Establishing Apical Patency and its Effect on Endodontic Outcomes

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

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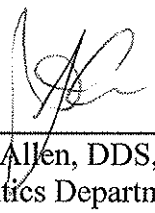

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Abstract

Introduction: Apical patency is open communication between the root canal space and periodontal ligament. Establishing apical patency is controversial with only 50% of dental programs in the United States teaching the concept. Both sides can cite articles favoring their position. However, the clinical impact of establishing patency on endodontic treatment outcome has not been well documented in the dental literature. The purpose of this study was to compare treatment outcome to establishment of apical patency with a minimum of 1 year follow-up exam. **Methods:** Data were collected from 2 formalized databases containing patient diagnostic and treatment information maintained in the Naval Postgraduate Dental School Endodontics Department. Outcomes were based on clinical examination and radiographic analysis using periapical index (PAI) scores. The primary outcome was based on clinical examination and the follow up radiograph alone. A secondary outcome was based upon the clinical examination and a composite PAI of the immediate post-operative and follow up radiographs. All data was analyzed using Pearson's Chi-Square (α=0.05). Cohen's Kappa was used to evaluate inter-examiner agreement. **Results:** Eighty seven teeth met study inclusion criteria of which 78.1% were patent. In the 68 teeth with patency, 68% were healed while in the 19 non-patent teeth, 63% were healed. No significant difference was noted with respect to achieving apical patency (p=0.785). **Conclusion:** There was no significance difference in endodontic outcome relative to establishment of apical patency.

Key Words

Endodontics, root canal, dentistry, patency, patency filing, establishing patency, apical patency, working length determination

Introduction

Apical patency refers to open communication between the apical canal orifice and the periodontal ligament (PDL) (1) where a small file can passively continue through the apical foramen (2). Establishing apical patency is controversial in that it is not universally taught in dental schools or postgraduate specialty training programs (3).

To date, the evidence relating to the effect of apical patency on healing in humans comes from indirect sources or based upon opinion. Ricucci and Langeland, using tissue biopsy, advised limiting canal manipulation to the apical constriction in both vital and necrotic teeth. They reported by not establishing apical patency, instrumenting and obturating at or just short of the apical foramen, reduced regional soft tissue damage leaving a more favorable healing environment (4). In an animal model, improved healing was also noted in vital teeth when patency was avoided. Because pathogenic organisms in this study were absent, it was argued that patency, and not microorganisms, contributed to the decreased outcome (5). Siqueira, also arguing against patency, claimed the extrusion of infected debris, secondary to mechanical instrumentation, as one cause of endodontic post-treatment pain (6). Alternatively, proponents of establishing patency have reported no effect on debris extrusion (7), a more favorable outcome by preventing dentinal debris blockage to ensure continued access to the apical foramen (8) and less postoperative pain experienced in non-vital cases (9).

Arguments for avoiding or establishing apical patency appear equivocal. To our knowledge, no clinical outcome study has reported on canal patency's effect on healing. This retrospective study evaluated 2 methods to evaluate the effect of establishing apical patency on the outcome of endodontic treatment.

Materials and Methods

This study was approved by the IRB, Walter Reed National Military Medical Center, Bethesda, MD. Data from consented patients were obtained from two ongoing patient treatment registries maintained in the graduate endodontic clinic at the Naval Postgraduate Dental School. Study inclusion criteria consisted of the following: initial nonsurgical root canal therapy or nonsurgical retreatment, a follow-up time or 12 of more months, one immediate post-operative and one follow-up radiograph, and completed data collection sheets.

Both data bases employ identical formalized data collection sheets covering sixty-five clinical variables at pre-, peri-, and post-operative time points. Calibrated examiners captured all information during treatment or follow-up visits. This study included single and multi-rooted teeth. The establishment of apical patency was recorded as "Yes" or "No" for every canal. In multi-rooted teeth, in order to be classified as "patent", each canal was required to be patent or the tooth was classified as "non-patent". The Root ZX II electronic apex locator (J. Morita Mfg. Corp ®, Tokyo, Japan) was used to establish patency when the instrument displayed "Apex" and elicited an auditable full tone. Patency was then confirmed through exposure of at least one periapical radiograph.

Radiographs were taken digitally with Kodak RVG 6100 (Carestream Dental LLC, Atlanta, GA) sensors or conventionally with Kodak Insight (Carestream Dental LLC, Atlanta, GA) film and developed in a Peri Pro III (Air Techniques Inc, Hicksville, NY). Conventional films were converted to digital files scanned (Hewlett-Packard Company, Palo Alto, CA, JPG) at 1200 DPI. All images were entered into Microsoft PowerPoint (Microsoft Corporation, Redmond, WA), magnified to a standard size, and displayed on a black background. The crown of each tooth was blocked out to eliminate scoring bias based on the tooth's restoration status. Projected radiographs were independently assessed by three board-certified endodontists. The periapical status was determined using a modified periapical index (PAI) scoring method as set forth by Orstavik (10), scores of 1 or 2 indicated "health", 3 "unsure" and 4 or 5 "disease". In multi-rooted teeth, the root receiving the highest PAI score determined the final PAI score. To avoid bias and the sequential viewing of a subject's immediate post-treatment and follow-up radiographs, all images were viewed in random order. In cases of disagreement, the final radiographic score for each tooth was reached by forced consensus. Clinical findings were based upon patient responses to pain, palpation and percussion during the follow-up examination.

This study evaluated 2 outcomes based upon the presence or absence of tooth symptomatology. The primary outcome was derived from the follow-up radiograph and post-operative clinical examination results. A subject's outcome was asymptomatic if there was a PAI score of 1 or 2 and there was absence of clinical symptoms. PAI scores of 4 or 5 and/or the presence of one or more clinical symptoms was scored as symptomatic. The secondary outcome evaluated change in the periapical region by comparing the 12 month follow-up and immediate post-operative radiographic PAI scores and post-operative clinical examination. A decreasing or

unchanged composite of the PAI scores plus the absence of all clinical symptoms were considered asymptomatic. Conversely, increasing composite PAI scores and/or the presence of clinical symptoms was deemed symptomatic. In both evaluations, PAI scores of 3 indicated an "unsure" response. These subjects were excluded from both analyses.

A power analysis was completed using an 80% confidence interval and 0.05 margin of error. Because establishing root canal patency is taught at the Naval Postgraduate Dental School, the majority patients consented would have patent canals. Allowing for 1:3 ratio of non-patent to patent subjects, a sample size of 36 non-patent to 108 patent is required. Pearson's Chi-Square (α=0.05) was used to analyze the data and Cohen's Kappa (κ) was used to compare the inter-observer radiographic agreement (SPSS v.18).

Results

The study sample consisted of 116 subjects; 81 males and 35 females with a mean age of 46 years. After excluding those with PAI scores of 3, the remaining 87 subjects were divided into non-patent (n=19, 21. 8%) and patent 78.2% (n=68, 78.2%) cohorts.

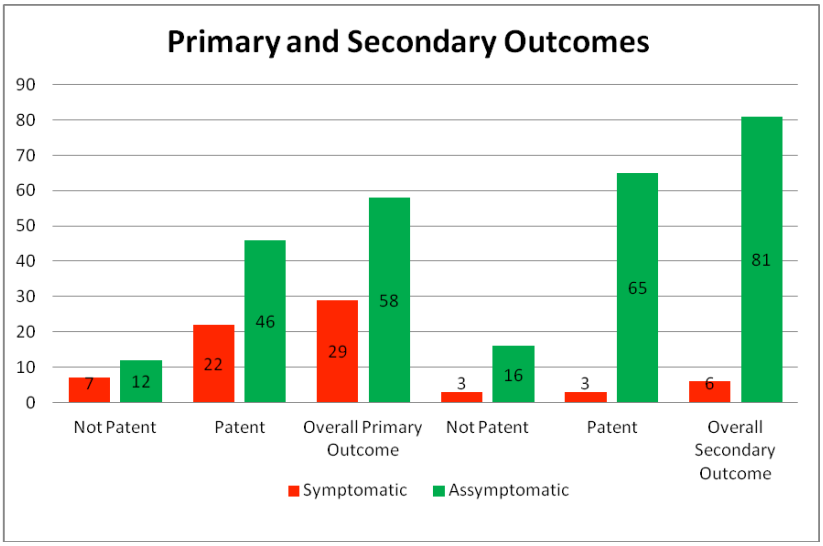

Figure 1.

For the primary study outcome, in the non-patent cohort, 37% (7 out of 19) were classified as symptomatic and 63% (12 out of 19) asymptomatic. In patent teeth, 32% (22 out of 68) were symptomatic while 68% (46 out of 68) were asymptomatic (Fig.1.). Pearson's Chi-Square revealed no significant difference between patent and non-patent teeth (p=0.785). Based on the post-operative radiograph and absence of clinical symptoms, this one radiograph "snapshot" of the primary outcome data revealed that 58 out of 87 were asymptomatic, which would indicate a 65.5% "healed" rate.

Evaluation of the secondary outcome revealed 16% (3 out of 19) symptomatic and 84% (16 out of 19) asymptomatic in non-patent teeth and 4% (3 out of 68) symptomatic and 95% (65 out of 68) asymptomatic in patent teeth.

Based upon the composite of the immediate post-operative and follow-up radiograph PAI scores and absence of clinical symptoms in the analysis of the secondary outcome, 93% (81 out of 87) were asymptomatic or "healing" (Fig. 1.). Breakdown of these 81 subjects revealed 36 (41%) showed no change in the composite PAI score, 45 (52%) underwent a decrease the composite score and 6 (7%) had an increase in the composite PAI scores and could be classified as "not healing" (Fig.2.). Teeth with no clinical symptoms, regardless of radiographic status, were classified as functional. The functional rate of the patency group was 97%; and non-patent group 95%. Inter-observer agreement between evaluators was moderate ($\kappa = .600$) (11).

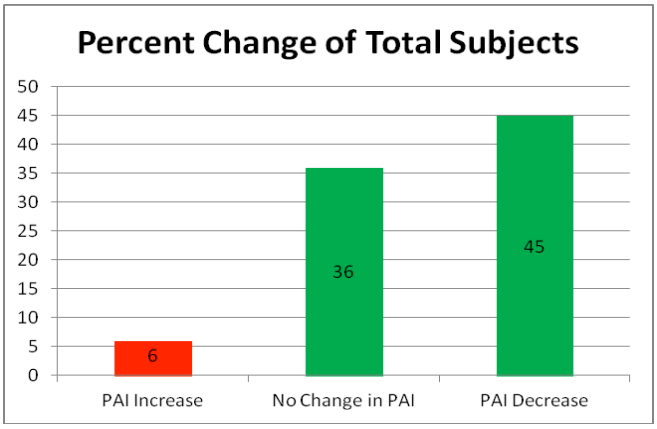

Figure 2.

A descriptive analysis of other variables revealed that the presence of preoperative apical pathosis, pulp necrosis, and obturation greater than 2mm from the radiographic root terminus appeared to correlate with decreased healing. Related to apical patency, a surprising finding was that subjects who presented with pre-operative symptoms were more likely to have apical patency established. This was shown to approach statistical significance ($p=0.063$). Ninety-five percent of teeth with preoperative symptoms were categorized as healing at the follow-up exam.

Discussion

The reporting of endodontic outcomes can vary based on loose (partial apical healing) or strict radiographic criteria (entire periapical healing or healed) (12). Two outcomes were evaluated and reported in this study to allow sufficient comparison to previously published literature and to provide clinically relevant information to aid clinical decisions. According to Friedman, approximately 90% of the teeth with apical periodontitis that will eventually heal demonstrate signs of healing at 1 year follow-up, and almost 50% are completely healed. Healing may take up to 5 years (13). Data presented here were in accordance with Friedman's

findings of 90% showing either radiographic improvement or stabilization at 12 month follow-up. Friedman also noted a continuous reduction of the radiolucency (comparing at least two follow-up examinations) can be considered as a forecast of complete healing at a later time (13). This gives more credence to the secondary outcome or healing reported in this study.

A thorough review of the literature indicates that methods and techniques used to achieve apical patency may be inconsistently applied in the profession. This variance or avoidance of apical manipulation may or may not be relevant to favorable outcomes, and therefore the intent of this investigation was to determine its relevance. According to the AAE glossary of terms, apical patency is a technique where the apical portion of the canal is maintained free of debris by recapitulation with a small file through the apical foramen (14). Recapitulation is defined as reintroduction of small files during canal preparation to keep the apical area clean and patent (14). Calibrated clinicians specifically recorded information relating to the establishment of apical patency. Further research may be warranted regarding the effect of maintaining apical patency on outcome.

Prior to the introduction of electronic apex locators (EAL's), root canal and instrumentation lengths were established using periapical radiographs. However, it has been demonstrated that radiographs alone cannot accurately locate the root canal terminus (15). This has been attributed to the apical foramen not being coincident with the anatomic apex in the majority of teeth (16,17). A more accurate assessment of canal length has been shown through the combined use of the EAL and periapical radiograph (18,19). Therefore, the Root ZX II electronic apex locator (J. Morita Mfg. Corp ®, Tokyo, Japan) was used as the standard to define patency. Patency was then confirmed through exposure of at least one periapical radiograph. An important argument favoring apical patency through the EAL lies in determining the correct root canal length (20,21,22). The most accurate root canal length is expected to positively impact the clinician's ability to clean, instrument, and obturate the optimal root canal space. Cleaning and shaping closer to the radiographic apex in non-vital teeth and between 0-2mm in vital teeth has been reported to improve the success of endodontic treatment (23).

Conclusion

The significant value of this study is that the data collected will aid in answering a controversy within endodontics, and it may alter accepted clinical treatment. Ultimately, this

information will allow clinicians to provide more accurate prognosis and improved treatment planning related to establishing apical patency. The preliminary results of this interim analysis indicate there was no significant difference in endodontic treatment outcome when apical patency was established.

References

(1) Buchanan LS. Management of the curved root canal. CDA 1989;17:19-27.
(2) Peters OA, Peters CI. Cleaning and shaping of the root canal system. In: Cohen S, Hargreaves KM. *Pathways of the Pulp*. 10th ed. St Louis, MO: Mosby Elsevier; 2011: 318.
(3) Cailleteau JG, Mullaney TP. Prevalence of teaching apical patency and various instrumentation and obturation techniques in United States dental schools. J Endod 1997;23:394-6.
(4) Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, part 2. A histological study. Int Endod J 1998;31:394-409.
(5) Holland R, Santa'Anna Junior A, de Souza V, et al. Influence of apical patency and filling material on healing process of dogs' teeth with vital pulp after root canal therapy. Braz Dent J 2005;16:9-16.
(6) Siqueira JF. Microbial causes of endodontic flare-ups. Int Endod J 2003;35:453-63.
(7) Lambrianidis T, Tosounidou E, Tzoanopoulou M. The effect of maintaining apical patency on periapical extrusion. J Endod 2001;27:696-8.
(8) Souza RA. The importance of apical patency and cleaning of the apical foramen on root canal preparation. Braz Dent J 2006;17:6-9.
(9) Arias A, Azabal M, Hidalgo JJ, et al. Relationship between postendodontic pain, tooth diagnostic factors, and apical patency. J Endod 2009;35:189-92.
(10) Orstavik D, Kerekes K, Eriksen HM. The periapical index: A scoring system for radiographic assessment of apical periodontitis. Endod Dent Traumatol 1986;2:20-34.
(11) Viera AJ, Garrett JM. Understanding interobserver agreement: The kappa statistic. Fam Med 2005;37:360-3.
(12) Ng YL, Mann V, Rahbaran S, et al. Outcome of primary root canal treatment: systematic review of the literature – part 1. Effects of study characteristics on probability of success. Int Endod J 2007;40:921-39.
(13) Friedman S. Prognosis of initial endodontic therapy. Endodontic Topics 2002;2:59-88.
(14) Glossary of endodontics terms. 7th ed. Chicago, IL: American Association of Endodontists;2003.
(15) Williams CB, Joyce AP, Roberts S. A comparison between *in vivo* radiographic working length determination and measurement after extraction. J Endod 2006;32:624-7.
(16) Burch JG, Hulen S. The relationship of the apical foramen to the anatomic apex of the tooth root. Oral Surg Oral Med Oral Pathol 1972;34:262-8.

(17) Stein TJ, Corcoran JF. Anatomy of the root apex and its histologic changes with age. Oral Surg Oral Med, Oral Pathol 1990;69:238-42.
(18) Vieyra JP, Acosta J, Mondaca JM. Comparison of working length determination with radiographs and two electronic apex locators. Int Endod J 2010;43:16-20.
(19) Fouad AF, Reid LC. Effect of using electronic apex locators on selected endodontic treatment parameters. J Endod 2000;26:364-7.
(20) Ounsi HF, Naaman A. *In vitro* evaluation of the reliability of the Root ZX electronic apex locator. Int Endod J 1999;32:120-3.
(21) Piasecki L, Carneiro E, Fariniuk LF, et al. Accuracy of Root ZX II in locating foramen in teeth with apical periodontitis: An *in vivo* study. J Endod 2011;37:1213-6.
(22) Rambo MVH, Gamba HR, Borba GB, et al. *In vivo* assessment of the impedance ratio method used in electronic foramen locators. Biomed Eng Online 2010;9:1-12.
(23) Chugal NM, Clive JM, Spanberg LSW. Endodontic infection: some biologic and treatment factors associated with outcome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:81-90.