REVIEW

The outcome of endodontic resurgery: a systematic review

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Abstract

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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.

Keywords: meta-analysis, outcomes, resurgery, surgical endodontics, systematic review.

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Introduction

Both clinical and radiographic follow-up evaluations are essential to determine successful outcomes after endodontic surgery. Because the patient is often clinically symptom free, the final case disposition is determined frequently by the radiographic findings only. Andreasen & Rud (1972) correlated the radiographic assessment of healing with histological results of successful and unsuccessful surgical endodontic cases. Rud *et al.* (1972a) further categorized the radiographic/histologic healing assessments into four categories (i) complete healing; (ii) incomplete healing; (iii) uncertain healing; and (iv) unsatisfactory healing. Persson (1973) outlined a radiographic assessment schema, not correlated with histology, consisting of three categories (i) successful; (ii) uncertain; and (iii) unsuccessful. Despite the above outlined categories, few subsequent studies have used any categorization to determine long-term success rates. To encourage clinicians to use the Rud *et al.* (1972a) classification system for evaluation purposes, Molven *et al.* (1987) further characterized each category into separate subgroups with radiographic visual aids to help the clinician discern the differences between each category and subgroup. The graphics developed by these researchers captured the different radiographic nuances of healing and outlined a framework for use in further evaluation studies of periradicular healing following surgery. A number of studies that have used these categories to assess the outcomes of periradicular surgery have led to variable success rates, ranging from 25 to 99% (Gutmann & Harrison 1994).

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The potential value of a reliable standard to assess postsurgical healing is enormous. It ranges from clinical usefulness in evaluating postsurgical treatment and determining future follow-up treatment, to the development of outcomes research aimed at evaluating surgical techniques, materials and surgeon performance, to the creation of academic directives for graduate student education, and finally the potential benefit of a tested model to study healing after endodontic surgery. This is possible through the use of a *systematic review* (Hedges & Olkin 1985, Chalmers & Altman 1995, Mulrow & Cook 1998) of studies completed previously, examining outcomes of surgical endodontic intervention. There is a large collection of literature that explores outcomes of surgical intervention. However, there is scant literature relating to a second surgery or resurgery of a persistent lesion that fails to heal after the initial surgery has been attempted.

The application of a statistical strategy that limits bias to the systematic assembly, critical appraisal, and synthesis of all relevant studies on resurgery have been incorporated in this systematic review. In doing so, it can be established whether treatment outcomes are consistent across populations, settings and differences in treatment. Can resurgery of a failing surgical lesion produce a successful outcome? What outcomes are produced? How do these outcomes compare to the outcomes of the initial surgical intervention? To summarize the answers to these questions, a statistical technique called meta-analysis (Hedges & Olkin 1985) was used. A meta-analysis is the antiquated term used to describe a systematic review that employs statistical methods, such as a weighted-average, to combine and summarize the results of several studies (Chalmers & Altman 1995, Mulrow & Cook 1998); it thus defines an outcome standard. This systematic review examines the radiographic assessment of healing following the initial and secondary (resurgery) periradicular surgery. The aim is to establish an outcome standard by delineating outcomes of surgery and resurgery using Persson's (1973) classification system after at least 1 year of healing.

Table 1 Study search summary

Type of search	Years reviewed
Medline search	1966 – present
OCLC first search	Oct. 1993 – present
Nat. Lib. of Medicine	1966 – present
EMBased Catalogue	1974 – present
Science Citation Index	1993
Internet: Alta Vista	Nov. 1998
Internet: Hot Bot	Nov. 1998

Materials and methods

An extensive literature review was accomplished with the assistance of a medical resource librarian searching all possible resources (Table 1). This extensive search yielded over 150 papers from various journals internationally, not limited to the English language only, relating to surgical endodontics. Forty-two papers qualified for initial review for inclusion in this systematic review (Tables 2 and 3). Of the 42 collected publications, the authors identified eight peer-reviewed studies published between 1970 and 1997 that reported resurgery results. A study's inclusion eligibility for the systematic review was determined by specific criteria that are listed in Table 4. Only a small number of papers reported data on the outcomes of resurgery and all that met the first six requirements were eligible for this study. Each criterion was rank ordered according to importance to the investigators, with the most important criteria listed first in Table 4. The majority of studies met all the criteria outlined. Those studies that failed to meet some of the less important criteria were still incorporated because they lacked only minor pieces of information (Persson *et al.* 1974, Finne *et al.* 1977, Persson 1982, Rud *et al.* 1997). The pool of valid papers was already small without these four papers and the overall sample population for

Table 2 Studies included in systematic review

Study	Year	Patients	Teeth	Resurgery teeth
Nord	1970	277	354	39
Nordenram & Svärdström	1970	697	697	61
Rud & Andreasen	1972	769	962	12
Persson	1973	111	129	129
Persson *et al.*	1974	161	220	51
Finne *et al.*	1977	156	218	16
Persson	1982	22	26	1
Rud *et al.*	1997	182	182	21
Total		2375	2788	330

Table 3 Studies excluded from systematic review[a]

Authors	Year	*n*	Teeth	Groups	Exclusion criteria
Blum	1930	98	98	3	See footnote
Keresztesi	1955		415	3	Not peer reviewed
Bush & Waite	1962	27		No	Different scale
Levinson	1965	0	0		Technique paper
Persson	1966	176	241	3	
Vees	1966	537	211	2	Not peer reviewed
Mattila & Altonen	1968		115	3	
Kappl	1969		182	2	Technique paper
Rusconi & Maccaferri	1969	0	0	No	Technique paper
Harty *et al.*	1970	1139		2	Different scale
Novák *et al.*	1971	534	675	3	Not peer reviewed
Rud *et al.*	1972a	120		4	
Platz	1973	270	200	5	Not peer reviewed
Ericson *et al.*	1974	276	314	3	
Summers	1975	0	0	No	Technique paper
Altonen & Mattila	1976	43	46	3	
Švejda & Brázda	1978		7	No	Histological study
Wörle	1981	89	94	3	
Jacobsen	1982	0	0	No	Technique paper
Urbani *et al.*	1983		135	3	
West & Lieb	1985	1		No	Case report
Cordes *et al.*	1987	78		2	Not randomized
Kopp *et al.*	1987	3281		1	Different scale
Molven *et al.*	1987	443	474	4	
Lewis & Block	1988	0	0	No	Review paper
Molven *et al.*	1991	224	222	4	
Rud *et al.*	1991	388		4	
August	1996	39	41	No	Different scale
Molven *et al.*	1996	24		No	Not original data
Rud *et al.*	1996	33		2	
Hepworth & Friedman	1997	0	0	No	Review
Pecora *et al.*	1997	0	0	No	Technical paper
Rubenstein & Kim	1999	94		2	
Zuolo *et al.*	2000	102	102	2	Different scale

[a]In addition to the listed exclusion criteria, all papers listed report no resurgical results.

Table 4 Study inclusion criteria summary

	Number of studies	
Criteria	Yes	No
Random research design	8	0
Peer reviewed	8	0
Retrofill material identified	8	0
Healing groups identified	8	0
Follow-up (at least 1 year)	8	0
Statistical methods identified	8	0
Age group delineated	5	3
Gender delineated	5	3
NSRCT prior to SRCT	7	1
Teeth/roots delineated	6	2
Reason for surgery	7	1
Number of surgeons delineated	6	2

the systematic review would be diminished if these were not included.

Studies were excluded if:

- The healing outcomes were not characterized according to Rud *et al.* (1972a) or Persson's (1973) radiographic healing schema
- The journal was not peer-reviewed
- Follow-up was less than a year or only provided for a portion of the population
- Statistical technique was not reported
- It was a case report or technical paper that failed to report outcomes

The assessment of each patient's healing radiographically was characterized originally using Rud *et al.*'s (1972a) four-group schema (complete or successful, incomplete or cicatrice-healed, uncertain and unsuccessful) or Persson's (1973) three-group schema

(successful, uncertain or unsuccessful). For the purpose of calculating a weighted-average across all studies, three of the studies that grouped patients according to Rud *et al.*'s (1972a) schema were modified (Nordenram & Svärdström 1970, Rud & Andreasen 1972, Rud *et al.* 1997). The categories of incomplete and uncertain were combined into one group, uncertain. This transformation homogenized the number of categories to three. The ramifications of this modification are minor, because the ultimate comparison of interest exists between the groups of successful and unsuccessful healing. Both the successful and unsuccessful groups were preserved, as reported in the original papers.

The weighted-average was calculated from compiled results taken from the eight studies. The sample size was used to determine a ratio that weighted the means derived from the outcome results in each study (Sokal & Rohlf 1995). The largest sample size was used as the dividend and the six remaining studies' sample size was divided by the largest sample size to provide a ratio by which outcomes were multiplied. This procedure gave the smaller sample studies less influence on the results and the larger studies more weight. In following this regimen, the error variance was reduced and the reliability of the studies maintained. Further outcomes were analysed according to the type of root-end filling material (Cavit, amalgam, and gutta-percha/chloropercha) used to differentiate any differences between material and technique used during the initial surgical procedure.

Results

Eight eligible studies comprised 2375 surgical patients and 2788 teeth. The author, year, population size, number of teeth and the number of resurgery patients are summarized in Table 2.

A 100% recall rate ranged from 1 year (six studies) to 6 $^{1}/_{2}$ years in one study (Nordenram & Svärdström 1970). A total of 330 patients, or 14% of the total surgical population, underwent resurgery. Of the surgical population that underwent the initial surgery, the weighted-average healing outcomes showed 64.2% success, 25.7% uncertain and 15.7% unsuccessful (Table 5).

Of the 14% that underwent a second surgery or a sample population of 330 patients, the weighted-average healing outcomes showed 35.7% success, 26.3% uncertain and 38% unsuccessful. The success rate of surgery was significantly greater than the resurgery percentage of success (Table 6).

Upon examining the initial surgery data according to the root-end filling material used, the highest success rate occurred with the gutta-percha/chloropercha material

Table 5 Summaries of surgical outcomes

Study	*n*	Success	Uncertain	Unsuccessful
Nord 1970	277	216	78	60
Nordenram & Svärdström 1970	697	445	109	143
Rud & Andreasen 1972	769	640	306	16
Persson 1973	111	47	33	49
Persson *et al.* 1974	161	91	79	50
Finne *et al.* 1977	156	108	41	69
Persson 1982	22	19	4	3
Rud *et al.* 1997	182	156	20	6
Total	2375	1722	670	396
Weighted-average (%)		64.2	25.7	15.7

Table 6 Summaries of resurgical outcomes

Study	*n*	Success	Uncertain	Unsuccessful
Nord 1970	39	15	6	18
Nordenram & Svärdström 1970	61	23	14	24
Rud & Andreasen 1972	12	6	5	1
Persson 1973	129	47	33	49
Persson *et al.* 1974	51	10	21	20
Finne *et al.* 1977	16	5	9	2
Persson 1982	1	1	0	0
Rud *et al.* 1997	21	16	2	4
Total	330	123	90	118
Weighted-average (%)		35.7	26.3	38

and technique (66.8%). Cavit showed the next highest rate of success (57.6%) and the highest rate of failure (19.3%) when comparing the three filling materials and technique subgroups. Amalgam showed the lowest rate of success (55.8%). The gutta-percha/chloropercha sample population was nearly three times larger than either the Cavit or amalgam subgroup. This discrepancy in the group size inflated the total initial surgical outcome weighted-averages.

Discussion

Very few studies exist delineating the outcomes of resurgery of a failing surgical intervention. The significance of using a systematic review to evaluate research results determining average effect sizes of surgical healing enables the creation of a reliable base level of knowledge. This has never before been achieved when reviewing outcomes of resurgery on nonhealing periradicular lesions.

The results of this systematic review showed that the outcome rates of resurgery success and failure are nearly equivalent. Of the sample population of 330 patients reviewed, 35.7% healed successfully after resurgery and 38% failed to heal by the one-year follow-up. If uncertain cases are considered, one can achieve a 26.3% uncertain rate that has the potential to heal although the healing qualifies as uncertain at the one-year follow-up time period. Comparing the successful initial surgical outcome of 64.2% to the resurgical success/uncertain outcome rate of 62.4%, it is in the patient's interest to attempt a second surgery. As shown in the Rud *et al.* (1972b) study, the uncertain group diminished in size the longer the observation period over several years and can heal successfully over time. Furthermore, comparing successful outcomes for initial surgical intervention versus resurgery, the 35.7% success rate for resurgery is greatly reduced from the 64.2% success rate of the initial surgery. However, it is important to consider that the sample population that underwent resurgery may be encountering different aetiologies that delay apparent healing than those found in initial surgical cases that healed successfully without further intervention. Different bacteria may be present or possibly anomalous dental anatomy that creates difficulty in the overall healing outcome.

Whilst the data obtained is valuable, its application to clinical practice may be limited. The surgical techniques and materials featured in the eight studies that comprised this systematic review have improved over the past 20–30 years. Furthermore, with the advent of better molecular biological research techniques, dentistry as a whole and endodontology specifically have been able to understand better the process of healing and which surgical materials and techniques create an environment conducive to healing. For example, surgical microscopes are presently available and allow the practitioner to visualize the surgical field, thereby enhancing accuracy of the procedure (Carr 1992). Magnification may influence outcomes simply by enhancing the practitioner's visual acuity, although there are no data to support this perception. The availability of a root-end filling material, such as MTA, offers advanced components that promote healing in the periradicular tissues (Torabinejad *et al.* 1994, 1995, Bates *et al.* 1996).

The education of those pursuing endodontic specialization has also improved over the years and includes rigorous studies in surgical technique, as well as dental anatomy based on current knowledge that in the past was not known. Furthermore, clinically supervised surgical experiences within the academic programmes also improves practitioner's outcomes once they complete their programme of specialty study. This experience is crucial to understanding the aetiology for failure and gaining the surgical skills necessary to apply the techniques to treat a periradicular lesion successfully. Finally, the indications for surgical endodontics have changed over time. It is an accepted practice to attempt retreatment prior to surgical intervention in order to achieve healing (Reit 1986, Weine 1995).

There are important differences between the studies that qualified for inclusion in the systematic review. These differences were minor and thus failed to disqualify the study for inclusion, however, the differences still need to be highlighted because they can easily be incorporated into future studies that will lead to further knowledge on healing and outcomes. There was inherent variation between the studies and the use of different operators at different skill levels. Also, there was variation in the follow-up intervals (Rud *et al.* 1992). Although all studies qualified for inclusion by having at least a one-year follow-up, some studies continued to follow patients postoperatively for 6 years and the outcomes changed with time. This is important to recognize and possibly incorporate into a future study on healing rates across multiple studies (systematic review) over time. A postsurgical study examining specific contributory healing factors across time at one, five, 10 and 15 years can be examined to delineate the progression of healing or nonhealing. This examination can then be developed into a framework so that a clinician can evaluate better the progression of a patient's healing. Moreover, the clinician can make reasonable assessments of the final surgical

outcome at different intervals of time. Ultimately, an outcome assessment according to the time interval since surgery can assist in the determination of the oral health status of a patient.

The use of weighted-average in this systematic review versus the use of a simple mean is supported by the intention not to allow the differences between studies sample size to skew the estimate of variation (Sokal & Rohlf 1995). If the sample size varies, so does the reliability of the result from that individual sample. A goal of this systematic review was to allow each study to influence the weighted-average in proportion to the size of the tested population. Thus the weighted-average was used to decrease bias toward smaller studies.

Clinically, the ability to assess postsurgical healing reliably is pertinent to the ultimate goal of endodontic surgical therapy, i.e. resolution of infection and regeneration of tissues. Molven *et al*. (1987) reported that the framework of healing categories created by Rud *et al*. (1972a) is rarely used today to assess surgical outcomes. The quality of postsurgical healing inherent to the surgical wound varies with surgeon, surgical technique, tissue response, materials used, oral and systematic health of the patient, complications, time elapsed since surgery, and many other uncontrollable factors. Postsurgical healing progresses transformationally from a surgical wound to any of the healing categories identified over time. The clinical evaluator must be able to categorize the patient's healing status reliably and to schedule follow-up care dependent on that status. Molven *et al*.'s (1987) framework could easily be used to assist the clinician in assessing surgical wound healing so that follow-up could be administered.

Conclusions

A total of 330 patients, or 14% of the total surgical population reviewed, 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. Although there is nearly equal distribution of results between all categories, a 35.7% rate of radiographic healing is essentially equivalent to the 38% failure rate.

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