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The cost-effectiveness of meniscal repair versus partial meniscectomy: A model-based projection for the United States

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ABSTRACT

Background: Meniscal tears are the most common knee condition requiring surgery, and represent a substantial disease burden with clinical and cost implications. The success rates partial meniscectomy and meniscal repair have been studied, but limited information is available investigating their long-term costs and effects. Our objective was to assess the long-term cost-effectiveness of meniscal repair compared to meniscectomy.
Methods: We constructed a decision-analytic Markov disease progression model, using strategy-specific failure rates and treatment-specific probabilities for the development of osteoarthritis (OA) and subsequent knee replacement (TKR). Failure rates and OA incidence were derived from controlled and uncontrolled studies as well as meta-analyses. Costs were derived from 2014 U.S. reimbursement amounts and published literature.
Results: Meniscal repair was associated with an increased failure rate (RR of 4.37), but meaningful reductions in OA and TKR incidence (29.7% vs. 39.4% and 19.6% vs. 27.9%, respectively) in our model-based analysis. Over the 30-year horizon, meniscal repair was associated with an increase in discounted QALYs to 16.52 (compared to 16.37 QALYs for meniscectomy), at overall discounted savings of $2384, making it the dominant index procedure strategy. Using age-specific per-patient cost and QALYs projected for the 30-year horizon, our computations suggest that payers could save approximately $43 million annually if 10% of current meniscectomies could be performed as meniscal repairs.
Conclusions: Our projection suggests that meniscal repair, despite substantially higher failure rates, is associated with improved long-term outcomes and cost savings relative to meniscectomy in the majority of patients, making it the dominant treatment strategy.

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1. Introduction

More than 500,000 meniscal tears are treated annually in the United States [1]. The menisci are fibrocartilage discs that are vital for maintaining the health of the cartilage in the knee, by distributing load, absorbing shock, and providing additional stability [2,3]. Tears to the meniscal are common with athletic activities, and can occur without significant trauma in the setting of cartilage degeneration and early osteoarthritis (OA).

There are two surgical treatment options for patients with meniscal tears and without significant OA. In younger patients with large meniscal tears involving the periphery of the meniscal (i.e., longitudinal tears or tears in the red-red and red-white zone) or in those patients with tears disrupting the hoop stresses of the knee (i.e., radial and root tears), meniscal repair is indicated to preserve the biomechanical stresses on the knee [4]. Partial meniscectomy is indicated for patients with degenerative tears, or tears that do not have an adequate blood supply, and for patients who have failed previous repair attempts [5]. In short- and long-term follow-up, meniscal repair has generally been found to be associated with higher failure rates when compared to partial meniscectomy [6,7]. Recent studies have shown that repair can be successful for older patients and patients with horizontal cleavage tears, suggesting expanding indications for meniscal repair are imminent [8–10]. Further, partial meniscectomy has been shown to increase the risk of OA [4], and increased cartilage degeneration after partial meniscectomy has been observed in a number of studies even at short-term follow-up [11]. In cases where cartilage degenerates following partial or complete meniscectomy, OA can progress to the point where it is necessary to perform TKR—a procedure associated with significant costs to the healthcare system [12].

Meniscal injuries therefore present a substantial disease burden with long-term clinical and cost implications [13]. Our objectives were to develop an analytical framework for assessing the long-term cost-effectiveness of meniscectomy compared to meniscal repair, and to

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project the impact of potential changes in current treatment strategy for the United States healthcare system.

2. Materials and methods

2.1. Overview and modeling framework

We developed a decision-analytic Markov disease progression model to assess the clinical outcomes and costs associated with the two index procedure strategies—meniscal repair and meniscectomy—and to compute the incremental costs and effects associated with each strategy.

The model was designed to use a cycle length of 1 month, and took into account index strategy-specific failure rates as well as treatment-specific probabilities for the development of osteoarthritis (OA). In the case of an index procedure failure, one reintervention was allowed for each strategy. For both meniscal repair failure and partial meniscectomy failure, it was assumed that the reintervention would entail a meniscectomy. Subsequent to OA development, total knee replacement (TKR) was considered as a follow-on intervention, modeled to include up to two repeat TKRs in the case of TKR failure. All analyses were conducted for a 30-year horizon, with other follow-up horizons explored in sensitivity analyses (Figure 1).

The primary outcome of interest was the incremental cost-effectiveness ratio (ICER), defined as the incremental direct costs of medical treatment and related consequences divided by the incremental health benefits, and expressed as quality-adjusted life-years (QALYs) [14,15]. Costs and effects were discounted at 3% per year, in line with current health-economic guidelines [14].

2.2. Input parameters

Baseline patient characteristics were modeled in accordance with a large prospective study of arthroscopy-based partial meniscectomy, with baseline age assumed to be 37.7 years, and gender 79% male [16]. All other input parameters were derived from systematic searches of the PubMed literature and from published statistics and databases (Table 1).

2.2.1. Therapy effectiveness

Therapy effectiveness was considered at several levels. First, failure rates were modeled in accordance with estimated 10-year failure rates of 6.36% for meniscectomy and 30.1% for meniscal repair. The meniscectomy failure rate was based on the combined average of study-reported data from 362 medial and 109 lateral meniscal tears [16]. The meniscal repair failure rate was based on the 30.1% failure probability reported for follow-up periods from 4 to 10 years [17]. For both meniscectomy and meniscal repair, the 10-year probabilities were converted via rates to obtain monthly probabilities as input to the model. For patients older than age 30, we modeled an increased failure rate for repair to reflect clinical experience in older patients (see Table 1 and Appendix).

Second, we considered the probability of index-strategy-dependent development of OA. Based on a cohort study of 155 patients, we assumed a proportion of 25.16% radiographic OA (ROA; Kellgren/Lawrence grade > 2) at 16-year follow-up [18]. This proportion was significantly greater than the 7.3% incidence of ROA found among patients in the healthy control group of the earlier study. To estimate the proportion of ROA among patients treated with meniscal repair, we conservatively assumed a relative risk of 0.5 compared to meniscectomy, for an estimate of 12.6% at 16 years. This assumption is supported by recent biomechanics studies [19,20].

Third, TKR incidence was estimated based on time-to-event information reported in a recent study of 1286 TKR patients, 29 of whom had a history of knee surgery [21].

Fourth, the incidence of revision TKRs after primary TKR was modeled according to time-dependent data from a recent U.S. TKR cost-effectiveness study, based on Australian registry data [22]. We allowed for one additional reintervention after TKR revision, using time-dependent incidence data based on the same source.

2.2.2. Costs

Costs were considered from a U.S. Medicare third-party payer perspective, including only direct healthcare costs associated with treatment of the underlying conditions considered in this analysis. Costs for meniscectomy and meniscal repair were obtained from Medicare reimbursement schedules for outpatient treatment. Costs for OA treatment, TKR, and revision TKR were based on cost data from the published literature [12,22–24]. Unless derived from FY 2014 Medicare reimbursement schedules, all cost estimates were converted to 2014 U.S. dollars using the general consumer price index for the United States [25].

2.2.3. Mortality and health-related quality of life

Age- and gender-specific baseline mortality rates were based on 2010 U.S. life tables [26]. Except for procedure-related mortality, we did not assume increased mortality related to any underlying conditions.

Utility estimates for the disease states included in the model were obtained from the published literature. We assumed procedure-related disutility for meniscal repair, meniscectomy, TKR, and revision TKR procedures in accord with expert opinion and the published literature.

2.3. Analysis of uncertainty

Comprehensive deterministic one-way and two-way sensitivity analyses were conducted to evaluate the effects of parameter uncertainty. Parameter ranges were derived from the literature and, where applicable, from expert opinion (Table 1). For one-way sensitivity analyses, the ICER was computed for each scenario.

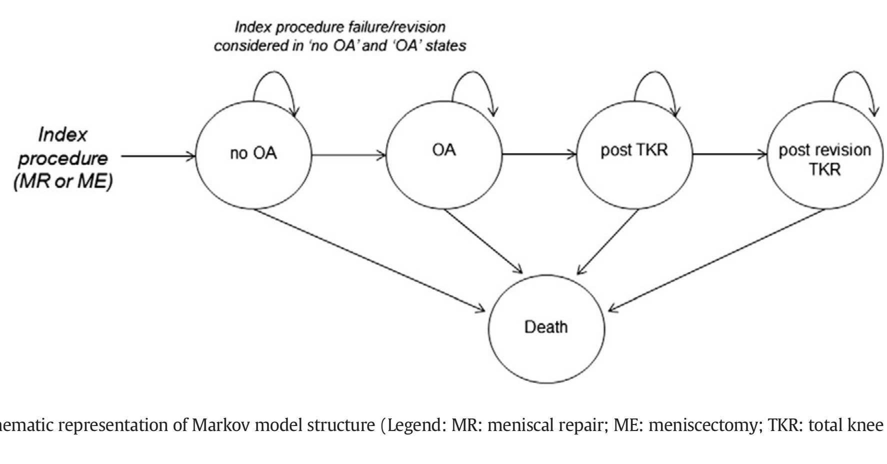

Figure 1. Schematic representation of Markov model structure (Legend: MR: meniscal repair; ME: meniscectomy; TKR: total knee replacement).

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