Determining the Optimal Obturation Length: A Meta-Analysis of Literature

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Abstract

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 (obturated 0–1 mm from apex) versus group C (obturated 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 (obturated >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.

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There has been disagreement where to terminate instrumentation and obturation (1). Kuttler (2) believed termination should be to the apical constriction, when the apical constriction exists. Seltzer et al. (3) found that the reaction to tissues were milder when instrumenting short of the apex as compared to instrumenting beyond the apex. In a subsequent study, Seltzer et al. (4) concluded that optimum tissue repair was found when canals were instrumented and filled short of the apex; material that was forced into the periapical tissues caused a chronic inflammatory response. Green (5, 6) Weine, (7) Frank (8), and Stein (9) advocated obturating short of the radiographic apex (0.5–2.0 mm). They based their arguments on Kuttler's microscopic analysis (2) or on their own studies. Walton and Torabinejad (10) and Weine (5) also agree with obturating short of the radiographic apex, with the additional consideration that, in the presence of root and/or bone resorption, preparation and obturation should be to even shorter lengths. Alternatively, Schilder (11, 12) advocated debridement and obturation to the radiographic apex, which often results in material being extruded into periradicular tissues.

Given the varying opinions on where to terminate, a meta-analysis of the literature may clarify this issue. Meta-analysis is a statistical procedure that combines the results of independent studies that are determined to be "combinable" (13). Assessment of the validity and quality of the independent studies is essential (14). Through a meta-analysis, information is maximized when obtained from the available data; this would not be possible from any single study. The goals of a meta-analysis include: (a) increasing statistical power for comparing end-points and subgroups, (b) resolving uncertainty when reports disagree, (c) encouraging improvements in the quality of primary research, and (d) helping to plan for future research (15).

The process of conducting a meta-analysis is similar to other research plans: first, formulate the problem to be addressed; next, collect and analyze the data; and finally, report the results. A detailed research protocol that states the objectives, primary endpoints for data analysis, the subgroups of interest, and the proposed methods and criteria for identifying and selecting relevant studies must be documented a priori (16).

The purpose of this meta-analysis of literature was to aid in assessing an optimal terminal point for root canal therapy to improve the prognosis. This was accomplished by analyzing the English language literature on success and failure based on obturation length. The hypothesis was that obturating materials confined to the canal space would correlate to a higher success rate.

Materials and Methods

Using the National Library of Medicine computerized bibliographic database MEDLINE, a search from January 1966 through June 2000 was conducted using a combination of the following words*: root canal, apical, prognosis, endodontic success, endodontic failure, apical third, endodontic, periapical, and root canal termination*. The combination of search words that produced the best results was *root canal, apical, and prognosis.* Sixty studies resulted from the three search words. The abstracts or complete manuscripts as identified on MEDLINE were analyzed and screened. At this preliminary phase, the selection criterion was broad. The study had to be on humans (in vivo) and had to contain radiographic information on the terminal point of obturation. Using these criteria, 17 of the 60 studies fulfilled the criteria and were evaluated more closely. More stringent criteria were then applied. The inclusion criteria included: (a) a minimum follow-up of at least 2 yr; (b) data on termination of obturation/instrumentation; (c) failures of treatment were defined adequately (with a minimum radiographic

evaluation for failure outlined and defined); (d) data available on success/failure of root canal therapy in relationship to the obturation/instrumentation length; and (e) presence or absence of rarefaction. Five out of the 17 studies met these criteria (17–21) A 2 yr recall rate was selected based on a study by Bender et al. (22) They pointed out that the majority of unsuccessful cases were identifiable within 2 yr of treatment.

To cover the probability that more studies existed on the topic than were found on the computer search, the references from these five articles were evaluated using the broad criteria stated above. Thirty-eight more studies (covering the years of 1956–2000) were identified. Using the more stringent eligibility list, seven of these studies met the criteria. This resulted in a total of 12 studies (17–21, 23–29). This meta-analysis considered three categories of obturation length from the radiographic apex: (a) 0–1 mm (group A), (b) >1 mm but <3 mm (group B), (c) obturated past the radiographic apex, including sealer (group C). From the remaining 12 studies, only four studies included data that could be placed into the three categories of lengths (23–26) (see Table 1). This gave a total of four studies for final analysis and pooling of data, which included a total of 2178 teeth.

According to the principles and procedures of a meta-analysis (14), the four remaining studies were then scored for quality by two independent readers. To asses the quality of the studies used in the meta-analysis, the study protocol and data analysis were evaluated. The readers were blinded to the names of the authors and their institutions, names of the journals, sources of funding, and acknowledgments. The studies were read in opposite order to avoid any systematic errors because of learning through the reading process. The criteria for quality was based on the following: number of teeth in the study, the loss of teeth to follow-up, who read the radiographs (student versus trained individual), and if statistical analysis of methods were specified and given, and finally if the exam of the patient was both clinical and radiographic. The scores ranged from 0 to 2. The studies with the higher scores were weighted more when the statistical analyses were performed (see Table 2).

Statistical analyses were done using the DerSimonian and Laird (30) estimates. After scoring the four studies for quality, the scores were used in a single random effects regression model (31). The estimated difference in success rate were compared between groups A and B and between groups A and C (see Table 3).

After the four studies were scored for quality, the scores were used in a single random effects regression model to evaluate the relation between quality and the magnitude of the difference in success. In this analysis, significant heterogeneity was observed (tau squared = 0.03) among the study results. Heterogeneity may exist, for example, when study populations differ or when statistical methods have considerable variation.

TABLE 1. Comparison of the four studies that were used in the meta-analysis

Study	Method	Participants	# of teeth	Treated by	Results
Harty et al, 1970	Does not state who read the radiographs. Retrospective study	All patients accepted for RCT on upper and lower incisor and canine teeth between 1954–1963 at the Department of Conservative Dentistry, Institute of Dental Surgery (London, England).	1025 teeth	Post-graduate students and staff at the Department of Conservative Dentistry, Institute of Dental Surgery.	The teeth obturated between 0–1 mm (acceptable) were more successful (92.6%) than short (87.82%) or long (86.81%).
Kerekes et al, 1979	Interpretation of the radiographs were done independently by two endodontists. Prospective study.	All patients accepted for RCT and treated by undergraduate students at the University of Oslo (Norway) in 1971 and who participated in regular clinical and radiographic follow-up exams.	501 of 647 teeth were evaluated.	Undergraduate students at the University of Oslo (Norway).	In vital teeth, roots that were short of the apex >1 mm had a higher success rate (96%) than at the apex) (0–1 mm) (92%). In necrotic teeth, roots that were short of the apex >1 mm had a lower success rate (85%) than those at the apex (93%).
Matsumoto et al, 1987	Does not state who read the radiographs. Prospective study. 62% loss to follow-up (85 of 223 evaluated).	Patients were treated at the School of Dentistry, AichiGakuin University in Nagoya, Japan.	85 of 223 teeth were eval for the minimum 2–3 year follow-up exam	Members of the endodontic staff at the School.	The teeth obturated between 1.1–2.0 mm underextended (100%) were more successful than 0.5–1.0 mm underextended (88%) or 0–0.4 mm underextended (61.5%) or overextended (40%)
Kerekes et al, 1978	The interpretation of the radiographs were done independently by two endodontists. Retrospective study. Clinical exam.	Two retrospective studies were done. The first survey evaluated 188 root canals treated by undergraduate students (US) at the U of Oslo in 1969 and had been followed for 3–5 years. The second survey consisted of 379 root canals treated by general dentists (GP).	188 teeth done by undergrads at U of Oslo and 379 teeth done by general dentists (GP) in Norway.	RCT done by Undergraduate students at the University of Oslo (Norway) in 1969. 2nd group of RCT done by general dentists (GP) in Norway in 1968.	Those root canals done by US short of apex 1–3 mm were more successful (88%) than at apex 0–1 mm (84%), than overfilled (79%) than short of apex >3 mm (79%). Those root canals done by GP at apex (0–1 mm) were more successful (73%) than short of apex 1–3 mm (71%) than short of apex >3 mm (54%) than overfilled (44%).

TABLE 2. Quality scores of four studies

	Quality Scores			
	Harty	Kerekes, 1979	Matsumoto	Kerekes, 1978
How many teeth were in the study?	2	1	0	2
What was the loss to follow-up?	1	2	0	2
Who read the radiographs?	0	1	0	1
Were the statistical analyses of methods specified & given?	1	0	1	0
Was the exam clinical as well as radiographic?	1	0	1	0
Total out of 7 possible points	5	4	2	5

TABLE 3. Success/failure of root canal therapy in the four studies in relation to their length

Length	Successful	Failed	Uncertain	Total
Harty et al. 1970				
Group A	525 (92.60%)	42 (7.40%)	—	567 (49.78%)
Group B	173 (87.82%)	24 (12.18%)	—	197 (17.24%)
Group C	316 (86.81%)	48 (13.19%)	—	364 (31.98%)
Total	1025 (90.0%)	114 (10.0%)	—	1139 (100%)
Kerekes et al, 1979				
Group A	286 (91.96%)	10 (3.22%)	15 (4.82%)	311 (62.08%)
Group B	155 (90.12%)	13 (7.56%)	4 (2.33%)	172 (34.33%)
Group C	12 (66.67%)	3 (16.67%)	3 (16.67%)	18 (3.6%)
Total	453 (90.42%)	26 (5.19%)	22 (4.39%)	501 (100%)
Matsumoto et al, 1987				
Group A	30 (78.9%)	8 (21.1%)	—	38 (80.9%)
Group B	4 (100%)	0 (0%)	—	4 (8.5%)
Group C	2 (40%)	3 (60%)	—	5 (10.6%)
Total	36 (76.6%)	11 (23.4%)	—	47 (100%)
Kerekes et al, 1978				
Group A	122 (80.26%)	30 (19.74%)	—	152 (26.81%)
Group B	203 (63.44%)	117 (36.56%)	—	320 (56.44%)
Group C	22 (23.16%)	73 (76.84%)	—	95 (16.75%)
Total	347 (61.20%)	220 (38.80%)	—	567 (100%)

Rsults

In terms of percentage rates of success, the meta-analysis showed that obturation 0 to 1 mm short of the apex (group A) was better than obturation 1 to 3 mm short of the apex (group B); both were superior to obturation beyond the apex (group C).

The success rate in group A was 28.9% better than group C and 5.9% better than group B (95% CI = −3.8%, 61.5%), p = 0.08 and (95% CI = −1.3%, 13.1%), p = 0.11, respectively. After adjustment for quality, the results remained unchanged. The success rate in group A was 2.7% greater than group B and 26.2% better than group C (95% CI = −38.9%, 44.3%), p = 0.80 and (95% CI = −19.9, 72.4%), p = 0.09, respectively. The regression beta for the quality score is equal to 0.05 (p = 0.49) indicating neither substantial nor significant relation between quality and success rate.

Discussion

Our hypothesis was proved, that is, confining obturating materials to the canal space did indeed correlate with a higher success rate. These findings correspond to a recent meta-analysis study (32), in which the investigators found a higher success rate when the root canal filling was close to, or at the radiographic apex. Swartz et al. (33) also made the same observation and conclusion. This finding is not surprising; it has been shown (34) that obturating materials in periradicular tissues are an irritant and adversely impact healing.

When comparing the four studies which were utilized and analyzed for the meta-analysis, many inconsistencies were observed. Not only were the defined lengths different, but also location of the teeth. In addition, radiographic definitions of success and failure were not consistent. Different intracanal medicaments were used, the type and concentration of irrigants varied, and the type of obturation material was not the same. The method of condensation was often not reported. In addition, there was no mention of the terminal point of instrumentation.

Recall rates varied between studies and even within studies. Longer recalls may lead to lower success rates than shorter recall rates. It was occasionally difficult to distinguish if a study was a prospective or a retrospective study.

Another observation was that follow-up of patients in these studies might be biased, since patients with problems are more likely to return for recall appointments as compared to those patients without problems. Therefore, more undocumented failures may have occurred and the success rates would be underestimated. Equivalent rates of follow-up visits would overcome this source of potential bias.

When we began this analysis, our goal was to evaluate more specific lengths (or end points) and to compare the prognosis of each length statistically. Another objective was to examine more detailed information in regard to pre-operative pulpal status, that is necrotic versus vital, as well as to evaluate if bone or apical root resorption in relationship to obturation length affected the outcome. Unfortunately, the literature was not standardized and lacked considerable information. Therefore, we were unable to combine many of the 98 studies examined. As a result, we had to look at broader categories for length.

From our analysis, the data is suggestive, and biologically, it is rational to recommend obturating short of the radiographic apex. This implies cause and effect. In reality, length and success are correlated.

This information is not new; most clinicians strive to confine instruments, irrigants, and obturating materials to the canal space. Group C included extruded sealer and gutta-percha and made no distinction between the two. There is the opinion that extrusion of only sealer from the root apex does not lower the prognosis of root canal therapy. We cannot make any claim that this is true or false from our meta-analysis. However, if extruding only sealer does not lower the prognosis of root canal therapy, then our findings would be overestimated for success of the "long" group. In either case, based on this meta-analysis, we agree with the recommendation (35) that obturation be short of the radiographic apex to ensure a better prognosis.

CONCLUSIONS

The results of this meta-analysis demonstrated that obturating materials extruding beyond the radiographic apex correlated with a decreased prognosis. In addition, we realized that standardized protocols are necessary in endodontic procedures and in dental research. If studies are to be compared and the information used clinically, the design of the studies must be similar and repeatable. The results of prospective studies will then be comparable and the data can be combined statistically, thereby creating a more powerful, clinically useful meta-analysis.

Acknowledgment

We acknowledge Graham A. Colditz, MD, for his guidance in conducting this meta-analysis; Catherine S. Berkey, DSc, for her expertise in analyzing the data statistically; and Michelle Mazur-Kary, DDS, for participating as a reader in this meta-analysis.

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