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Restoring root-canal treated molars: Cost-effectiveness-analysis of direct versus indirect restorations

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ABSTRACT

Objectives: Root-canal treated molars can be directly restored, usually using resin-based-composite restorations (RBCs), or indirectly restored using full or partial crowns (FCs/PCs). Both the initial treatment costs and the risks of restorative and endodontic complications differ between RBCs and FCs/PCs. We aimed to assess the cost-effectiveness of RBCs versus FCs/PCs for restoring root-canal treated molars.

Methods: A mixed public-private payer's perspective within German healthcare was taken. Risks of complications were extracted from large cohort studies or systematic reviews. Costs were estimated using fee-items catalogues of public and private German insurance. A Markov-model was constructed to follow up a root-canal treated molar receiving different restorations in an initially 50-year-old patient over his lifetime. Monte Carlo-microsimulations were performed to assess lifetime costs and effectiveness (tooth retention time), and the resulting cost-effectiveness.

Results: RBCs were less costly than FCs/PCs (749 Euro versus 782 Euro), but also less effective (22 years versus 24 years), the incremental-cost-effectiveness-ratio was 10.80 Euro/year. This ratio increased if costs for direct restorations decreased, or costs for indirect restorations increased. If no teeth were replaced, RBC was far more cost-effective (the incremental cost-effectiveness ratios was 52.95 Euro/year). If all teeth were replaced, FC was both more effective and less costly.

Conclusions: RBCs showed lower costs, but also lower effectiveness than FCs/PCs. Consequently, the cost-effectiveness of both strategies depended on the willingness-to-pay of patients or other payers, i.e. their willingness to invest in higher effectiveness. Clinically, a large number of tooth, patient and dentist-related factors will impact on decision-making and should be considered.

Clinical Significance: We found composite restorations to be less costly, but also less effective than indirect restorations for root-canal treated teeth. Over a long-term period, the initial treatment costs and associated cost-differences between strategies may be outweighed by costs of follow-up treatments.

1. Introduction

Root-canal treated molars can be restored using direct restorations, namely resin-based composites (RBCs) or, less frequently today, amalgams. Alternatively, indirect restorations, namely full or partial crowns (FCs/PCs), made of metal or porcelain or both (like porcelain-fused-to-metal crowns) can be used. Both strategies have a number of advantages and disadvantages. RBCs are placed in one visit, are highly aesthetic, and generate limited initial treatment costs. Indirect restorations require more effort and generate higher treatment costs, while teeth restored using FCs/PCs also show a higher fracture resistance than those restored using RBCs [1]. A recent evaluation of large cohorts of root-canal treated teeth over periods of 3–5 years, mainly using claims data, found indirect restorations like FCs/PCs to show lower risks of both restorative and endodontic complications [2–4]. Short-term randomized trials did not necessarily see these advantages [5].

One aspect which has so far not been assessed when comparing RBCs and FCs/PCs for restoring root-canal treated teeth is cost-effectiveness. Cost-effectiveness analyses aim to quantify the differences in costs of two treatments in relation to the differences in effectiveness; costlier but also more effective treatments may as well be cost-effective, if payers are willing to invest into such higher effectiveness. The cost-effectiveness difference between two strategies is described as

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incremental cost-effectiveness ratio, which is the cost difference per effectiveness difference. Positive values usually indicate additional costs per additional effectiveness (i.e. the additional money payers needed to invest to gain one unit of effectiveness), while negative values usually indicate additional costs per effectiveness loss (such treatment would not be cost-effectiveness) [6].

A range of methods for cost-effectiveness analysis are available. Trial-based methods use purposively collected data on resources and health outcomes to assess cost and effectiveness. Model-based methods use data collected in other studies, often compiled via meta-analysis. They allow researchers to follow individuals or teeth over a range of health states, oftentimes long-term, by combining compiled data on the risk of certain events (complications) occurring in a sequence. For example, teeth can be followed from an initial restorative procedure over further restoration replacements being needed to tooth removal and replacement. Model-based analysis allows a larger range of sensitivity analysis to explore the impact of parameter uncertainty (in costs, for example), heterogeneity (in patients' characteristics, for example) or model structure on cost-effectiveness [7].

The present study aimed to assess the cost-effectiveness of RBCs versus FCs/PCs for restoring root-canal treated teeth, in this case molars. As discussed, RBCs and FCs/PCs may have different initial treatment costs. However, they might also, as described, generate different long-term complications, which lead to different re-treatments, again generating costs. To reflect these aspects, a model-based approach was chosen. Our findings should be of interest for clinicians, patients and other payers as well as healthcare researchers, as they could guide both clinical and non-clinical decision making as well as future studies.

2. Material and methods

2.1. Setting, perspective, population, horizon

This study adopted a mixed public-private-payer perspective in the context of German healthcare. We modelled a population of initially 50-year-old male individuals with a molar which had completed root-canal treatment. Molars were assumed to require a restoration of a four-surfaced cavity using either RBCs or FCs/PCs. Molars were followed over the patient's lifetime (TreeAge Pro 2013, TreeAge Software, Williamstown, MA, USA), which was determined by age and gender.

All cost-effectiveness evaluations were performed per one molar to avoid clustering and increase the ease of interpretation of our findings. A number of different factors, which influence the cost-effectiveness were incorporated into our assessment, namely patients' age (we also modelled patients aged 40 and 60 years, respectively), the extent and type of direct restoration (we also modelled an amalgam restoration instead of an RBC, and a five-surfaced instead of a four-surfaced RBC), the type of indirect restoration (we modelled full and partial metal crowns, and also porcelain-fused-to-metal full crowns), and the proportion of replaced teeth (we also modelled none or all of the lost teeth to be replaced, respectively). Note that for the type of direct or indirect restoration (RBC versus amalgam, full versus partial metal crown versus porcelain-fused-to-metal crown), we did not model a different effectiveness given that data supporting such different effectiveness are scarce [8]. Note that we also did not model further factors which influence the survival of root-canal treated teeth and restorations, like the accessibility and configuration of the root canal system, the type or exact brand of RBC used, or the specific cementation strategy for placing FCs/PCs. We also assumed the molars to be generally restorable using either RBCs or FCs/PCs, i.e. to have sufficient coronal substance to not require a post-retained restoration. The cost-effectiveness of different post-retained restorations has been recently assessed [9].

2.2. Comparators

We compared direct restorations (namely RBCs, or amalgams in a sensitivity analysis) and indirect restorations (metal FCs, metal PCs, and porcelain-fused-to-metal FCs). The base-case was RBC versus metal FC, as is standard under the assumptions of the statutory insurance in Germany for molars.

Table 1
Parameters used for effectiveness estimation.

Event[a]	Transition probability per year	Triangular distribution[b]
RBC [2]		
Restoration renewal	0.060	0.5;1.0;1.5
Placement of FC/PC	0.018	0.5;1.0;1.5
Non-surgical re-treatment	0.006	0.5;1.0;1.5
Surgical re-treatment	0.002	0.5;1.0;1.5
Extraction	0.021	0.5;1.0;1.5
PC/FC [2]		
Restoration repair/recement	0.012	0.5;1.0;1.5
Replacement	0.009	0.5;1.0;1.5
Non-surgical re-treatment	0.003	0.5;1.0;1.5
Surgical re-treatment	0.003	0.5;1.0;1.5
Extraction	0.011	0.5;1.0;1.5
Non-surgically retreated [9,35]		
Surgical re-treatment	0.040	0.5;1.0;1.5
Extraction	0.020	0.5;1.0;1.5
Surgically retreated [4]		
Extraction	0.070	0.5;1.0;1.5
Implant-supported single crown [11,36]		
Implant renewal	0.016	0.5;1.0;1.7
Implant crown complications	0.047	0.6;1.0;1.8

[a] Renewal or repairs were only possible once.

[b] Distributions were used to express uncertainty, with triangular distributions being used for random sampling during probabilistic sensitivity analyses. Triangular distributions were either taken from the referenced studies, or constructed to simulate the assumed uncertainty (mainly for the risk of restorative and endodontic complications in RBCs versus FCs/PCs, which we assumed to be substantial based on the variance between different large cohort studies, but also between cohort studies and randomized trials) [2,4,5].

2.3. Model and assumptions

Molars were assumed to experience endodontic and restorative complications, which could either be non-fatal (can be attended by restoration repair, recementation, or renewal; or by non-surgical or surgical endodontic re-treatment) or fatal (require extraction). These were extracted from a large cohort study from Sweden, which reported in detail on the different risks in directly and indirectly restored teeth of nearly 250,000 treated cases [2]. Restorative complications (Table 1) were dealt with according to the initially placed restoration (RBC or FC/PC). For RBC (and also amalgam restorations in a sensitivity analysis), restoration renewal (i.e. placement of a new composite or amalgam) or the placement of an indirect restoration (PC/FC) or extraction was assumed. If the second RBC (or amalgam) failed, an indirect restoration (FC/PC) was assumed to be placed. For FC/PC, repair (including recementation, refurbishing, repair of fractures, or repair fillings) as well as the placement of another indirect restoration or extraction was assumed. An FC/PC which had been repaired was assumed to be treated by renewal of the FC/PC in case of another complication. Transition probabilities can be found in Table 1.

Endodontic complications (Table 1) were assumed to be addressed by nonsurgical (orthograde) or surgical retreatment (apicectomy). Teeth which had experienced orthograde re-treatment were treated surgically in case of further endodontic complications; those which had received surgical re-treatment were extracted in case of further endodontic complications.

A number of sensitivity analyses were performed. Risks of