-based information regarding healing determinants. The objective of this meta-analysis was to review clinical articles on apical surgery with root-end filling in order to assess potential prognostic factors. **METHODS:** An electronic search of PubMed and Cochrane databases was performed in 2008. Only studies with clearly defined healing criteria were included, and data for at least two categories per prognostic factor had to be reported. Prognostic factors were divided into patient-related, tooth-related, or treatment-related factors. The reported percentages of healed teeth ("the healed rate") were pooled per category. The statistical method of Mantel-Haenszel was applied to estimate the odds ratios and their 95% confidence intervals. **RESULTS:** With regard to tooth-related factors, the following categories were significantly associated with higher healed rates: cases without preoperative pain or signs, cases with good density of root canal filling, and cases with absence or size $<$ or $=$ 5 mm of periapical lesion. With regard to treatment-related factors, cases treated with the use of an endoscope tended to have higher healed rates than cases without the use of an endoscope. **CONCLUSIONS:** Although the clinician may be able to control treatment-related factors (by choosing a certain technique), patient- and tooth-related factors are usually beyond the surgeon's power. Nevertheless, patient- and tooth-related factors should be considered as important prognostic determinants when planning or weighing apical surgery against treatment alternative.

Vital pulp therapy, regeneration, apexification

Different materials for direct pulp capping: systematic review and meta-analysis and trial sequential analysis.

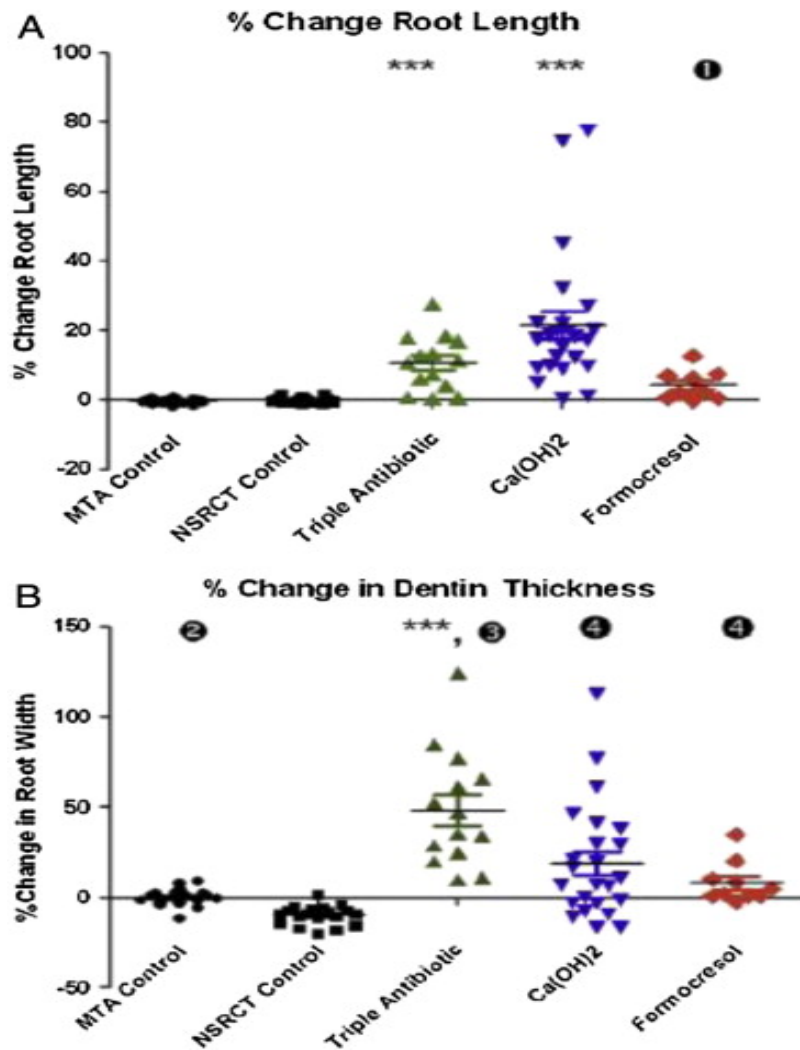
Schwendicke F, Clin Oral Investig. 2016

OBJECTIVES: We systematically assessed randomized controlled trials comparing direct pulp capping materials. **METHODS:** Trials comparing materials for direct capping and evaluating clinically and/or radiographically determined success after minimum 3 months were included. Two reviewers independently screened electronic databases (Medline, Central, Embase) and performed hand searches. Risk of bias was assessed and meta-analyses were performed, separated for dentition. Trial sequential analysis was used to assess risk of random errors. Strength of evidence was graded using the GRADE approach. **RESULTS:** From a total of 453 identified studies, 11 (all with high risk of bias) investigating 1094 teeth (922 patients) were included. Six studies were on primary teeth (all with carious exposures) and five on permanent teeth (carious and artificial exposures). Mean follow-up was 14 months (range 3-24). Most studies used calcium hydroxide as control, comparing it to mineral trioxide aggregate (MTA) (three studies), bonding without prior etching/conditioning (two), or bonding with prior etching/conditioning, enamel matrix proteins, resin-modified glass ionomer cement, calcium sulfate, zinc oxide eugenol, corticosteroids, antibiotics, or formocresol (each in only one study). One study compared MTA and calcium-enriched cement. In permanent teeth, risk of failure was significantly decreased if MTA instead of calcium hydroxide was used (risk ratio (RR) [95 % confidence intervals (CI)] 0.59 [0.39/0.90]); no difference was found for primary teeth. Other comparisons did not find significant differences or were supported by only one study. No firm evidence was reached according to trial sequential analysis. **CONCLUSION:** There is insufficient data to recommend or refute the use of a specific material. More long-term practice-based studies with real-life exposures are required. **CLINICAL RELEVANCE:** To reduce risk of failure, dentists might consider using MTA instead of calcium hydroxide (CH) for direct capping. Current evidence is insufficient for definitive recommendations.

Treatment Options: Biological Basis of Regenerative Endodontic Procedures

Kenneth M. Hargreaves JEO, 2013

(A) Percentage change in root length from preoperative image to postoperative image, measured from the cemento-enamel junction to the root apex. *** $P < .001$ versus MTA apexification control group ($n = 20$) and NSRCT control group ($n = 20$). (1) $P < .05$ versus MTA control group only. Median values for each group are depicted by *horizontal line*, and individual cases are indicated by the corresponding symbol. (B) Percentage change in dentinal wall thickness from preoperative image to postoperative image, measured at the apical third of the root (position of apical third defined in the preoperative image). *** $P < .001$ versus MTA apexification control group and NSRCT control group. (2) $P < .05$ versus NSRCT control group only. (3) $P < .05$ versus Ca(OH)₂ and formocresol groups. (4) $P < .05$ versus NSRCT control group only. (From Bose R, Nummikoski P, Hargreaves K. A retrospective evaluation of radiographic outcomes in immature teeth with necrotic root canal systems treated with regenerative endodontic procedures. J Endod 2009;35:1343.)



Apexification of immature teeth with calcium hydroxide or mineral trioxide aggregate: systematic review and meta-analysis

Chala, S., Abouqal, R., Rida, S., Chala, Sanaa, Abouqal, Redouane, Rida, Sana. Oral Surgery Oral Medicine Oral Pathology Oral Radiology & Endodontics. ;112(4):36-42

OBJECTIVE: The aim of this study was to conduct a quantitative systematic review, including published data, comparing the efficacy of mineral trioxide aggregate and calcium hydroxide as material used for the endodontic management of immature teeth. STUDY DESIGN: Relevant studies published through November 2009 were identified through literature searches using Pubmed (Medline) and Scopus databases. Controlled trials in which calcium hydroxide versus mineral trioxide aggregate were used for the apexification of immature permanent teeth were selected for this study. The evaluation included clinical outcome and apical barrier formation. The principal measure of treatment effect was risk difference. The overall effect was tested by using Z score. Heterogeneity was tested by using the chi(2) statistic and I square (I(2)). A fixed-effect model was used when the studies in the subgroup were sufficiently similar. A random-

effects model was used in the summary analysis when there was heterogeneity between the subgroups. RESULTS: Based on reduction of relative risk with 95% confidence intervals we found that the rate of clinical success ($P = .29$) and apical barrier formation ($P = .76$) of the 2 interventions had no perceivable discrepancy. Regarding success and apical barrier formation, either calcium hydroxide or mineral trioxide aggregate may be used for the apexification of immature teeth.

Can SHED or DPSCs be used to repair/regenerate non-dental tissues? A systematic review of in vivo studies

Dalton, F. P., Mendonca, P. P., Mantesso, A., Deboni, M. C. . Braz Oral Res. 2014;28(1):303-13

Dental pulp has been identified as a novel and promising stem cell source. The following systematic review presents and summarises in vivo studies that have used stem cells from the dental pulp of permanent and deciduous teeth to repair or regenerate non-dental tissues. An electronic customised search was performed using 4 different databases (Entrez PubMed, Cab Abstracts, Scopus and Web of Science). Only full-text research manuscripts published in English between the years of 2000 and 2012 were included. The manuscripts were retrieved based on the following keywords and/or abbreviations: [Stem Cells from Human Exfoliated Deciduous teeth (SHED)] AND/OR [Dental Pulp Stem Cells (DPSC)] AND [tissue regeneration] AND [tissue repair]. Only manuscripts involving in vivo applications of SHED or DPSC for the repair and/or regeneration of non-dental tissues were included. The search strategy produced 2309 papers, from which 14 were eligible according to the predetermined inclusion and exclusion criteria. Although human tissue was the source of cells in half of the studies included in our review, all of the studies involved transplantation into animals of other species, such as pigs, rats and mice. Most of the manuscripts reported the successful use of DPSCs or SHED for non-dental tissue repair or regeneration. While these cell populations represent promising alternative sources of stem cells for tissue engineering and cell-based regenerative medicine therapies, it is not yet possible to guarantee the appropriate clinical management of this technique.

Clinical and radiographic success of mineral trioxide aggregate compared with formocresol as a pulpotomy treatment in primary molars: A systematic review and meta-analysis

Marghalani, A. A., Omar, S., Chen, J. W. . J Am Dent Assoc. 2014;145(7):714-21

BACKGROUND: The authors conducted a systematic review and meta-analysis to compare the long-term clinical and radiographic success of using mineral trioxide aggregate (MTA) and formocresol (FC) as a pulp-dressing material in pulpotomy treatment in primary molars. TYPES OF STUDIES REVIEWED: The authors searched MEDLINE, Thomson Reuters Web of Science and the Cochrane Central Register of Controlled Trials for randomized controlled trials (RCTs) published from Jan. 1, 1990, to May 9, 2013. For an RCT to be included, the authors required that the primary molars treated with a pulpotomy procedure must have received stainless steel crowns as a final restoration and that rubber dam isolation was used during treatment; that the pulp must have been vital as determined clinically by means of hemorrhage control with a cotton pellet; and that the RCT must have included a follow-up period of at least two years. For each included RCT, two authors assessed the risk of bias

independently. RESULTS: The authors identified 20 trials and included five of them. A total of 377 primary molars were treated. The authors judged that none of the included RCTs had a low risk of bias. They noted no significant differences in clinical success (relative risk [RR] = 1.01; 95 percent confidence interval [CI], 0.98-1.05) and radiographic success (RR = 1.09; 95 percent CI, 0.97-1.21) for primary molars treated with MTA versus those treated with FC. PRACTICAL IMPLICATIONS: On the basis of the limited evidence, pulpotomy procedures performed in primary molars involving the use of MTA or FC showed comparable clinical success rates.

Evaluation of formocresol versus ferric sulphate primary molar pulpotomy: a systematic review and meta-analysis

Peng L, Ye L, Guo X, Tan H, Zhou X, Wang C, Li R . Int Endod J. 2007;40(10):751-7

AIM: To present a systematic review of the effects of formocresol and ferric sulphate when used as medicaments in pulpotomized primary molar teeth. METHODOLOGY: The study list was obtained by using MEDLINE, the Cochrane Library, EMBASE and SCI search. Only those papers which met the inclusion criteria were accepted. The quality of studies used for meta-analysis was assessed by a series of validity criteria according to Jadad's scale. A systematic review and meta-analysis were performed. RESULTS: Eleven clinical studies comprising four randomized-clinical trials (RCTs), four controlled clinical trials (CCTs) and three retrospective studies were included. The results of the meta-analysis of six prospective clinical trials suggested that the two popular pulpotomy medicaments were not significantly different in terms of clinical outcomes, radiographic findings, prevalence of apical and furcal destruction, internal root resorption or pulp canal obliteration. The relative risk (RR) value and 95% CI for those parameters were 0.72 (0.43-1.23), 0.87 (0.59-1.30), 0.67 (0.27-1.66), 1.77 (0.56-5.58) and 1.41 (0.63-3.15), respectively. The overall clinical and radiographic success rates based on the data of treatments with ferric sulphate from the 11 studies included ranged from 78% to 100% (mean 91.6 +/- 8.15%) and from 42% to 97% (mean 73.5 +/- 18.40%), respectively. CONCLUSIONS: In primary molar teeth with exposure of vital pulps by caries or trauma, pulpotomies performed with either formocresol or ferric sulphate have similar clinical and radiographic success. Ferric sulphate may be recommended as a suitable replacement for formocresol.

Evaluation of the formocresol versus mineral trioxide aggregate primary molar pulpotomy: a meta-analysis

Peng L, Ye L, Tan H, Zhou X . Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006

OBJECTIVE: To apply meta-analysis to compare the clinical and radiographic effects of mineral trioxide aggregate (MTA) with formocresol (FC) when used as wound dressing for pulpotomy of primary molars. STUDY DESIGN: The study list was obtained by searching MEDLINE, The Cochrane Library, EMBASE, and SCI. Only those papers that met the inclusion criteria were analyzed. RESULTS: Six studies met the inclusion criteria. There was significant difference between the success rates of FC- and MTA-treated pulpotomized primary molars ($P < .05$). Clinical assessments and radiographic findings of the MTA versus FC pulpotomy suggested that MTA was superior to FC in pulpotomy resulting in a lower failure rate, with the RR (Relative Risk) being 0.32 (95% confidence interval [CI] 0.11 to 0.90) and 0.31 (95% CI 0.13 to 0.74), respectively. Internal root resorption happened less in the MTA

group with RR 0.29, 95% CI 0.11 to 0.77. CONCLUSION: MTA induces less undesirable responses and might be FC's suitable replacement.

Evidence of pulpotomy in primary teeth comparing MTA, calcium hydroxide, ferric sulphate, and electrosurgery with formocresol

Stringhini Junior, E., Vitcel, M. E., Oliveira, L. B. . Eur Arch Paediatr Dent. 2015;16(4):303-12

AIM: The aim of this study was to evaluate the scientific evidence of pulpotomy in primary teeth comparing mineral trioxide aggregate (MTA), calcium hydroxide, ferric sulphate, and electrosurgery with formocresol. METHODS: A systematic search using key words was conducted using seven databases up to December 10, 2013. Clinical articles in English, Portuguese and Spanish were selected, which were in accordance with the inclusion and exclusion criteria and the research objective of comparing whether pulpotomy performed with formocresol in primary teeth is more effective than other medicaments or techniques. RESULTS: Out of the 12,515 publication initially identified, 30 clinical articles were included in the systematic review and analysed by four meta-analyses. The success rate of MTA (94.6 %) was higher than that of formocresol (87.4 %), with a statistically significant difference (OR = 0.39; 95 % CI = 0.25-0.62). Formocresol pulpotomy success was not statistically different from ferric sulphate or electrosurgery. CONCLUSION: MTA was clinically and radiographically superior to formocresol for pulpotomy of primary teeth. The other alternatives to formocresol such as electrosurgery and ferric sulphate can be used instead of formocresol since they showed success similar to formocresol. In addition, there is no evidence to support calcium hydroxide for pulpotomies in primary teeth.

Evidence-based assessment: evaluation of the formocresol versus ferric sulfate primary molar pulpotomy

Loh A, O'Hoy P, Tran X, Charles R, Hughes A, Kubo K, Messer LB . Pediatr Dent. 2004;26(5):401-9

PURPOSE: Formocresol and ferric sulfate were evaluated as pulpotomy medicaments using evidence-based dentistry principles. Formocresol has been challenged as a potential carcinogen and mutagen, leading to consideration of ferric sulfate. METHODS: The PICOT statement was: (P) In human carious primary molars with reversible coronal pulpitis, (I) does a pulpotomy performed with ferric sulfate, (C) compared with formocresol, (O) result in clinical/radiographic success, (T) in time periods up to exfoliation? Relevant papers (N=894) were identified from databases and inclusion criteria were applied; 94 papers remained (randomized clinical trials [RCTs]=7; clinical trials [CTs]=28; case-control studies=14; opinions, cohort, and cross-sectional studies=4; reviews=22; irretrievable papers=19). Three RCTs and 10 CTs (total teeth: formocresol=753; ferric sulfate=90) were meta-analyzed; 1 RCT and 1 CT were tested for homogeneity (odds ratios; 95% confidence intervals); 3 RCTs and 10 CTs were examined by student's t test. RESULTS: Clinical data indicated ferric sulfate was significantly more successful than formocresol (OR=1.95; CI=1.01-3.80). Radiographic data indicated no difference between medicaments (OR=0.90; CI=0.58-1.39). Medicaments did not differ with t-tests of clinical ($P>.10$) and radiographic ($P>.50$) data. CONCLUSIONS: This evidence-based assessment concluded that, in human carious primary molars with reversible coronal pulpitis, pulpotomies performed with either formocresol or ferric sulfate are likely to have similar clinical/radiographic success.

Formation of a hard tissue barrier after pulp cappings in humans. A systematic review

Olsson H, Petersson K, Rohlin M . Int Endod J. 2006;39(6):429-42

AIM: To evaluate the evidence on the formation of a hard tissue barrier after pulp capping in humans. METHODOLOGY: A PubMed and CENTRAL literature search with specific indexing terms and a hand search were made. The authors assessed the level of evidence of each publication as high, moderate or low. Based on this, the evidence grade of the conclusions was rated as strong, moderately strong, limited or insufficient. RESULTS: The initial search process resulted in a total of 171 publications. After reading the abstracts and hand searching the reference lists of the retrieved publications, 107 studies were retrieved in full-text and interpreted. After the interpretation, 21 studies remained and were included in the systematic review and given a level of evidence. No study had a high level of evidence, one study had moderate and 20 studies had a low level of evidence. There was heterogeneity between the studies; therefore, no meta-analysis was performed. The majority of studies on pulp capping using calcium hydroxide based materials reported formation of hard tissue bridging, studies on other pulp capping materials such as bonding agents presented inferior results. The evidence grade was insufficient. CONCLUSIONS: Insufficient evidence grade does not necessarily imply that there is no effect of a pulp capping procedure or that it should not be used. Rather, the insufficient evidence underpins the need for high-quality studies.

Mineral trioxide aggregate as a pulpotomy medicament: an evidence-based assessment

Ng FK, Messer LB . European Archives of Paediatric Dentistry: Official Journal of the European Academy of Paediatric Dentistry. 2008;9(2):58-73

AIM: The principles of evidence-based dentistry were used to compare mineral trioxide aggregate (MTA), formocresol (FC), ferric sulphate (FS) and calcium hydroxide (CH) as primary molar pulpotomy medicaments. METHODS: Electronic databases were searched and sieved for relevant papers by examining titles, abstracts and finally full texts. Included were randomized clinical trials (RCTs) and clinical trials (CTs) comparing the clinical and radiographic successes of MTA, FC, FS and CH pulpotomies. Data were extracted and common odds ratios (CORs) were derived by fixed effects meta-analysis (direct or indirect MA). Mean clinical and radiographic success rates from relevant study arms were examined. RESULTS: Eighteen RCTs and 10 CTs (total 1,260 molars) were identified to compare MTA and FC. Direct MAs found MTA was significantly more successful clinically (COR=3.11; 95%CI=1.09-8.85) and radiographically (COR=4.50; CI=1.78-11.42) than FC, and clinical and radiographic data confirmed this. Fourteen RCTs and 4 CTs (total 959 molars) were identified to compare MTA and FS. Indirect MAs found no statistically significant difference in clinical successes, but a statistically significant difference in the radiographic successes of MTA and FS (COR=4.69; CI=1.70-12.95). Clinical and radiographic data showed MTA was significantly more successful than FS. Nine RCTs and 7 CTs (total 531 molars) were identified to compare MTA and CH. Indirect MAs found statistically significant differences in the clinical (COR=6.48; CI=1.75-24.0) and radiographic (COR=10.47; CI=3.35-32.76) successes of MTA and CH. Clinical and radiographic data confirmed MTA was significantly more successful than CH. CONCLUSION: Currently available evidence suggests MTA compared with FC, FS and CH as a pulpotomy medicament resulted in significantly higher clinical and radiographic successes in all time periods up to exfoliation.

Mineral trioxide aggregate in primary teeth pulpotomy. A systematic literature review

Simancas-Pallares, M. A., Diaz-Caballero, A. J., Luna-Ricardo, L. M. Medicina Oral, Patologia Oral y Cirugia Bucal. 2010;15(6):942-6

Evidence-based dentistry is a critical evaluation, awareness of the available evidence to improve decision making about the care of individual patients and/or communities. OBJECTIVE: To systematically analyze the available scientific literature on clinical and radiographic results of two materials used in pulpotomy in primary teeth: formocresol and mineral trioxide aggregate. MATERIALS AND METHODS: It was identified relevant publications through a search of electronic databases such as MEDLINE (Ovid) and The Cochrane Library. To be included in the review, studies had to define the material used in child patients with pulp exposure by caries or tooth-alveolar trauma. RESULTS: Of the 21 articles obtained in the initial phase of the review, only 19 were available in full text and of these only met the requirements for inclusion 6 items, which were confronted, analyzed and discussed later. CONCLUSIONS: The clinical evidence available showed significant differences regarding the use of a material or another. In addition to the findings of clinical follow--radiographic and taking into account the potential toxicity of formocresol suggest the use of mineral trioxide aggregate pulpotomy of primary teeth.

Pulp response to resin-modified glass ionomer and calcium hydroxide cements in deep cavities: A quantitative systematic review

Mickenautsch, S., Yengopal, V., Banerjee, A. Dental Materials. 2010;26(8):761-70

OBJECTIVE: To quantitatively determine whether the pulp response to resin-modified glass ionomer cements placed in deep cavities differs from that generated by calcium hydroxide cement. SOURCES: Five databases were searched for articles up to 31 May 2009. STUDY SELECTION: Inclusion criteria: titles/abstracts relevant to topic; published in English; two-arm longitudinal in vivo trial; containing computable dichotomous datasets for test and control group. Exclusion criteria: not all entered subjects accounted for at the end of the trial; subjects of both groups not followed up in the same way; trial on animal tissue. DATA: One randomized and five non-randomized control trials, reporting on 1 and 17 datasets, respectively, were accepted. From non-randomized trials, the Relative Risk with 95% Confidence Interval of 13 datasets showed no statistically significant differences ($p>0.05$) and 4 showed a statistically significant difference between both materials. Meta-analysis of datasets from these trials found no difference between the inflammatory cell response after 30 days (0.87; 95%CI 0.59-1.26; $p=0.46$); 38% less inflammatory cell response with calcium hydroxide after 60 days (0.62; 95%CI 0.50-0.76)

Regenerative Endodontic Therapy: A Data Analysis of Clinical Protocols

Kontakiotis, E. G., Filippatos, C. G., Tzanetakis, G. N., Agrafioti, A. J Endod. 2014;40(8):1045-53

INTRODUCTION: The aim of the present study was to systematically analyze the protocols that have been used in regenerative endodontic therapy and to detect any variations in clinical procedures. METHODS: An electronic search was executed in PubMed using appropriate Medical Subject Heading terms covering the period from January 1993 to May 2014. Additional publications from hand searching and the reference section of each relevant article enriched the article list. The relevance of each article was initially evaluated by scanning all titles and corresponding abstracts. The definite inclusion of each article in the study was

determined by using specific criteria applied independently by 3 reviewers. RESULTS: Sixty relevant publications were finally included. The canal walls were not mechanically instrumented in 68% of the clinical articles. Sodium hypochlorite was included in 97% of the clinical studies either as the only irrigant or in combination with other irrigants. Antibiotic combination paste was used as the intracanal medicament in 80% of the clinical articles. Sodium hypochlorite, chlorhexidine, and EDTA were used in the final irrigation protocol in 75%, 4%, and 13% of the clinical studies, respectively. Neither the creation of a blood clot nor the use of platelet-rich plasma/platelet-rich fibrin was described in 13% of the clinical articles. Mineral trioxide aggregate was used as an intracanal coronal barrier in 85% of the relevant clinical studies. CONCLUSIONS: The variability of the clinical protocols applied during regenerative endodontic procedures is considerably high. A thorough analysis of regenerative protocols may constitute an additional source to provide useful clinical considerations for REPs.

Vital pulp therapy in vital permanent teeth with cariously exposed pulp: a systematic review

Aguilar, P., Linsuwanont, P. Journal of Endodontics. 2011;37(5):581-7

INTRODUCTION: This systematic review aims to illustrate the outcome of vital pulp therapy, namely direct pulp capping, partial pulpotomy, and full pulpotomy, in vital permanent teeth with cariously exposed pulp. METHODS: Electronic database MEDLINE via Ovid, PubMed, and Cochrane databases were searched. Hand searching was performed through reference lists of endodontic textbooks, endodontic-related journals, and relevant articles from electronic searching. The random effect method of weighted pooled success rate of each treatment and the 95% confidence interval were calculated by the DerSimonian-Laird method. The weighted pooled success rate of each treatment was estimated in 4 groups: >6 months-1 year, >1-2 years, >2-3 years, and >3 years. All statistics were performed by STATA version 10. The indirect comparison of success rates for 4 follow-up periods and the indirect comparison of clinical factors influencing the success rate of each treatment were performed by z test for proportion ($P < .05$). RESULTS: Overall, the success rate was in the range of 72.9%-99.4%. The fluctuation of the success rate of direct pulp capping was observed (>6 months-1 year, 87.5%; >1-2 years, 95.4%; >2-3 years, 87.7%; and >3 years, 72.9%). Partial pulpotomy and full pulpotomy sustained a high success rate up to more than 3 years (partial pulpotomy: >6 months-1 year, 97.6%; >1-2 years, 97.5%; >2-3 years, 97.6%; and >3 years, 99.4%; full pulpotomy: >6 months-1 year, 94%; >1-2 years, 94.9%; >2-3 years, 96.9%; and >3 years, 99.3%). CONCLUSIONS: Vital permanent teeth with cariously exposed pulp can be treated successfully with vital pulp therapy. Current best evidence provides inconclusive information regarding factors influencing treatment outcome, and this emphasizes the need for further observational studies of high quality.

Direct Pulp Capping with Calcium Hydroxide or Mineral Trioxide Aggregate: A Meta-analysis

Zhaofei Li, JOE 2015

Introduction The purpose of this study was to compare the effectiveness of mineral trioxide aggregate (MTA) and calcium hydroxide (CH) as pulp capping materials in humans by means of a meta-analysis. **Methods** The PubMed, Cochrane Library, Embase, and Web of Knowledge databases were used in the literature search from their establishment date until December 7, 2014. Studies that met the inclusion criteria were accepted, and necessary information was extracted by 2 authors independently using a standardized form. The success rate, inflammatory response, and dentin bridge formation were evaluated. **Results** Thirteen studies met the inclusion criteria. There was no significant heterogeneity between studies, so a fixed-effects model was used. The MTA treatment groups showed a significantly higher success rate compared with CH-capped groups (randomized controlled trials: odds ratio [OR] = 2.26; 95% confidence interval [CI] = 1.33–3.85; $P = .003$; retrospective nonrandomized trials: OR = 2.88; 95% CI, 1.86–4.44; $P < .00001$). MTA was superior to CH in terms of the absence of an inflammatory response as well as dentin bridge formation, with the OR being 4.56 (95% CI, 2.65–7.83) and 3.56 (95% CI, 1.89–6.70), respectively. **Conclusions** MTA has a higher success rate and results in less pulpal inflammatory response and more predictable hard dentin bridge formation than CH. MTA appears to be a suitable replacement of CH used for direct pulp capping.

Crack, VRF:

Diagnosis of vertical root fractures in endodontically treated teeth based on clinical and radiographic indices: a systematic review

Tsesis, I., Rosen, E., Tamse, A., Taschieri, S., Kfir, A. Journal of Endodontics. 2010;36(9):1455-8

INTRODUCTION: The diagnosis of vertical root fracture (VRF) is at times complicated for lack of specific signs, symptoms, and/or radiographic features. The purpose of this study was to systematically search and evaluate the literature regarding the diagnostic accuracy of clinical signs and symptoms and radiographic indices for the diagnosis of VRF in endodontically treated teeth by means of a systematic review. Copyright 2010 American Association of Endodontists. Published by Elsevier Inc. All rights reserved. **METHODS:** An exhaustive literature search combined with strict inclusion and exclusion criteria was undertaken to identify clinical studies that assessed the diagnosis of VRF. Copyright 2010 American Association of Endodontists. Published by Elsevier Inc. All rights reserved. **RESULTS:** There is no substantial evidence regarding the accuracy of the clinical and radiographic indices for the diagnosis of VRF in endodontically treated teeth. Copyright 2010 American Association of Endodontists. Published by Elsevier Inc. All rights reserved. **CONCLUSIONS:** Evidence-based data concerning the diagnostic accuracy and clinical effectiveness of clinical and radiographic dental evaluation for the diagnosis of VRF in endodontically treated teeth are lacking. The need for evidence-based research efforts to elucidate the currently unknown situation is of utmost significance.

Direct composite resin fillings versus amalgam fillings for permanent or adult posterior teeth

Rasines Alcaraz, M. G., Veitz-Keenan, A., Sahrman, P., Schmidlin, P. R., Davis, D., Iheozor-Ejiofor, Z. The Cochrane database of systematic reviews. 2014

BACKGROUND: Amalgam has been the traditional material for filling cavities in posterior teeth for the last 150 years and, due to its effectiveness and cost, amalgam is still the restorative material of choice in certain parts of the world. In recent times, however, there have been concerns over the use of amalgam restorations (fillings), relating to the mercury release in the body and the environmental impact following its disposal. Resin composites have become an esthetic alternative to amalgam restorations and there has been a remarkable improvement of its mechanical properties to restore posterior teeth. There is need to review new evidence comparing the effectiveness of both restorations. **OBJECTIVES:** To examine the effects of direct composite resin fillings versus amalgam fillings for permanent posterior teeth, primarily on restoration failure. **SEARCH METHODS:** We searched the Cochrane Oral Health Group's Trials Register (to 22 October 2013), the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library 2013, Issue 9), MEDLINE via OVID (1946 to 22 October 2013), EMBASE via OVID (1980 to 22 October 2013), and LILACs via BIREME Virtual Health Library (1980 to 22 October 2013). We applied no restrictions on language or date of publication when searching the electronic databases. We contacted manufacturers of dental materials to obtain any unpublished studies. **SELECTION CRITERIA:** Randomized controlled trials comparing dental resin composites with dental amalgams in permanent posterior teeth. We excluded studies having a follow-up period of less than three years. **DATA COLLECTION**

AND ANALYSIS: We used standard methodological procedures expected by The Cochrane Collaboration. MAIN RESULTS: Of the 2205 retrieved references, we included seven trials (10 articles) in the systematic review. Two trials were parallel group studies involving 1645 composite restorations and 1365 amalgam restorations (921 children) in the analysis. The other five trials were split-mouth studies involving 1620 composite restorations and 570 amalgam restorations in an unclear number of children. Due to major problems with the reporting of the data for the five split-mouth trials, the primary analysis is based on the two parallel group trials. We judged all seven trials to be at high risk of bias and we analyzed 3265 composite restorations and 1935 amalgam restorations. The parallel group trials indicated that resin restorations had a significantly higher risk of failure than amalgam restorations (risk ratio (RR) 1.89, 95% confidence interval (CI) 1.52 to 2.35, P value < 0.001 (fixed-effect model) (low-quality evidence)) and increased risk of secondary caries (RR 2.14, 95% CI 1.67 to 2.74, P value < 0.001 (low-quality evidence)) but no evidence of an increased risk of restoration fracture (RR 0.87, 95% CI 0.46 to 1.64, P value = 0.66 (moderate-quality evidence)). The results from the split-mouth trials were consistent with those of the parallel group trials. Adverse effects of dental restorations were reported in two trials. The outcomes considered were neurobehavioral function, renal function, psychosocial function, and physical development. The investigators found no difference in adverse effects between composite and amalgam restorations. However, the results should be interpreted with caution as none of the outcomes were reported in more than one trial. AUTHORS' CONCLUSIONS: There is low-quality evidence to suggest that resin composites lead to higher failure rates and risk of secondary caries than amalgam restorations. This review reinforces the benefit of amalgam restorations and the results are particularly useful in parts of the world where amalgam is still the material of choice to restore posterior teeth with proximal caries. Though the review found insufficient evidence to support or refute any adverse effects amalgam may have on patients, new research is unlikely to change opinion on its safety and due to the decision for a global phase-down of amalgam (Minamata Convention on Mercury) general opinion on its safety is unlikely to change.

Trauma

Effect of treatment delay upon pulp and periodontal healing of traumatic dental injuries -- a review article

Andreassen JO, Andreassen FM, Skeie A, Hjorting-Hansen E, Schwartz O . Dent Traumatol. 2002;18(3):116-28

Based on an analysis of the literature concerning parameters influencing the prognosis of traumatic dental injuries, few studies were found to have examined possible relationships between treatment delay and pulpal and periodontal ligament healing complications. It has been commonly accepted that all injuries should be treated on an emergency basis, for the comfort of the patient and also to reduce wound healing complications. For practical and especially economic reasons, various approaches can be selected to fulfill such a demand, such as acute treatment (i.e. within a few hours), subacute (i.e. within the first 24 h), and delayed (i.e. after the first 24 h). In this survey the consequences of treatment delay on pulpal and periodontal healing have been analyzed for the various dental trauma groups. Applying such a treatment approach to the various types of injuries, the following treatment guidelines can be recommended, based on our present rather limited knowledge of the effect of treatment delay upon wound healing. Crown and crown/root fractures: Subacute or delayed approach. Root fractures: Acute or subacute approach. Alveolar fractures: Acute approach (evidence however questionable). Concussion and subluxation: Subacute approach. Extrusion and lateral luxation: Acute or subacute approach (evidence however questionable). Intrusion: Subacute approach (evidence however questionable). Avulsion: If the tooth is not replanted at the time of injury, acute approach; otherwise subacute. Primary tooth injury: Subacute approach, unless the primary tooth is displaced into the follicle of the permanent tooth or occlusal problems are present; in the latter instances, an acute approach should be chosen. These treatment guidelines are based on very limited evidence from the literature and should be revised as soon as more evidence about the effect of treatment delay becomes available.

Emergency orthodontic treatment after the traumatic intrusive luxation of maxillary incisors

Chaushu S, Shapira J, Heling I, Becker A . Am J Orthod Dentofacial Orthop. 2004;126(2):162-72

Treatment of traumatically intruded teeth is based largely on empirical clinical experience rather than on scientific data. The aim of this qualitative meta-analysis was to provide an evidence base to evaluate the orthodontic repositioning approach. In a MEDLINE search of the literature in English, 14 reported patients involving 22 teeth were found to have been treated by this modality. Additionally, 3 new patients, involving 9 intruded teeth and presented herein, were combined to form a total study sample of 17 subjects (7 girls, 10 boys, aged 8.9 +/- 1.2 years). Orthodontic extrusive forces were applied in the immediate posttrauma period (up to 3 months), with a variety of orthodontic appliances. Repositioning was achieved for 90.3% of the affected teeth but failed in 9.7% because of inflammatory resorption (2 teeth) or a misdiagnosis of root fracture (1 tooth). Early complications included loss of pulp vitality and external root resorption. All intruded teeth with closed root apices lost their vitality regardless of the degree of intrusion, whereas among those with incomplete apices, 45.5% that had been

moderately intruded remained vital. External resorption was encountered in 54.8% of the teeth. Loss of marginal bone support was rarely encountered. Late complications included inflammatory root resorption in teeth with closed apices, in which endodontic treatment was not initially performed, and obliteration of the pulp tissue in teeth that remained vital. The results show that this method is superior to other treatment alternatives.

Interventions for treating traumatized necrotic immature permanent anterior teeth: inducing a calcific barrier & root strengthening

Al Ansary MA, Day PF, Duggal MS, Brunton PA . Dental Traumatology. 2009;25(4):367-79

BACKGROUND: Apical barrier formation and root strengthening procedures have been extensively described in the literature. This systematic review attempts to establish where the effects of interventions using multi-visit apexification, single visit apical plug techniques and root strengthening procedures are consistent and where they may vary significantly. **OBJECTIVES:** To evaluate the relative effectiveness of apexification and apical plug techniques as well as root strengthening procedures for treating traumatized necrotic immature permanent anterior teeth through a systematic review of randomized controlled trials. Reported immediate and/or long-term adverse events and effects of the materials and techniques are also evaluated. **SEARCH STRATEGY & SELECTION CRITERIA:** Structured electronic and hand search was performed with no restriction on the language of publication. Only randomized controlled trials comparing different apical barrier formation techniques and root strengthening procedures in traumatized necrotic immature anterior teeth were assessed. **RESULTS:** Two hundred studies were identified but only two were suitable for inclusion. Included studies investigated multi-visit apexification techniques using calcium hydroxide and tricalcium phosphate. There were no eligible studies investigating root strengthening procedures or any other intervention for apical barrier formation in necrotic immature anterior teeth. No reliable information was available on long-term adverse effects of the reported interventions or cost implications. **CONCLUSIONS:** Based on two included studies, there is weak evidence supporting the use of either calcium hydroxide or tricalcium phosphate for apical barrier formation in necrotic immature anterior teeth employing multi-visit apexification techniques. The evidence is insufficient to provide guidelines for practice. There was no reliable evidence on adverse events or long-term effects after the use of calcium hydroxide or tricalcium phosphate justifying caution in their use in apical barrier formation techniques.

Pulp canal obliteration after replantation of avulsed immature teeth: a systematic review

Abd-Elmeguid, A., ElSalhy, M., Yu, D. C. . Dent Traumatol. 2015

BACKGROUND: Avulsion of permanent teeth is one of the most serious dento-alveolar traumatic injuries. Pulp canal obliteration (PCO) is one of the consequences after replantation of avulsed immature teeth. The aim of this systematic review was to determine when calcification following replantation of an avulsed immature tooth begins and to evaluate the prevalence of PCO in these cases. **MATERIALS AND METHODS:** Electronic database MEDLINE via Ovid, PubMed, Cochrane, and Web of science databases were searched. Hand searching was performed through reference lists of endodontic and trauma textbooks, endodontic and trauma-related journals, and relevant articles from electronic searching. Pooled data from the selected articles were analyzed for prevalence of healing and PCO as well as mean first evidence of PCO. **RESULTS:** Pulp healing after replantation of immature teeth occurred in 32.9%, while pulpal necrosis occurred in 67.1% of teeth. PCO was the most

frequent outcome of pulpal healing as it occurred in 96% of healed pulps. First evidence of obliteration was observed from 3 to 14 months with mean time of 9.5 months (95% CI = 4.5-14.5 months). **CONCLUSIONS:** PCO is considered the mechanism by which the pulp heals after replantation of avulsed immature permanent teeth. PCO is very fast and can be recognized radiographically during the first year from the onset of the trauma.

Pulpal Response after Acute Dental Injury in the Permanent Dentition: Clinical Implications—A Review

Frances M. Andreasen JOE 2015

Introduction Pulpal reactions after acute dental injury have been puzzling for many clinicians. The management of dental trauma and an understanding of clinical and treatment factors in outcomes arose from multivariate statistical analyses of archive material from Copenhagen. **Methods** The aim of this article was to review the works of this period with respect to pulpal reaction after acute mechanical trauma. These traumas include luxation, avulsion, root fracture, and crown fracture. A PubMed search identified other literature where multivariate analysis was used, and these results were compared with earlier pioneering studies. **Results and Conclusions** This article will describe pulpal responses after the said acute injuries and outline the competition that takes place between ingrowth of a new neurovascular system into the traumatized tissue versus bacterial invasion. If there is an intact neurovascular supply to the pulp, then the same immunologic defenses that are found in the rest of the body can function and defend against infection. If this is disturbed in any way, alterations in the pulp (eg, pulp canal obliteration, resorption processes) or pulp death (pulp necrosis) will occur. Intermediary stations in pulpal response (ie, transient apical breakdown) mimicked the cardinal signs of pulp necrosis, which could be reversible and lead to pulpal healing. These processes will also be addressed with respect to a more conservative treatment approach. In young patients, it is of the utmost importance that pulp vitality be maintained to ensure continued root growth and development and an intact dentition.

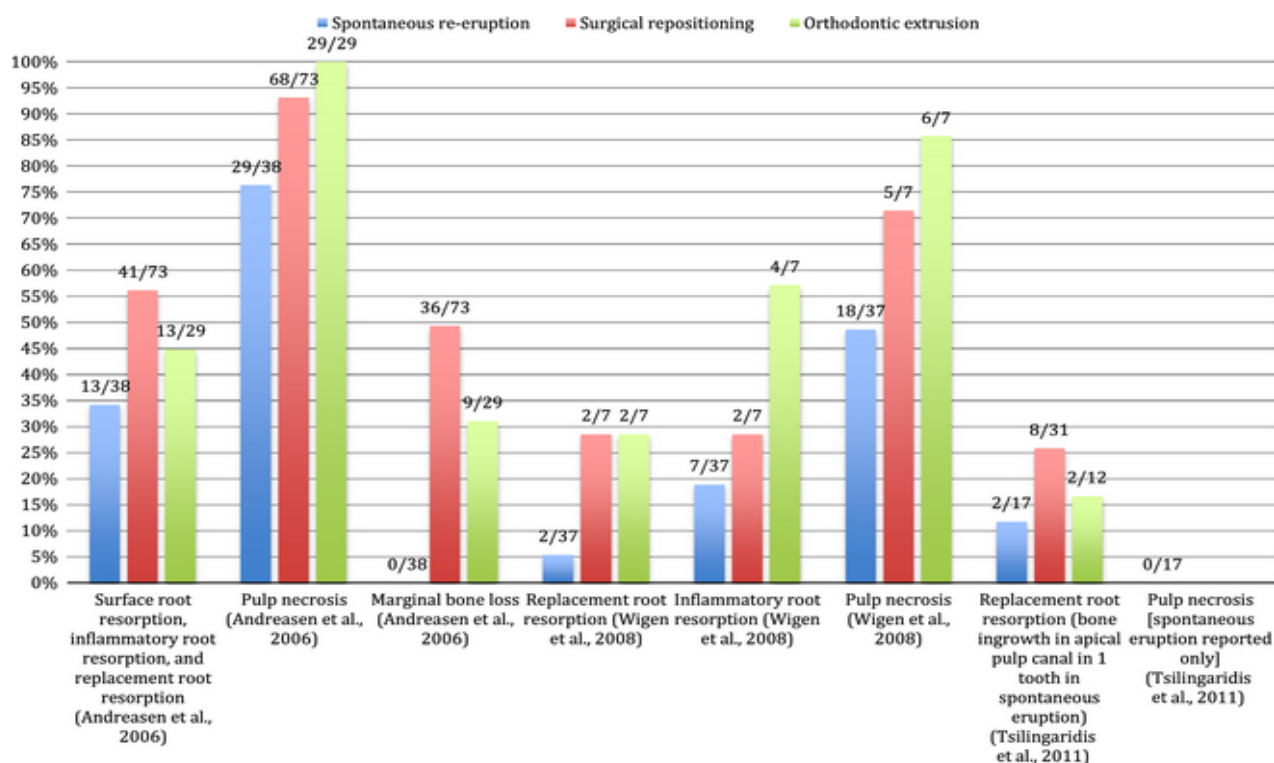
Intrusive luxation of permanent teeth: a systematic review of factors important for treatment decision-making.

AlKhalifa JD, Dent Traumatol. 2014

OBJECTIVES: To conduct a literature review and assess the current strength of evidence of the available studies and to investigate factors important for treatment choice. **METHODOLOGY:** Structured electronic and hand searches were performed, restricted to English records for all age groups. Only cohort studies comparing spontaneous eruption and surgical and orthodontic extrusion were assessed. Risk of bias assessment was made by the method introduced by the Cochrane collaboration and the Newcastle-Ottawa quality assessment scale for cohort studies, and the body of evidence was assessed by the GRADE approach. **RESULTS:** One hundred seventeen studies were identified, but only three were suitable for inclusion; these were not meta-analyzed because of methodological and clinical heterogeneity. Spontaneous eruption had a low failure rate of 5-12%. **CONCLUSION:** Given that infection can be controlled by endodontic therapy, it appears that spontaneous eruption results in the fewest complications in immature teeth, regardless of the degree of intrusion.

Furthermore, there appear to be no significant differences between surgical and orthodontic extrusion in terms of adverse outcomes. Limitations of the majority of current cohort studies include selection bias (no confounding adjustment and no demonstration that outcomes were absent at the start of the study), reporting bias, and no information on whether investigators were blinded from the outcomes assessed. Furthermore, there is a serious indirectness in the current body of evidence regarding each outcome. Therefore, guidelines for treatment are currently not based on strong evidence.

Figure detail the frequency of complications following different treatment protocols



Interventions for treating traumatized permanent front teeth: avulsed (knocked out) and replanted.

Day, Cochrane Database Syst Rev. 2010

BACKGROUND: Dental trauma is common. One of the most severe injuries is when a permanent tooth is knocked completely out (avulsed) of the mouth. In most circumstances the tooth should be replanted as quickly as possible. There is uncertainty on how best to prepare teeth for replantation. **OBJECTIVES:** To compare the effects of a range of interventions for managing traumatised permanent teeth with avulsion injuries. **SEARCH STRATEGY:** The Cochrane Oral Health Group's Trials Register (to 28th October 2009); CENTRAL (The Cochrane Library 2009, Issue 4); MEDLINE (1950 to October 2009); EMBASE (1980 to October 2009); www.clinicaltrials.gov/; www.controlled-trials.com/ and reference lists of articles were searched. There were no language restrictions. **SELECTION CRITERIA:** Only randomised controlled trials (RCTs), that included a minimum follow-up period of 12 months, for interventions for avulsed and replanted permanent teeth were considered. **DATA COLLECTION AND ANALYSIS:** Two review authors independently extracted data and

assessed trial quality and the risk of bias in studies to be included. MAIN RESULTS: Three studies, involving a total of 162 patients and 231 teeth were identified. Study one (with a high risk of bias) investigated the effect of extra-oral endodontics. This showed no significant difference in radiographic resorption compared with intra-oral endodontics provided at week 1 for teeth avulsed for longer than 60 minutes dry time. Study two (which had a moderate risk of bias) investigated a 10-minute soaking in thymosin alpha 1 prior to replantation and then its further use as a daily gingival injection for the first 7 days. They reported a strong benefit at 48 months (14% with periodontal healing in the control group versus 77% for the experimental group). Study three (with a high risk of bias) investigated a 20-minute soaking with gentamycin sulphate (4×10^7 U/L) for both groups prior to replantation and then the use of hyperbaric oxygen daily in the experimental group for 80 minutes for the first 10 days. They reported a strong benefit at 12 months (43% periodontal healing versus 88% for the experimental group). There was no formal reporting of adverse events. AUTHORS' CONCLUSIONS: The available evidence suggests that extra-oral endodontics is not detrimental for teeth replanted after more than 60 minutes dry time. Studies with moderate/high risk of bias indicate that soaking in thymosin alpha 1 and gentamycin sulphate followed by hyperbaric oxygen may be advantageous however, they have not previously been reported as interventions for avulsed teeth and need further validation. More evidence with low risk of bias is required and, with the low incidence of avulsed teeth, collaborative multicentre trials are indicated.

Interventions for the management of external root resorption

Zohreh Ahangari Cochrane review 2010

Diagnosis: Whichever classification is used, early diagnosis is a critical factor in the management of ERR because the sooner treatment is initiated the less severe the long-term consequences of resorption (da Silveira 2007). Diagnosis should be based on a combination of radiographic and clinical examination. Intraoral radiographs of the lesion usually show an uneven root surface outline, and radiographs obtained at different angles may be useful to determine which surface is affected (Bergmans 2002). Vitality testing may also be helpful in detecting the type of ERR (Fuss 2003; Nance 2000). Recent studies have indicated that computed tomography, with its higher sensitivity and specificity may be a useful diagnostic tool particularly in detecting small and less accessible root resorption (da Silveira 2007). Diagnosis should also seek to differentiate between ERR and internal root resorption (IRR) (Carrotte 2004). Description of the condition: External root resorption tends to occur more frequently in patients aged between 21 and 30 years (28.40%) and is more common in females (59.04%) than males (Opacic 2004). Trauma, previous periodontal surgery, pressure from adjacent unerupted teeth and pathological conditions such as tumours as well as tooth re-implantation have all been implicated as aetiological factors (Opacic 2004; St George 2006). Orthodontic tooth movement may also play a role in ERR especially where the forces applied to induce tooth movement are not controlled and in these situations the resorption usually occurs in the apical third of the root (Abuabara 2007). Root resorption may also occur as a result of systemic disease and endocrine disorders i.e. hyperparathyroidism, Paget's disease, calcinosis, Gaucher's disease and in Turner's syndrome as well as after radiation therapy (Carrotte 2004). However, it is generally accepted that in the majority of cases two factors, injury and stimulation, are required to initiate root resorption (Fuss 2003). Treatment alternatives will depend on the type and extent of resorption and may include symptomatic treatment for relief of pain and swelling and the stabilisation of any mobile teeth if appropriate (Trope 2000). If there is pulpal involvement, endodontic therapy together with surgery to remove the granulation tissue and filling of the resorptive defect may be required (Fuss 2003). Root canal medications and intracanal cements, such as MTA, have also been used in an attempt to arrest the resorptive process and provide an apical seal for the tooth (Gulsahi 2007). If the root resorption is extensive and the cervical margin (adjacent to the gum) is involved with the most apical parts of the root, the treatment is usually more complicated and not infrequently extraction may be the only option (Fuss 2003; Gulsahi 2007; Trope 2002). If it has occurred as a result of pressure from an unerupted tooth or erupting teeth or during orthodontic treatment and there is no sign of infection, removal of the tooth or pressure will usually stop further root resorption (Heithersay 2007). However, if teeth are severely mobile after completion of orthodontic treatment splinting may be required. In case of hyperplastic invasive cervical resorption, due to its invasive nature, total removal or inactivation of the resorptive tissue via chemical approach or surgical modalities is essential (Heithersay 2007). As for replacement resorption (ankylosis), the treatment will depend on the stage of tooth development, the severity of trauma and the extent of periodontal ligament necrosis. In younger patients, there is a greater chance of early tooth loss followed by ridge resorption, and therefore a need for the clinician to consider timely and appropriate management of the resorptive process. This may involve regenerative treatments, orthodontic space closure, or ultimately extraction of the ankylosed tooth followed by bone augmentation (Sapir 2008). Currently there is no consensus on the management of the different forms of external root resorption (Fuss 2003; Majorana 2003).

Authors' conclusions: We were unable to identify any reports of randomised controlled trials regarding the efficacy of different interventions for the management of external root resorption. In view of the lack of any high level evidence on this topic, it is suggested that clinicians decide on the most appropriate means of managing this condition according to their clinical experience with regard to patient related factors. Future research should consist of robust clinical trials which conform to the CONSORT statement

Biomaterial

Histological responses of the periodontium to MTA: a systematic review

Katsamakidis, S., Slot, D. E., Van der Sluis, L. W., Van der Weijden, F. . Journal of Clinical Periodontology. 2013;40(4):334-44

AIM: The purpose of this systematic review was to investigate whether a mineral trioxide aggregate (MTA) restoration of an endodontic-periodontal communication leads to regeneration of the adjacent periodontal tissues. METHODOLOGY: The databases MEDLINE-PubMed, Cochrane-CENTRAL, and EMBASE were searched, up to July 2012. In vivo studies that reported on the histological response of the periodontium to MTA were selected. RESULTS: The screening of 98 title-abstracts, full-text reading, and hand searches in literature lists yielded 24 papers. All of them involved animals. There were no studies reporting on human histology. Study protocols presented heterogeneity regarding treated lesions, intervention, and reported outcomes. The histological results of the animal studies showed minimal inflammatory reactions, bone healing, periodontal ligament presence, and consistent cementum formation. Time lapse after mixing, bacterial contamination, root canal disinfection, and inflammation influenced MTA's cementoconductive properties. CONCLUSIONS: Within the limitations of the selected papers concerning inhomogeneous study protocols and low methodological quality scores, their findings were consistent with regard to MTA's biocompatibility and cementogenic ability. Experimental animal studies show that MTA can promote healing towards regeneration. There is now a distinct need to examine the clinical performance of MTA in well-controlled prospective human cohort studied

Biodentine material characteristics and clinical applications: a review of the literature

Rajasekharan, S., Martens, L. C., Cauwels, R. G., Verbeeck, R. M. . Eur Arch Paediatr Dent. 2014;15(3):147-58

INTRODUCTION: Biodentine is a new version of calcium silicate-based inorganic cement. AIM: The aim of this review is to provide a detailed analysis of the physical and biological properties of Biodentine and to compare these properties with those of other tricalcium silicate cements viz. mineral trioxide aggregate (MTA) and Bioaggregate (Bioaggregate). STUDY DESIGN: A comprehensive systematic literature search for all publications to date was performed on 20th November 2013 by two independent reviewers in Medline (PubMed), Embase, Web of Science, CENTRAL (Cochrane), SIGLE, SciELO, Scopus, Lilacs and clinicaltrials.gov using the search terms Biodentine, "tricalcium silicate", Ca_3SiO_5 , "dentine substitute", "dentin substitute" and RD 94. In addition to the electronic search, hand searches and reference searches were performed to include articles published in journals that were not indexed in Medline. Randomised control trials (RCT), case control studies, case series, case reports, in vitro studies, animal studies and short communications in English language were considered for this review. CONCLUSIONS: Considering the superior physical and biologic properties, Biodentine could be an efficient alternative to MTA to be used in a variety of clinical applications. There appears to be a wide range of clinical applications where Biodentine could be used in the field of endodontics, dental traumatology, restorative dentistry and pediatric dentistry. Although it seems to be good clinical practice, currently there is little clinical evidence to support all potential indications.

Systematic disease, apical pathosis

Tooth loss and oral health-related quality of life: a systematic review and meta-analysis

Gerritsen, Anneloes E., Allen, P. Finbarr, Witter, Dick J., Bronkhorst, Ewald M., Creugers, Nico H. J. Health & Quality of Life Outcomes. 2010;8():126

BACKGROUND: It is increasingly recognized that the impact of disease on quality of life should be taken into account when assessing health status. It is likely that tooth loss, in most cases being a consequence of oral diseases, affects Oral Health-Related Quality of Life (OHRQoL). The aim of the present study is to systematically review the literature and to analyse the relationship between the number and location of missing teeth and oral health-related quality of life (OHRQoL). It was hypothesized that tooth loss is associated with an impairment of OHRQoL. Secondly, it was hypothesized that location and distribution of remaining teeth play an important role in this. METHODS: Relevant databases were searched for papers in English, published from 1990 to July 2009 following a broad search strategy. Relevant papers were selected by two independent readers using predefined exclusion criteria, firstly on the basis of abstracts, secondly by assessing full-text papers. Selected studies were grouped on the basis of OHRQoL instruments used and assessed for feasibility for quantitative synthesis. Comparable outcomes were subjected to meta-analysis; remaining outcomes were subjected to a qualitative synthesis only. RESULTS: From a total of 924 references, 35 were eligible for synthesis (inter-reader agreement abstracts $k = 0.84 \pm 0.03$; full-texts: $k = 0.68 \pm 0.06$). Meta-analysis was feasible for 10 studies reporting on 13 different samples, resulting in 6 separate analyses. All studies showed that tooth loss is associated with unfavourable OHRQoL scores, independent of study location and OHRQoL instrument used. Qualitative synthesis showed that all 9 studies investigating a possible relationship between number of occluding pairs of teeth present and OHRQoL reported significant positive correlations. Five studies presented separate data regarding OHRQoL and location of tooth loss (anterior tooth loss vs. posterior tooth loss). Four of these reported highest impact for anterior tooth loss; one study indicated a similar impact for both locations of tooth loss. CONCLUSIONS: This study provides fairly strong evidence that tooth loss is associated with impairment of OHRQoL and location and distribution of tooth loss affect the severity of the impairment. This association seems to be independent from the OHRQoL instrument used and context of the included samples.

Association of tobacco use and periapical pathosis - a systematic review

Walter, C., Rodriguez, F. R., Taner, B., Hecker, H., Weiger, R. International Endodontic Journal. 2012;45(12):1065-73

The aim was to review the current evidence regarding an association between tobacco use, that is, cigarette smoking, and periapical pathosis. A systematic MEDLINE search of articles published prior to October 2011 (4th) was conducted using the keywords 'smoking and endodontics OR smoking and periapical index'. The study selection, data preparation and validity assessment were conducted by two reviewers. Nine studies fulfilled the inclusion criteria and represented data from 3008 individuals. The studies differed with respect to (i) study design, (ii) radiographic techniques, (iii) assessment of periapical pathosis, (iv) classification of smoking characteristics and/or (v) potential confounders accounted for in the

analyses. Five of six cross-sectional studies revealed a significant positive association (OR 1.35-16.8) between periapical pathosis and current cigarette smoking. One of three longitudinal studies indicated an increased risk (OR 1.7) of root treated teeth for current smokers. The substantial heterogeneity of the included studies limited their interpretation. Further, well-designed studies are required to investigate the association between tobacco use and periapical pathosis. 2012 International Endodontic Journal.

Association between diabetes and the prevalence of radiolucent periapical lesions in root-filled teeth:systematic review and meta-analysis.

Segura-Egea JJ, Clin Oral Investig. 2016

INTRODUCTION: The question of whether diabetes mellitus can influence the outcome of root canal treatment (RCT) remains unclear. The aim of this systematic review and meta-analysis was to analyze scientific available evidence on the association between diabetes and the presence of radiolucent periapical lesions (RPLs) in root-filled teeth (RFT). **METHODS:** The review question was as follows: in adult patients who had endodontically treated teeth, does the absence or presence of diabetes result in an increase in the prevalence of RPL associated to RFT? A systematic MEDLINE/PubMed, Wiley Online Database, Web of Science, and Scopus search was conducted using the following MeSH and keywords: Diabetes Mellitus OR Diabetes OR Diabetic OR Hyperglycemia, AND Endodontics, Periapical Periodontitis, Periapical Diseases, Apical Periodontitis, Periradicular Lesion, Periapical Radiolucency, Radiolucent Periapical Lesion, Root Canal Treatment, Root Canal Preparation, Root Canal Therapy, Root Filled Teeth, Endodontically Treated Teeth. Seven studies reporting data on the prevalence of RPL associated to RFT both in diabetic and control subjects were included. **RESULTS:** After the study selection, seven epidemiological studies fulfilled the inclusion criteria, representing data from 1593 root canal treatments, 1011 in non-diabetic control subjects, and 582 in diabetic patients. The calculated pooled odds ratio (OR = 1.42; 95 % CL = 1.11-1.80; p = 0.0058) indicates that diabetic patients have higher prevalence of RFT with RPLs than controls. **CONCLUSION:** Available scientific evidence indicates that diabetes is significantly associated to higher prevalence of periapical radiolucencies in endodontically treated teeth, being an important putative pre-operative prognostic factor in RCT.

Diabetes mellitus and inflammatory pulpal and periapical disease: a review

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Diabetes mellitus (DM) is one of the most common metabolic disorders. DM is characterized by hyperglycaemia, resulting in wound healing difficulties and systemic and oral manifestations, which have a direct effect on dental pulp integrity. Experimental and clinical studies have demonstrated a higher prevalence of periapical lesions in patients with uncontrolled diabetes. The influence of DM on periapical bone resorption and its impact on dental intervention of such patients are reviewed, and its aetiology and pathogenesis are analysed at molecular level. Pulpals from patients with diabetes have the tendency to present limited dental collateral circulation, impaired immune response, increased risk of acquiring pulp infection (especially anaerobic ones) or necrosis, besides toothache and occasional

tendency towards pulp necrosis caused by ischaemia. In regard to molecular pathology, hyperglycaemia is a stimulus for bone resorption, inhibiting osteoblastic differentiation and reducing bone recovery. The relationship between poorly controlled diabetes and bone metabolism is not clearly understood. Molecular knowledge about pulp alterations in patients with diabetes could offer new therapeutic directions. Knowledge about how diabetes affects systemic and oral health has an enduring importance, because it may imply not only systemic complications but also a higher risk of oral diseases with a significant effect on pulp and periapical tissue.