

Management of the Immature Apex Tooth: An Online Study Guide

Abstract

The Editorial Board of the *Journal of Endodontics* has developed a literature-based study guide of topical areas related to endodontics. This study guide is intended to give the reader a focused review of the essential endodontic literature and does not cite all possible articles related to each topic. Although citing all articles would be comprehensive, it would defeat the idea of a study guide. This section will cover apexogenesis, revascularization/regeneration, apexification, and artificial apical barriers. (*J Endod* 2008;34:e79–e85)

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Introduction

The delivery of high quality clinical care requires a thorough understanding of the endodontic literature. The Editorial Board of the *Journal of Endodontics* has developed this online study guide for endodontists and fellow clinicians interested in endodontics.

There are several potential applications for an online study guide. First, an online study guide permits clinicians to focus in on particular areas of endodontics where they can quickly review key papers devoted to one particular topic. For example, this particular study guide provides a summary of key papers in the area of apexogenesis, revascularization/regeneration, apexification, and artificial apical barriers.

Second, a study guide permits speakers to efficiently review background material in preparation for future courses, lectures, or continuing educational events. Third, an online study guide permits students to review key papers in preparation for future examinations or for development of residency seminars. Fourth, an online study guide permits readers to quickly and efficiently access either the abstract or the entire paper cited in the Tables (see Discussion for details).

Methods

One potential problem in developing an online study guide was to provide a summary of major papers that contributed to a given topic area. The inclusion of all possible papers on a given topic would lead to an unwieldy collection that failed to clearly identify key papers in the area. Of course, exclusion of key papers is also problematic. To address this issue, the JOE Editorial Board developed the overall list of topics to be covered and then for each topic generated an initial tabulation of key historical and contemporary papers on that topic. This list was then sent to two outside reviewers who were both experienced educators and Diplomates of the American Board of Endodontics. These reviewers then recommended additions and deletions of papers to the proposed topic list.

To maintain currency, the JOE Editorial Board proposes to periodically update each topical study guide by using the same peer-reviewed process as described above.

Results

The results of the study guide (1–52) provide an overview of selected literature that will cover apexogenesis, revascularization/regeneration, apexification, and artificial apical barriers. This information is organized into Tables 1–4.

Discussion

The journey to clinical excellence requires not only outstanding clinical skills, but also that special knowledge that accrues from a study of the endodontic literature. The purpose of the JOE online study guide is to serve as one source for efficiently reviewing key papers that are organized by topic area and presented with the advantages of online Internet technology.

Although JOE readers are undoubtedly familiar with many aspects of the Internet, there are special features available at JOE online that provide particular advantages in their application for a study guide. For example, if this particular study guide is downloaded as a pdf, it provides a useful but static listing of the cited articles. On the other hand, if the reader navigates to the Table of Contents page for the Online Study Guide and then clicks on “Full Text” (Fig. 1), they will be taken to an HTML version of the Study Guide. This online version of the study guide has special capabilities including the fact that the references are hyperlinked. Thus, the

Online Study Guide

reader can quickly obtain abstracts of nearly all cited papers and can review the entire paper of many of the cited papers with only a few clicks of their mouse (Fig. 2). Thus, combining a study guide with online capabilities provides particular benefits for efficiently reviewing key papers in the endodontic literature.

We hope that this Study Guide will prove useful to you as one source for developing a focused and special base of endodontic knowledge. As always, we are interested in your thoughts on this initiative and how the *JOE* can better serve you, our readers. Feel free to email us at: JEndodontics@UTHSCSA.edu.

TABLE 1. Apexogenesis

Ref #	Title
1.	Tronstad L. Reaction of the exposed pulp to Dycal treatment. <i>Oral Surg Oral Med Oral Pathol</i> 1974;38:945–53.
2.	Krakow AA, Berk H, Gron P. Therapeutic induction of root formation in the exposed incompletely formed tooth with vital pulp. <i>Oral Surg Oral Med Oral Pathol</i> 1977;43:755–65.
3.	Tenca JI, Tsamtsouris A. Continued root end development: apexogenesis and apexification. <i>J Pedodon</i> 1978;2:144–57.
4.	Cvek M. A clinical report on partial pulpotomy and capping with calcium hydroxide in permanent incisors with complicated crown fracture. <i>J Endod</i> 1978;4:232–7.
5.	Gutmann JL, Heaton JF. Management of the open (immature) apex: 1—vital teeth. <i>Int Endod J</i> 1981;14:166–72.
6.	Cvek M, Cleaton-Jones PE, Austin JC, Andreasen JO. Pulp reactions to exposure after experimental crown fractures grinding in adult monkeys. <i>J Endod</i> 1982;8:391–7.
7.	Cvek M, Lundberg M. Histological appearance of pulps after exposure by a crown fracture, partial pulpotomy, and clinical diagnosis of healing. <i>J Endod</i> 1983;9:8–11.
8.	Goldberg F, Massone EJ, Spielberg C. Evaluation of the dentinal bridge after pulpotomy and calcium hydroxide dressing. <i>J Endod</i> 1984;10:318–20.
9.	Fuks AB, Chosack A, Klein G, Eidelman E. Partial pulpotomy as a treatment alternative for exposed pulps in crown-fractured permanent incisors. <i>Endod Dent Traumatol</i> 1987;3:100–2.
10.	Mejare I, Cvek M. Partial pulpotomy in young permanent teeth with deep carious lesions. <i>Endod Dent Traumatol</i> 1993;9:238–42.
11.	Bakland LK. Management of traumatically injured pulps in immature teeth using MTA. <i>J Calif Dent Assoc</i> 2000;28:855–8.

TABLE 2. Revascularization/Regeneration

Ref #	Title
12.	Sato I, Ando-Kurihara N, Kota K, Iwaku M, Hoshino E. Sterilization of infected root-canal dentine by topical application of a mixture of ciprofloxacin, metronidazole and minocycline <i>in situ</i> . Int Endod J 1996;29:118–24.
13.	Hoshino E, Kurihara-Ando N, Sato I, et al. In-vitro antibacterial susceptibility of bacteria taken from infected root dentine to a mixture of ciprofloxacin, metronidazole and minocycline. Int Endod J 1996;29:125–30.
14.	Yanpiset K, Trope M. Pulp revascularization of replanted immature dog teeth after different treatment methods. Endod Dent Traumatol 2000;16:211–7.
15.	Iwaya S, Ikawa M, Kubota M. Revascularization of an immature permanent tooth with apical periodontitis and sinus tract. Dent Traumatol 2001;17:185–7.
16.	Ritter AL, Ritter AV, Murrah V, Sigurdsson A, Trope M. Pulp revascularization in replanted immature dog teeth after treatment with minocycline and doxycycline assessed by laser Doppler flowmetry, radiography, and histology. Dent Traumatol 2004;20:75–84.
17.	Banchs F, Trope M. Revascularization of immature permanent teeth with apical periodontitis: new treatment protocol? J Endod 2004;30:196–200.
18.	Saito T, Ogawa M, Hata Y, Bessho K. Acceleration effect of human recombinant bone morphogenetic protein-2 on differentiation of human pulp cells into odontoblasts. J Endod 2004;330:205–8.
19.	Murray PE, Garcia-Godoy F. Stem cell responses in tooth regeneration. Stem Cells Dev 2004;13:255–62.
20.	Windley W, Teixeira F, Levin L, Sigurdsson A, Trope M. Disinfection of immature teeth with a triple antibiotic paste. J Endod 2005;31:439–43.
21.	Nakashima M, Akamine A. The application of tissue engineering to regeneration of pulp and dentin in endodontics. J Endod 2005;31:711–8.
22.	Chueh LH, Huang GT. Immature teeth with periradicular periodontitis or abscess undergoing apexogenesis: a paradigm shift. J Endod 2006;32:1205–13.
23.	Murray PE, Garcia-Godoy F, Hargreaves KM. Regenerative endodontics: a review of current status and a call for action. J Endod 2007;33:377–90.
24.	Thibodeau B, Teixeira F, Yamauchi M, Caplan DJ, Trope M. Pulp revascularization of immature dog teeth with apical periodontitis. J Endod 2007;33:680–9.

TABLE 3. Apexification

Ref #	Title
25.	Frank AL. Therapy for the divergent pulpless tooth by continued apical formation. J Am Dent Assoc 1966;72:87-93.
26.	Steiner JC, Dow PR, Cathey GM. Inducing root end closure of nonvital permanent teeth. J Dent Child 1968;35:47-54.
27.	Heithersay GS. Stimulation of root formation in incompletely developed pulpless teeth. Oral Surg Oral Med Oral Pathol 1970;29:620-30.
28.	Cvek M. Treatment of non-vital permanent incisors with calcium hydroxide: I—follow-up of periapical repair and apical closure of immature roots. Odont Revy 1972;23:27-44.
29.	Cvek M, Sundstrom B. Treatment of non-vital permanent incisors with calcium hydroxide: V—histologic appearance of roentgenographically demonstrable apical closure of immature roots. Odont Revy 1974;25:379-91.
30.	Roberts SC, Brilliant JD. Tricalcium phosphate as an adjunct to apical closure in pulpless permanent teeth. J Endod 1975;1:263-9.
31.	Nevens AJ, Finkelstein F, Borden BG, Laporta R Revitalization of pulpless open apex teeth in rhesus monkeys, using collagen-calcium phosphate gel. J Endod 1976;2:159-65.
32.	Citrome GP, Kaminski EJ, Heuer MA. A comparative study of tooth apexification in the dog. J Endod 1979;5:290-7.
33.	Gutmann JL, Heaton JF. Management of the open (immature) apex: 2—non-vital teeth. Int Endod J 1981;14:173-8.
34.	Schindler WG, Schwartz SA. Apical closure in the presence of pulpal necrosis: report of two cases. J Endod 1989;15:555-8.
35.	Kleier DJ, Barr ES. A study of endodontically apexified teeth. Endod Dent Traumatol 1991;7:112-7.
36.	Mackie IC, Worthington HV, Hill FJ. A follow-up study of incisor teeth which had been treated by apical closure and root filling. Br Dent J 1993;175:99-101.
37.	Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as root canal dressing may increase risk of root fracture. Dent Traumatol 2002;18:134-7.
38.	Rafter M. Apexification: a review. Dent Traumatol 2005;21:1-8.
39.	Ham KA, Witherspoon DE, Gutmann JL, Ravindranath S, Gait TC, Opperman LA. Preliminary evaluation of BMP-2 expression and histological characteristics during apexification with calcium hydroxide and mineral trioxide aggregate. J Endod 2005;31:275-9.

TABLE 4. Artificial Apical Barriers

Ref #	Title
40.	Shabahang S, Torabinejad M. Treatment of teeth with open apices using mineral trioxide aggregate. <i>Pract Periodont Aesthet Dent</i> 2000;12:315–20.
41.	Witherspoon DE, Ham K. One-visit apexification: technique for inducing root-end barrier formation in apical closures. <i>Pract Proced Aesthet Dent</i> 2001;13:455–60.
42.	Hachmeister DR, Schindler WG, Walker WA III, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. <i>J Endod</i> 2002;28:386–90.
43.	Steinig TH, Regan JD, Gutmann JL. The use and predictable placement of Mineral Trioxide Aggregate® in one-visit apexification cases. <i>Aust Endo J</i> 2003;29:34–42.
44.	Aminoshariae A, Hartwell GR, Moon PC. Placement of Mineral Trioxide Aggregate using two different methods. <i>J Endod</i> 2003;29:679–82.
45.	Lawley GR, Schindler WG, Walker WA III, Kolodrubetz D. Evaluation of ultrasonically placed MTA and fracture resistance with intracanal composite resin in a model of apexification. <i>J Endod</i> 2004;30:167–72.
46.	Matt GD, Thorpe JR, Strother JM, McClanahan SB. Comparative study of white and gray Mineral Trioxide Aggregate (MTA) simulating a one- or two-step apical barrier technique. <i>J Endod</i> 2004;30:876–9.
47.	de Leimburg ML, Angeretti A, Ceruti P, Lendini M, Pasqualini D, Berutti E. MTA obturation of pulpless teeth with open apices: bacterial leakage as detected by polymerase chain reaction assay. <i>J Endod</i> 2004;30:883–6.
48.	Al-Kahtani A, Shostad S, Schifferle R, Bhambhani S. In-vitro evaluation of microleakage of an orthograde apical plug of Mineral Trioxide Aggregate in permanent teeth with simulated immature apices. <i>J Endod</i> 2005;31:117–9.
49.	Felippe WT, Felippe MC, Rocha MJ. The effect of mineral trioxide aggregate on the apexification and periapical healing of teeth with incomplete root formation. <i>Int Endod J</i> 2006;39:2–9.
50.	Simon S, Rilliard R, Berdal A, Machtou P. The use of mineral trioxide aggregate in one-visit apexification treatment: a prospective study. <i>Int Endod J</i> 2007;40:186–97.
51.	Martin RL, Monticelli F, Brackett WW, et al. Sealing properties of mineral trioxide aggregate orthograde apical plugs and root fillings in an in vitro apexification model. <i>J Endod</i> 2007;33:272–5.
52.	Pace R, Giuliani L, Pini Prato L, Baccetti T, Pagavino G. Apical plug technique using mineral trioxide aggregate: results from a case series. <i>Int Endod J</i> 2007;40:478–84.

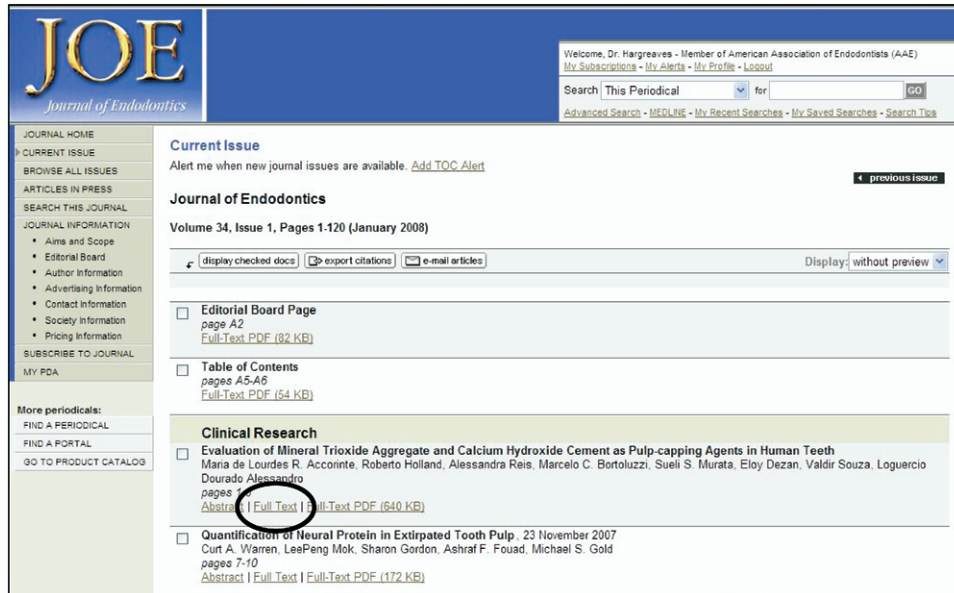


Figure 1. Navigation to HTML version.

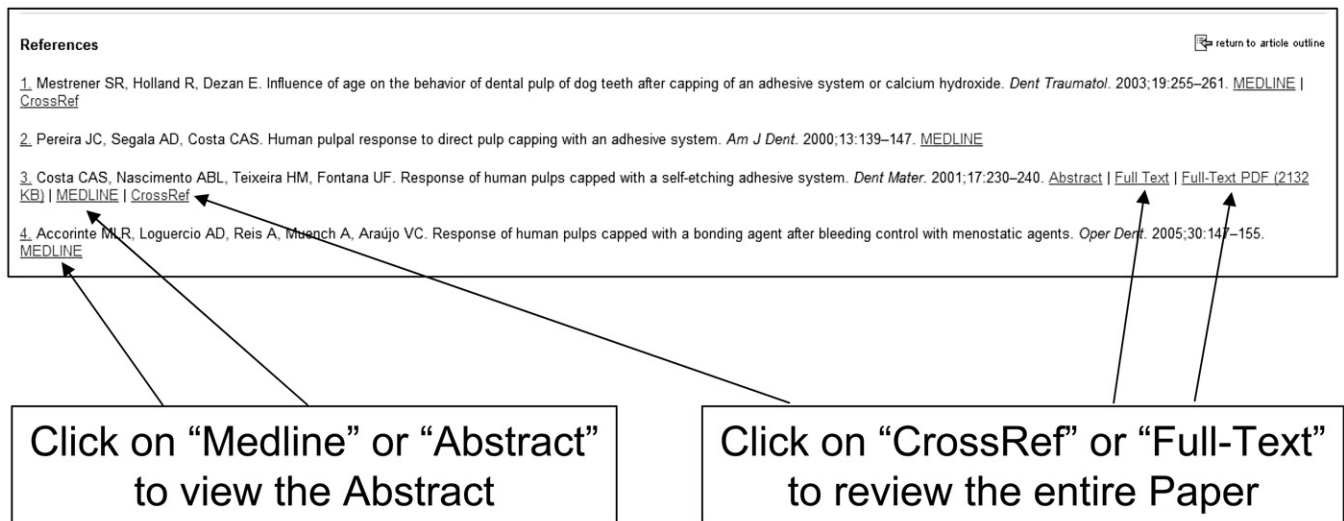


Figure 2. Hyperlink to References.

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