Original Article

Early Arthroscopic Debridement May Be More Cost-Effective Than Nonoperative Management for Symptomatic Osteochondritis Dissecans Lesions of the Capitellum

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Purpose: To compare the cost-effectiveness of an initial trial of nonoperative treatment to that of early arthroscopic debridement for stable osteochondritis dissecans (OCD) lesions of the capitellum. **Methods:** A Markov Chain Monte Carlo probabilistic model was developed to evaluate the outcomes and costs of 1,000 simulated patients undergoing nonoperative management versus early arthroscopic debridement for stable OCD lesions of the capitellum. Health utility values, treatment success rates, and transition probabilities were derived from the published literature. Costs were determined on the basis of the typical patient undergoing each treatment strategy at our institution. Outcome measures included costs, quality-adjusted life-years (QALYs), and the incremental cost-effectiveness ratio (ICER). **Results:** Mean total costs resulting from nonoperative management and early arthroscopic debridement were $5,330 and $21,672, respectively. On average, early arthroscopic debridement produced an additional 0.64 QALYS, resulting in an ICER of $25,245/QALY, which falls well below the widely accepted $50,000 willingness-to-pay (WTP) threshold. Overall, early arthroscopic debridement was determined to be the preferred cost-effective strategy in 69% of patients included in the microsimulation model. **Conclusion:** Results of the Monte Carlo microsimulation and probabilistic sensitivity analysis demonstrated early arthroscopic debridement to be a cost-effective treatment strategy for the majority of stable OCD lesions of the capitellum. Although early arthroscopic debridement was associated with higher total costs, the increase in QALYS that resulted from early surgery was enough to justify the cost difference based on an ICER substantially below the $50,000 WTP threshold. **Level of Evidence:** Level III, economic computer simulation model.

Osteochondritis dissecans (OCD) of the capitellum is a well-recognized cause of elbow pain and dysfunction in athletes,[1,2] most commonly, throwers and gymnasts.[3,4] Although the cause is not entirely clear, a commonly proposed mechanism for OCD is analogous to a stress fracture of the subchondral bone.[1,2,5,6] In milder presentations, there may be stable fragments with either no symptoms or mild pain. In more severe presentations, there can be mechanical symptoms, catching, and locking from unstable lesions or loose intra-articular osteochondral fragments.[1-4,7]

The appropriate treatment algorithm of capitellar OCD is debated and lacks clear consensus. For many surgeons, decision-making is predicated on mechanical symptoms and lesion stability.[8,9] Historically, in the absence of mechanical symptoms, the first-line treatment is nonoperative. This usually entails a period of rest from throwing or similar sports activities and

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avoidance of repetitive upper extremity weight-bearing activities, with the duration of this period being nonstandardized.[4,10] Patients with mechanical symptoms or unstable lesions are typically selected for operative management with one of several procedures, including debridement with marrow stimulation, fragment fixation, osteochondral autograft transfer, or osteochondral allograft transplantation.[4,9-14] Recent studies suggest that many patients with symptomatic, stable OCD lesions, who are initially treated nonoperatively, eventually progress to surgical intervention.[7,10] Furthermore, surgical management tends to be favorable in the short and medium term, with most athletes returning to sport within that time frame.[11,13-17] One study reported less pain, better range of motion, higher functional outcome scores, and fewer mechanical symptoms with surgical management at long-term, follow-up when compared with nonoperative management.[8]

To avoid unnecessary surgery, the potential for complications, and the increased recovery timeline, the most common initial treatment for stable capitellar OCD lesions is nonoperative. However, since many patients eventually undergo surgery, the cost effectiveness of this strategy is unclear. A multidimensional analysis that considers both the costs of initial treatment, as well as outcomes and progression to future surgery after nonoperative versus operative treatment, would help support fully informed decisions on the management of capitellar OCD. The purpose of this study was to compare the cost-effectiveness of an initial trial of nonoperative treatment to that of early arthroscopic debridement for stable OCD lesions of the capitellum. We hypothesized that early arthroscopic debridement of capitellar OCD would be a cost-effective treatment option when compared to nonoperative management with a physical therapy regimen alone.

Methods

Introduction to Markov Modeling

Markov models are decision trees used to model clinical courses of treatment as transitions between discrete health states based on probabilistic events occurring over a specified period of time.[18] As summarized below, each state is associated with a quality-of-life (QOL) value, transition probabilities, and costs that are determined from empirically derived or estimated data. QOL values range from 0 (death) to 1 (perfect health) and provide a measure of disease burden on an individual's life. According to the transition probabilities, experimental patients transition between health states through Markov cycles, accruing QOL values and costs at each state. QOL values are aggregated into quality-adjusted life-years (QALYs). The primary outcome of a Markov study is the incremental cost-effectiveness ratio (ICER), which is defined as the difference in costs between two treatment options divided by the difference in QALYs for those treatments.[19] For the present study, treatment strategies were 1) nonoperative management with physical therapy and 2) early arthroscopic debridement. A willingness-to-pay (WTP) threshold is set and defined as the maximum amount that society is willing to pay to achieve one additional QALY. A WTP of $50,000 is considered standard.[20] If a treatment results in an ICER below the WTP threshold, it is considered cost-effective; as a result, the treatment with the most QALYs would be considered the optimal strategy. If a treatment results in both lower costs and more QALYs, it is considered to be a "dominant treatment."[21]

Model Structure

The Markov decision tree model utilized in this study was constructed from publicly available software (TreeAge Pro; TreeAge Software, Williamstown, MA). An adolescent athlete meeting the indications for either conservative treatment or arthroscopic debridement of a stable capitellar OCD lesion serves as the base case for our model. This age group was selected to reflect a cohort of young athletes who experience capitellar OCD and participate in high-volume and high-level sports. The age range of 12-18 years was selected to most closely match the ages of patients included in the studies from which model input parameters were derived. As such, they represent the demographic most likely to be faced with the decision of whether to undergo nonoperative or operative treatment for a stable capitellar OCD lesion. All patients in the model are assumed to have a symptomatic stable OCD lesion with no loose bodies or fragmentation at the time of presentation. The two primary treatment arms are 1) nonoperative management with physical therapy alone and 2) early arthroscopic debridement. For each treatment arm, there are two postoperative outcomes: 1) success or 2) recurrence (defined as persistent pain despite the intervention). For patients who fail an initial trial of nonoperative management, a portion will undergo delayed arthroscopic debridement. For patients who experience recurrence after arthroscopic debridement (either early or delayed), a subset is assumed to undergo repeat debridement. An overview of the model is shown in Fig 1.

Model Parameters

To obtain outcomes and model inputs for patients treated with an initial trial of nonoperative management versus early arthroscopic debridement, a targeted literature search was performed. Success rates after nonoperative management and arthroscopic debridement were derived from a systematic review of the literature investigating treatment strategies and outcomes for OCD of the capitellum.[22] From this review, it was determined that 36.7% of patients in studies report persistent pain after a well-designed program of nonoperative treatment. For patients treated with debridement, 17.3% of patients seem to experience persistent pain after surgery.[22] These probabilities were used to derive treatment success and failure rates for the model. The probability of undergoing delayed arthroscopic debridement after failed nonoperative management, as well as the probability of undergoing repeat arthroscopic debridement after a failed debridement, were also derived from this systematic review (Table 1).[22]

Costs for each treatment strategy and transition state in the model were considered from the payer perspective (commercial or government) and obtained from institutional data at a large, academic medical center. Costs for nonoperative treatment included outpatient consultation fees (initial consultation and subsequent evaluations), imaging (radiograph and magnetic resonance imaging [MRI]), an initial evaluation for physical therapy, and a series of 6, 45-minute physical therapy sessions. The cost of arthroscopic debridement included all fees associated with nonoperative management in addition to the cost of surgery, which included all costs associated with hospital fees, surgeon fees, anesthesia, operating room equipment, medications while in the hospital, brace/splint, and all physician visits during the 90-day postoperative period. Surgically treated patients were assumed to undergo a series of 6, 45-minute physical therapy sessions as well; thus, these costs were included in the cost of undergoing arthroscopic debridement (Table 1).

The Mayo Elbow Performance Index (MEPI) was used to quantify the utility of each treatment strategy based on long-term outcomes of a geographic cohort of 50 patients from the Rochester Epidemiology Project (REP), who were diagnosed with capitellar OCD from 1995 to 2020 and underwent either definitive nonoperative management, delayed arthroscopic debridement, or early arthroscopic debridement (Table 1).[8]

Monte Carlo Microsimulation and Probabilistic Sensitivity Analysis

In contrast to methods used to create predictive models with fixed input values, Monte Carlo simulation enables the construction of models that leverage probability distributions for variables with inherent uncertainty. In the present study, Monte Carlo microsimulation was used to generate hypothetical patients who repeatedly traverse the model, each time with a set of different input parameters drawn from a corresponding probability distribution. For each microsimulation, patients accrue costs and utilities, and these are averaged and compared over many simulated cycles to produce more robust results that consider the uncertainty associated with estimated model inputs. A greater number of cycles that produce similar results corresponds to increased confidence that the result in question does, in fact, reflect reality despite the inherent uncertainty associated with selected input parameters. In this study, probabilistic sensitivity analysis (PSA) was used to simultaneously vary all cost and probability input parameters in the model. PSA has been shown to better estimate uncertainty in the model when compared to standard sensitivity analysis for microsimulation models.[23,24] One thousand patients were simulated over 1,000 cycles, with cost parameters assigned gamma distributions based on their means, probability parameters assigned beta distributions based on their means, and utilities assigned normal distributions based on their means.[25] Standard deviations for probabilities and costs were assumed to be 20% of the mean based on prior analyses.[26] For utility values, a standard deviation of .05 was assumed. In this study, both costs and QALYs were discounted at a rate of 3% annually.[27] The ICER was used to evaluate the cost-effectiveness of each treatment arm by providing a measure of the cost per year acquired by undergoing the specific treatment arm that results in the highest number of QALYs. Cycle length was defined as 1 year, and a time horizon of 10 years was chosen to correspond to the mean follow-up of the study, from which utilities were derived.[8]

Results

Monte Carlo Microsimulation and Probabilistic Sensitivity Analysis

The results of the Monte Carlo microsimulation and PSA are shown in Table 2. Mean total costs resulting from nonoperative management and early arthroscopic debridement were $5,330 and $21,672, respectively. On average, however, early arthroscopic debridement produced an additional 0.64 QALYs. In this case, where neither treatment resulted in both lower costs and more QALYs, the ICER is used to determine the most cost-effective treatment strategy at a given WTP threshold. Assuming the standard $50,000 WTP threshold for cost-effective interventions,[20] arthroscopic debridement was determined to be highly cost-effective, with an ICER of $25,245/QALY. Figure 2 displays cost-effectiveness acceptability curves for each treatment strategy at WTP thresholds from $0/QALY to $100,000/QALY. The WTP threshold below which nonoperative management is preferred over arthroscopic debridement was found to be less than $30,000/QALY, suggesting that arthroscopic debridement is a highly cost-effective treatment strategy when compared to nonoperative management for stable OCD lesions of the capitellum.

Results of the microsimulation are depicted in Fig 3. Out of 1,000 samples run over 1,000 trials, arthroscopic debridement was the optimal strategy in 69% of cases, with nonoperative management being the optimal

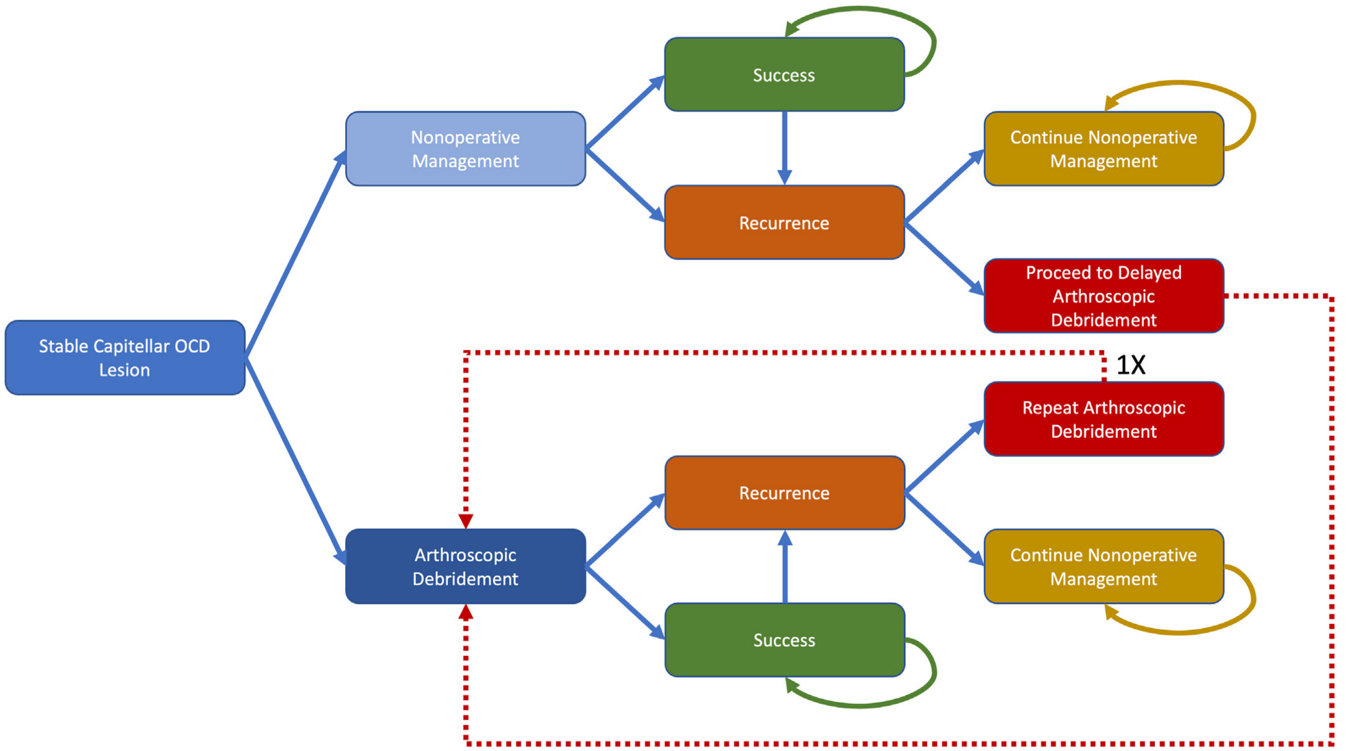

Fig 1. Markov model diagram depicting flow of patients in the decision model. OCD, osteochondritis dissecans.

strategy in the remaining 31% of cases (Fig 4). The ICER scatterplot shown in Fig 5 illustrates the model's predictions and confidence for patients faced with the decision of arthroscopic debridement versus nonoperative management. Points in green correspond to the 69% of patients for whom the model correctly predicted early debridement as the most cost-effective treatment strategy, while points in red correspond to points in which

Table 1. Model Inputs

	Base Case Value	PSA 10-90% Range (Distribution Type)	Source
Transition Probabilities			
Success after nonoperative management	.63	.45-.79 (beta)	Sayani et al.[22]
Success after arthroscopic debridement	.83	.57-.99 (beta)	Sayani et al.[22]
Undergo arthroscopic debridement after failing nonoperative management	.16	.12-.20 (beta)	Sayani et al.[22]
Undergo repeat arthroscopic debridement after failed primary arthroscopic debridement	.05	.038-.063 (beta)	Sayani et al.[22]
Costs (US $)			
Nonoperative	**$5,223**	**$4,002-$6,766 (gamma)**	Institutional Data
Outpatient consultation (initial consult and follow-up)	$410		
Radiograph	$188		
MRI	$2,288		
Evaluation of physical therapy	$303		
Series of six 45-minute physical therapy sessions	$2,034		
Arthroscopic debridement	**$21,813**	**$16,511-27,004 (gamma)**	Institutional Data
Outpatient consultation (initial consult)	$205		
Radiograph	$188		
MRI	$2,288		
Surgery	$16,795		
Evaluation of physical therapy	$303		
Series of six 45-minute physical therapy sessions	$2,034		
Utilities			
Success after arthroscopic debridement	.90	.84-.97 (normal)	Braig et al.[8]
Success after nonoperative management	.83	.77-.89 (normal)	Braig et al.[8]
Recurrence	.70	.63-.76 (normal)	Braig et al.[8]

PSA, probabilistic sensitivity analysis.

nonoperative management would have been the most cost-effective treatment strategy. The model's confidence is shown with the 95% confidence ellipse.

Discussion

The most important finding of this study was that, on the basis of currently published outcomes, early arthroscopic debridement is a cost-effective treatment option for most stable OCD lesions of the capitellum. Although early arthroscopic debridement was associated with higher total costs, the increase in QALYS over the 10-year time horizon that resulted from early surgery was enough to justify the cost difference based on an ICER substantially below the $50,000 WTP threshold. While neither nonoperative management nor early arthroscopic debridement resulted in both lower costs and higher QALYs, and, thus, neither treatment was determined to dominate over the other, the results of the Monte Carlo microsimulation model and PSA demonstrated early arthroscopic debridement to be the preferred and optimal strategy in 69% of cases, with nonoperative management and physical therapy determined optimal for the remaining 31% of patients.

Algorithms for treating capitellar OCD include various operative and nonoperative management courses, with failure of nonoperative treatment, lesion instability, or mechanical symptoms, traditionally serving as the impetus for selecting a surgical procedure.[10,15] However, for stage I and stable stage II capitellar OCD lesions, appropriate first-line management continues to be a topic of debate. While a trial of nonoperative treatment has historically been performed prior to considering surgery for these patients, new evidence suggests potential benefits to the consideration of surgery earlier in a patient's treatment course, which may alter the preferred treatment strategy for many patients.[8] Thus, shared decision-making between the orthopedic surgeon and the patient regarding management of capitellar OCD should include evidence-based consideration of the risks of surgery, short- and long-term outcomes, initial cost, and now potentially, the cost-effectiveness data presented herein. This study adds to the body of evidence that patients and surgeons have available when considering early surgery versus nonoperative management by demonstrating that early arthroscopic debridement is cost-effective and likely the preferred treatment strategy for approximately two-thirds of young athletes participating in high-frequency, high-intensity overhead sports.

Because of the relatively low number of capitellar OCD lesions treated at individual practices, randomized controlled trials comparing nonoperative management with early arthroscopic debridement are lacking. Thus, in order to obtain probabilities of success and failure

Table 2. Results of Monte Carlo Microsimulation and PSA

Dominance	Strategy	Cost ($) (Mean ± SD)	Incremental Cost ($)	Effectiveness (QALYs) (Mean ± SD)	Incremental Effectiveness (QALYs)	ICER ($/QALY)	NMB ($) (Mean ± SD)	Percentage of Iterations Optimal
Undominated	Nonoperative Management	5,330 ± 1,036		2.02 ± 0.25			95,506 ± 12,361	30.7%
Undominated	Early Arthroscopic Debridement	21,672 ± 4,173	16,342	2.66 ± 0.56	0.64	25,245	111,531 ± 28,177	69.3%

The net monetary benefit (NMB) represents the value of an intervention in monetary terms when a willingness to pay threshold for a unit of benefit (one QALY) is known. It is calculated as the benefit of a therapy expressed in monetary terms minus the costs associated with that therapy.[35]

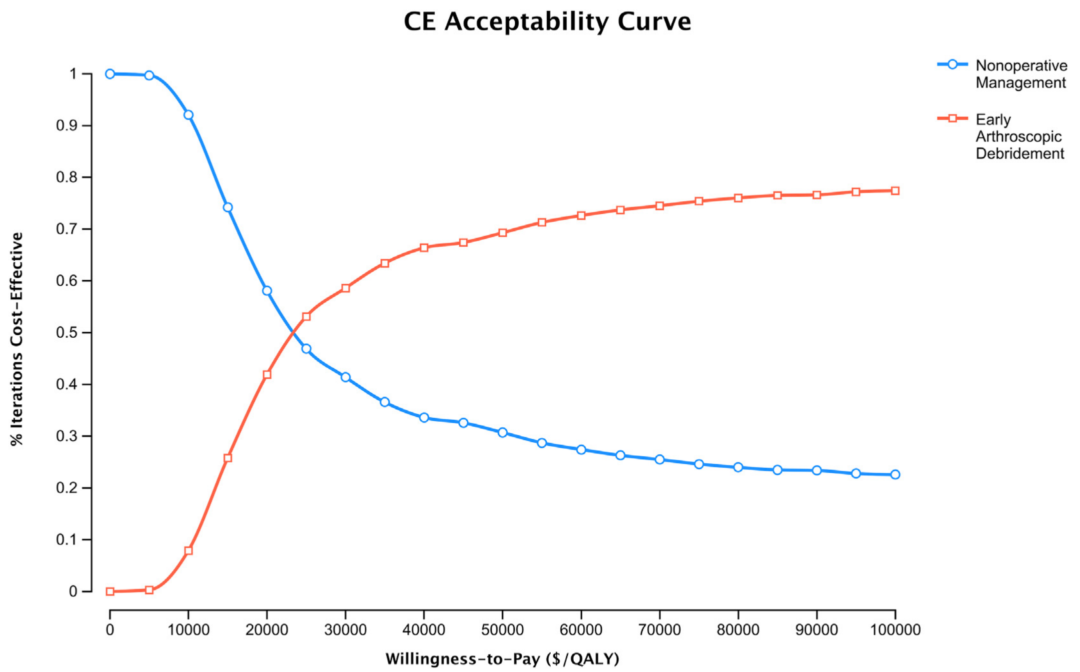

Fig 2. Cost-effectiveness (CE) acceptability curves for each treatment strategy at willingness-to-pay (WTP) thresholds from $0/ quality-adjusted life-years (QALY) to $100,000/QALY. The WTP threshold below which nonoperative management is preferred was found to be less than $30,000/QALY, suggesting that early arthroscopic debridement is cost-effective when compared to nonoperative management.

after each treatment option in the model, a systematic review of studies evaluating outcomes after nonoperative management and early arthroscopic debridement was used to derive model inputs, with a total of 109 patients and 422 patients included in the nonoperative and debridement treatment groups, respectively.[22] For this model, failure was defined as persistent pain despite an intervention, with overall rates of 36.7% and 17.3% for nonoperative treatment and debridement, respectively. The need for reoperation (after

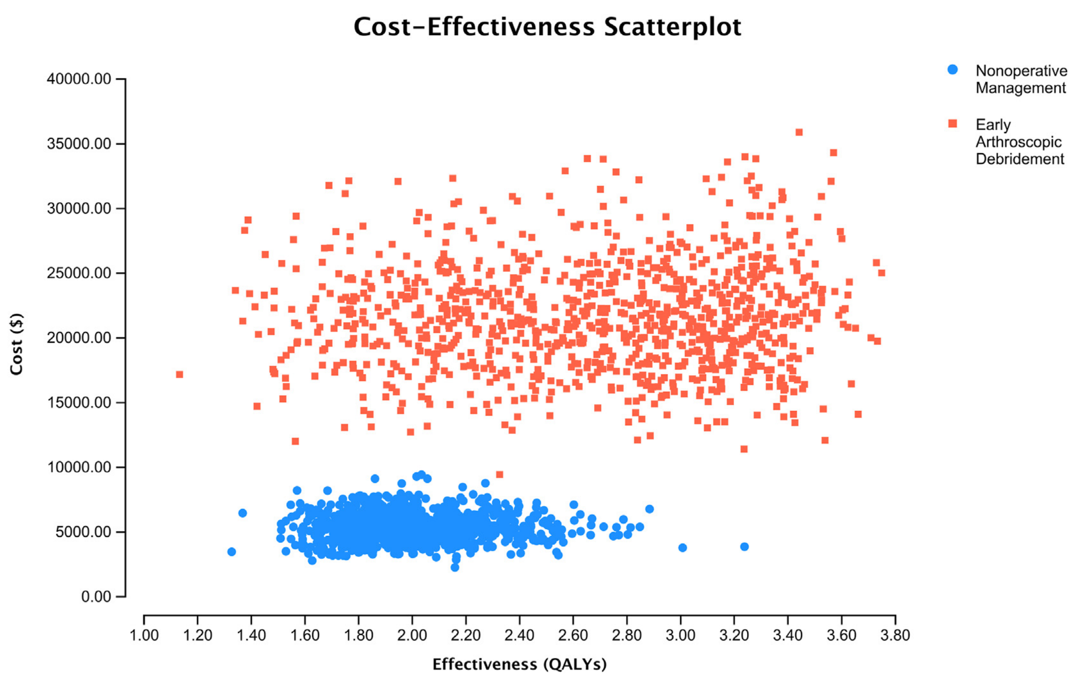

Fig 3. Costs and quality-adjusted life-years (QALYs) gained per patient for each of the 1,000 patients in the Monte Carlo microsimulation model.

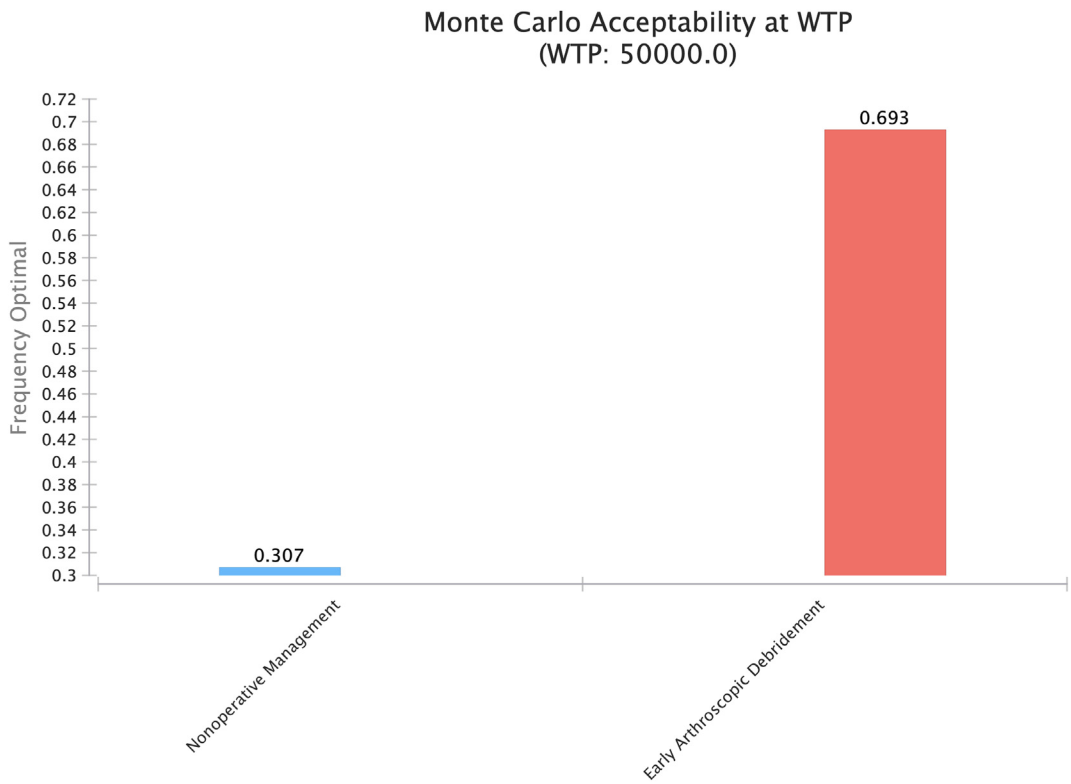

Fig 4. Frequency with which each treatment strategy was determined optimal assuming a willingness to pay of $50,000/ quality-adjusted life-years (QALY) over 1,000 samples and 1,000 trials of Monte Carlo microsimulation.

debridement) or progression to debridement (after nonoperative management) was also derived from this same cohort, which showed significantly lower reoperation rates in the debridement group (reoperation rate, 4.7%) compared with nonoperative treatment (15.6%), fixation (10.7%), and osteochondral autograft transplantation (12%).[22] It is important to note that patients with unstable lesions (Grades III and IV) were not able to be excluded entirely from these outcomes, and that while only 10 patients with unstable lesions were included in the nonoperative treatment group, there were 118 patients with unstable lesions included in the debridement group. By including these patients in the analysis, there may be a slight bias in favor of nonoperative treatment, since patients with unstable lesions may be expected to experience more advanced disease and persistent symptoms, resulting in worse outcomes.[15] Despite this bias, however, our results still favored early arthroscopic debridement.

Until recently, long-term outcomes after elbow arthroscopy for capitellar OCD were not well elucidated, preventing meaningful conclusions regarding the long-term cost-effectiveness of debridement vs. nonoperative management. Short-term outcomes had been encouraging for arthroscopic debridement for capitellar OCD, demonstrating improved range of motion, with the majority of patients returning to preinjury levels of competition,[28-30] but long-term outcomes remained poorly understood. Braig et al. evaluated long-term outcomes of 50 elbows with capitellar OCD at a mean 10.5-year follow-up.[8] They reported that patients treated with surgery earlier demonstrated better range of motion, better functional scores, less pain, and fewer mechanical symptoms at long-term follow up when compared with those treated nonoperatively.[8] Additionally, among patients who initially underwent at least 6 months of nonoperative management, 70% ultimately underwent surgery on the affected elbow.[8] Fortunately, delayed surgical patient outcomes were not inferior compared with patients who underwent early surgical management.[8] These promising long-term results after arthroscopic debridement are corroborated by Austin et al., who at the 11-year average follow-up, found the median visual analog scale (VAS) score for pain for patients treated with arthroscopic debridement to be 0 at latest follow up, with 96% of patients reporting durable improved elbow function compared with their preoperative state.[31] In addition, for those patients reaching a minimum of 20-year follow up, there was an 88% survival rate free of revision surgery.[31] These outcomes after arthroscopic debridement align with the results of our model, which found that despite higher total costs, early arthroscopic debridement produced enough of an

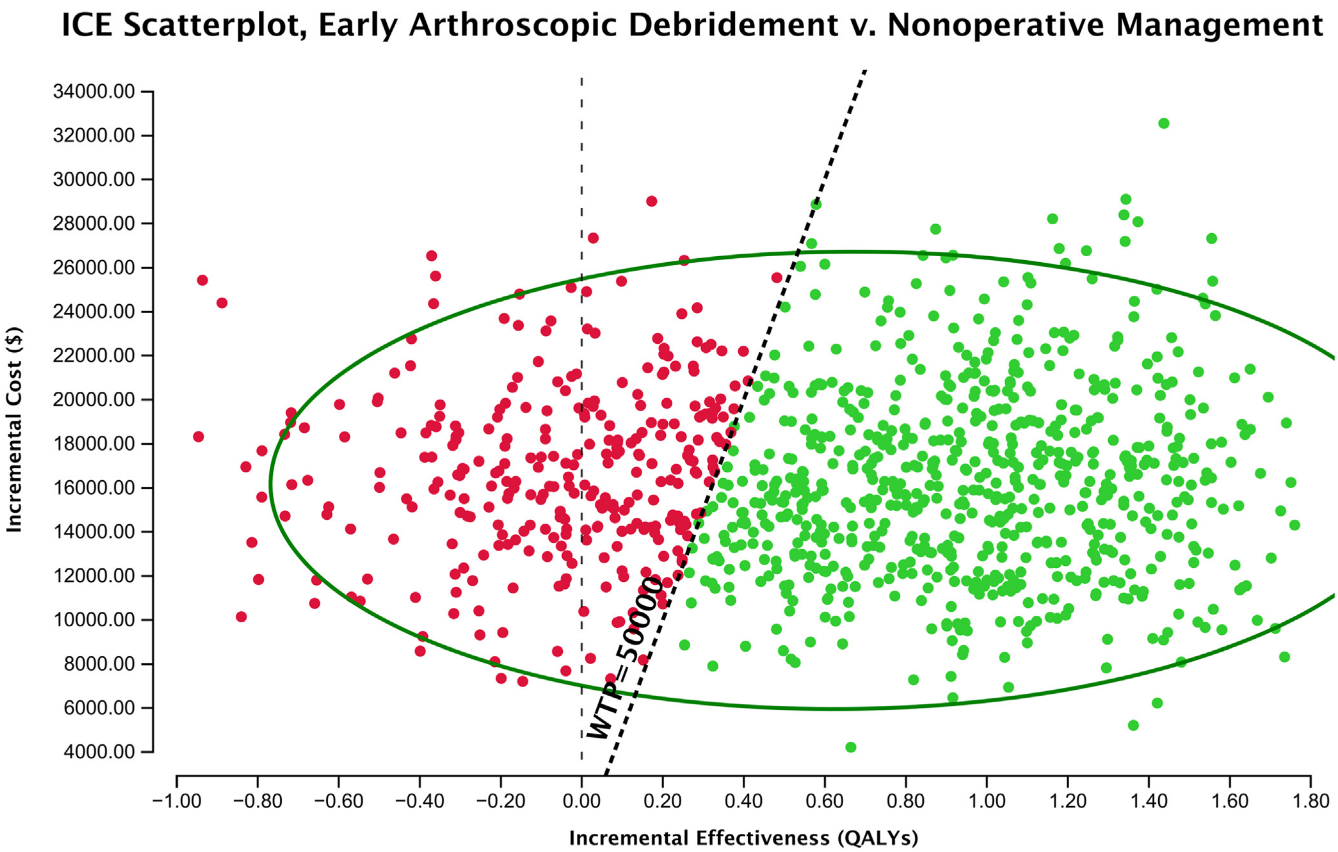

Fig 5. Incremental cost-effectiveness scatterplot from the probabilistic sensitivity analysis, shown with a 95% confidence ellipse. All points to the right of the diagonal willingness to pay (WTP) line represent the 69% of patients for whom the model correctly predicted early arthroscopic debridement as the cost-effective treatment strategy when compared to nonoperative management at a WTP of $50,000/QALY (green). Points to the left of the $50,000 WTP diagonal correspond to patients for whom nonoperative management is the optimal strategy (red).

increase in QALYs over the 10-year time horizon to justify the increased cost when compared to nonoperative management, based on a $50,000 WTP threshold.

In their systematic review of outcomes in patients with capitellar OCD lesions treated either nonoperatively or with arthroscopic debridement, Sayani et al. found that, for the 119 patients treated nonoperatively, there were no complications, whereas for the 422 patients treated with debridement, the complication rate was 1.9%.[22] Thus, because of the extremely low probabilities of experiencing a complication, disutility and costs associated with complications were not included in the present model. However, while risks associated with arthroscopy in general are low, individual patient factors must be evaluated when considering costs and complication risk. Patient factors associated with higher risks of complications, and presumably subsequent additional cost to overall care, are those with obesity, anatomic variants, inflammatory arthritis, diabetes mellitus, and previous elbow surgery.[32-34]

Limitations

This study is not without limitations. A Markov model is a rigid model for an "average" patient undergoing a treatment and must define definitive likelihoods of treatment failure, costs, and treatment pathways. While this limitation is minimized when applying Monte Carlo microsimulation and PSA, our methodology did not capture the unique experience of every patient undergoing treatment for a capitellar OCD lesion. Accordingly, a shared decision-making discussion should be conducted regarding nonoperative management versus early arthroscopic debridement based on individual patient factors, as many patients with stable OCD lesions can successfully be treated without surgery. To conduct our analysis, we had to make assumptions about transition probabilities and outcomes using the current literature, despite heterogeneity in lesion grade and location, as well as physeal status among patients, included the studies from which model inputs were derived. In addition, because there is variability in the cost of medical care based on practice settings and geographic location and since multiple factors contribute to an individual patient's potential for healing, our results may not be applicable to all patients. This limitation is mitigated by performing sensitivity analyses that account for a spectrum of model inputs; however, it is not possible to remove all uncertainty from the analysis.

Conclusion

Results of the Monte Carlo microsimulation and probabilistic sensitivity analysis demonstrated early arthroscopic debridement to be a cost-effective treatment strategy for the majority of stable OCD lesions of the capitellum. Although early arthroscopic debridement was associated with higher total costs, the increase in QALYS that resulted from early surgery was enough to justify the cost difference based on an ICER substantially below the $50,000 WTP threshold.

Disclosure

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References

1. Baker CL, Romeo AA, Baker CL. Osteochondritis dissecans of the capitellum. *Am J Sports Med* 2010;38:1917-1928.
2. Edmonds EW, Polousky J. A review of knowledge in osteochondritis dissecans: 123 years of minimal evolution from König to the ROCK Study Group. *Clin Orthop Relat Res* 2013;471:1118-1126.
3. Kida Y, Morihara T, Kotoura Y, et al. Prevalence and clinical characteristics of osteochondritis dissecans of the humeral capitellum among adolescent baseball players. *Am J Sports Med* 2014;42:1963-1971.
4. Takahara M, Mura N, Sasaki J, Harada M, Ogino T. Classification, treatment, and outcome of osteochondritis dissecans of the humeral capitellum. *J Bone Joint Surg* 2007;89:1205-1214.
5. Kobayashi K, Burton KJ, Rodner C, Smith B, Caputo AE. Lateral compression injuries in the pediatric elbow: Panner's disease and osteochondritis dissecans of the capitellum. *J Am Acad Orthop Surg* 2004;12:246-254.
6. Yamaguchi K, Sweet FA, Bindra R, Morrey BF, Gelberman RH. The extraosseous and intraosseous arterial anatomy of the adult elbow. *J Bone Joint Surg* 1997;79:1653-1662.
7. Mihara K, Tsutsui H, Nishinaka N, Yamaguchi K. Nonoperative treatment for osteochondritis dissecans of the capitellum. *Am J Sports Med* 2009;37:298-304.
8. Braig ZV, Uvodich ME, Till SE, et al. Osteochondritis dissecans of the capitellum of the elbow: Improved outcomes in surgically treated versus nonoperatively treated patients at long-term follow-up. *Arthrosc Sports Med Rehabil* 2023;5:e435-e444.
9. Logli AL, Bernard CD, O'Driscoll SW, et al. Osteochondritis dissecans lesions of the capitellum in overhead athletes: a review of current evidence and proposed treatment algorithm. *Curr Rev Musculoskelet Med* 2019;12:1-12.
10. Funakoshi T, Furushima K, Miyamoto A, Kusano H, Horiuchi Y, Itoh Y. Predictors of unsuccessful nonoperative management of capitellar osteochondritis dissecans. *Am J Sports Med* 2019;47:2691-2698.
11. Hennrikus WP, Miller PE, Micheli LJ, Waters PM, Bae DS. Internal fixation of unstable in situ osteochondritis dissecans lesions of the capitellum. *J Pediatr Orthop* 2014;35:467-473.
12. Logli AL, Leland DP, Bernard CD, et al. Capitellar osteochondritis dissecans lesions of the elbow: A systematic review of osteochondral graft reconstruction options. *Arthroscopy* 2020;36:1747-1764.
13. McLaughlin RJ, Leland DP, Bernard CD, et al. Both debridement and microfracture produce excellent results for osteochondritis dissecans lesions of the capitellum: A systematic review. *Arthrosc Sports Med Rehabil* 2021;3:e593-e603.
14. Ovesen J, Olsen BS, Johannsen HV. The clinical outcomes of mosaicplasty in the treatment of osteochondritis dissecans of the distal humeral capitellum of young athletes. *J Shoulder Elbow Surg* 2011;20:813-818.
15. Jones KJ, Wiesel BB, Sankar WN, Ganley TJ. Arthroscopic management of osteochondritis dissecans of the capitellum: Mid-term results in adolescent athletes. *J Pediatr Orthop* 2010;30:8-13.
16. Miyake J, Masatomi T. Arthroscopic debridement of the humeral capitellum for osteochondritis dissecans: Radiographic and clinical outcomes. *J Hand Surg* 2011;36:1333-1338.
17. Byrd JWT, Jones KS. Arthroscopic surgery for isolated capitellar osteochondritis dissecans in adolescent baseball players: Minimum three-year follow-up. *Am J Sports Med* 2002;30:474-478.

18. Beck JR, Pauker SG. The Markov process in medical prognosis. *Med Decis Making* 1983;3:419-458.
19. Gafni A, Birch S. Incremental cost-effectiveness ratios (ICERs): The silence of the lambda. *Soc Sci Med* 2006;62:2091-2100.
20. Neumann PJ, Cohen JT, Weinstein MC. Updating cost-effectiveness—The curious resilience of the $50,000-per-QALY threshold. *N Engl J Med* 2014;371:796-797.
21. Cohen DJ, Reynolds MR. Interpreting the results of cost-effectiveness studies. *J Am Coll Cardiol* 2008;52:2119-2126.
22. Sayani J, Plotkin T, Burchette DT, Phadnis J. Treatment strategies and outcomes for osteochondritis dissecans of the capitellum. *Am J Sports Med* 2021;49:4018-4029.
23. Doubilet P, Begg CB, Weinstein MC, Braun P, McNeil BJ. Probabilistic sensitivity analysis using Monte Carlo simulation. A practical approach. *Med Decis Making* 1985;5:157-177.
24. Briggs AH. Statistical approaches to handling uncertainty in health economic evaluation. *Eur J Gastroenterol Hepatol* 2004;16:551-561.
25. Dodd S, Bassi A, Bodger K, Williamson P. A comparison of multivariable regression models to analyse cost data. *J Eval Clin Pract* 2006;12:76-86.
26. Crall TS, Bishop JA, Guttman D, Kocher M, Bozic K, Lubowitz JH. Cost-effectiveness analysis of primary arthroscopic stabilization versus nonoperative treatment for first-time anterior glenohumeral dislocations. *Arthroscopy* 2012;28:1755-1765.
27. Sanders GD, Neumann PJ, Basu A, et al. Recommendations for conduct, methodological practices, and reporting of cost-effectiveness analyses: Second panel on cost-effectiveness in health and medicine. *JAMA* 2016;316:1093-1103.
28. Baumgarten TE, Andrews JR, Satterwhite YE. The arthroscopic classification and treatment of osteochondritis dissecans of the capitellum. *Am J Sports Med* 1998;26:520-523.
29. Bexkens R, Van Den Ende KIM, Ogink PT, Van Bergen CJA, Van Den Bekerom MPJ, Eygendaal D. Clinical outcome after arthroscopic debridement and microfracture for osteochondritis dissecans of the capitellum. *Am J Sports Med* 2017;45:2312-2318.
30. Rahusen FTG, Brinkman JM, Eygendaal D. Results of arthroscopic debridement for osteochondritis dissecans of the elbow. *Br J Sports Med* 2006;40:966-969.
31. Austin DC, Song B, Rojas Lievano JL, et al. Long-term patient-reported outcomes after arthroscopic debridement of grade 3 or 4 capitellar osteochondritis dissecans lesions. *Am J Sports Med* 2023;51:351-357.
32. Camp CL, Cancienne JM, Degen RM, Dines JS, Altchek DW, Werner BC. Factors that increase the risk of infection after elbow arthroscopy: Analysis of patient demographics, medical comorbidities, and steroid injections in 2,704 Medicare patients. *Arthroscopy* 2017;33:1175-1179.
33. Intravia J, Acevedo DC, Chung WLJ, Mirzayan R. Complications of elbow arthroscopy in a community-based practice. *Arthroscopy* 2020;36:1283-1290.
34. Werner BC, Fashandi AH, Chhabra AB, Deal DN. Effect of obesity on complication rate after elbow arthroscopy in a Medicare population. *Arthroscopy* 2016;32:453-457.
35. Shafrin J, May S, Skornicki M, et al. Use of net monetary benefit analysis to comprehensively understand the value of innovative treatments. *Value Health* 2016;19:A731.