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## Outcome of secondary root canal treatment – Systematic review of the literature

**Aims** To assess the success rates of secondary root canal treatment (2°RCT) and identify factors influencing outcome.
**Methodology** Longitudinal clinical studies investigating outcome of 2°RCT were identified by electronic (MEDLINE) and hand searches. Inclusion criteria were data on: number of samples, those successful and definition of success. Two reviewers independently assessed the studies and extracted the data onto a proforma. The pooled weighted success rates by each potential prognostic factor were estimated using the binomial random effect model (MLwiN version 2.02) whilst their pooled effects (expressed as odds ratio) on success rates were estimated using fixed and random effects meta-analysis with DerSimonean and Laird's methods (Stata version 9.2). 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 and root), duration after treatment when assessing success (at least 4 years or shorter), geographic location of the study (North American, Scandinavian and other countries), and qualification of the operator (undergraduate students, postgraduate students, general dental practitioners, specialist or mixed group).
**Results** Of the 41 studies identified, 18 studies published between 1921 and 2005 were included. The majority of studies were retrospective ($n = 13$) and only five prospective. The pooled weighted success rate of 2°RCT judged by complete healing was 77.6% (95% CI 73.2%, 81.4%) and by incomplete healing, 77.4% (95% CI 64.1%, 86.7%). The success rates were similar by 'year of publication' and 'country of study'. Eighteen clinical factors were investigated in various combinations in previous studies. The most frequently investigated were 'periapical status' ($n = 13$), 'size of lesion' ($n = 7$), 'culture results prior to RF' ($n = 5$), and 'apical extent of root filling (RF)' ($n = 4$). The effect of different aspects of previous treatment and re-treatment technique has been poorly tested.
**Conclusions** The pooled weighted estimated success rate of 2°RCT was 77%, which was significantly ($P \leq 0.001$) influenced by the presence and size of pre-operative periapical lesion. The effects of existing canal content, procedural error and re-treatment technique were poorly investigated.

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## Development of an *ex vivo* model for the study of microbial infection in human teeth

**Aims** (1) To infect human teeth artificially to mimic root canal and dentine infection, using the Constant Depth Film Fermenter (CDFF); (2) To verify the similarity of the infections to those found, *in vivo*, using culture and microscopy (SEM, LM and TEM).
**Methodology** Human teeth [$n = 38$ and $n = 28$, for phases I (preliminary) and II (definitive), respectively] were infected within the CDFF for a period of 28 days and at pre-selected time points were removed, externally decontaminated using validated protocols and subjected to either culture-dependent or microscopy protocols. The condition of the teeth was varied in phase I to establish the feasibility of the approach and identify optimal conditions. This informed the selection of optimal conditions for definitive test in phase II. For culture-dependent analysis in this phase, a dentine filing sample was obtained from the apical 5 mm of the root canal and cultured anaerobically to allow isolation of individual strains. Bacterial DNA was extracted from purified isolates, the 16S rRNA genes amplified by PCR and the amplicons sequenced for identity using sequence databases. Teeth assigned for microscopy were post-fixed in 3% gluteraldehyde after removal from the CDFF and then subjected to appropriate protocols prior to microscopic evaluation of the infection.
**Results** All three microscopy techniques and culture-dependent analysis confirmed infection of the human teeth using the CDFF, with root canal infections visually resembling closely those seen *in vivo*. Furthermore, partial 16S rRNA gene sequencing of DNA from cultured isolates confirmed a selective number of 7–9 genera/species in the apical portion of two teeth each at 7 and 28 days; these taxa are also commonly recovered from teeth with apical periodontitis, *in vivo*. There were no objective measures other than speciation and topographical evaluation to compare the artificial and real (*in vivo*) infections.
**Conclusions** The proposed *ex vivo* model has the potential for development into an investigative tool for studying the dynamics of bacterial ecology in infected root canals, both before and after treatment. Its advantage is the ability to control both the abiotic and biotic factors. There is a need for the development of objective measures to compare artificial and real bacterial biofilms.