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Appendix

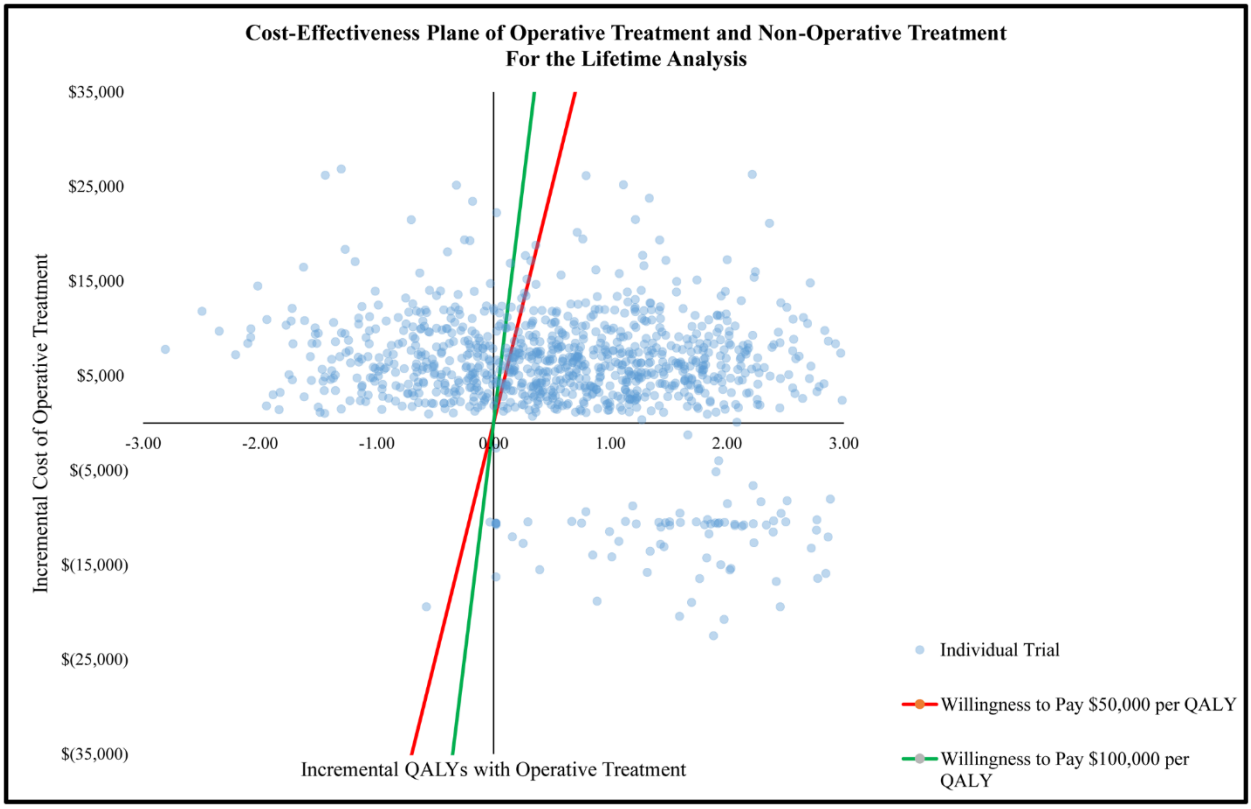

Fig. E-1

Cost-effectiveness plane for the lifetime analysis comparing operative and nonoperative treatment. In this analysis, the health utilities of operative and nonoperative treatment persist for the individual's lifetime. The x axis is the incremental QALYs with operative treatment, while the y axis is the incremental costs of operative treatment. The solid red and green lines are the willingness-to-pay thresholds of $50,000 per QALY and $100,000 per QALY, respectively. Data points to the right of these lines indicate that the particular trial is cost-effective according to the willingness-to-pay threshold. In the Monte Carlo simulation, 68.3% of the trials were to the right of the willingness-to-pay threshold of $50,000 per QALY. When the willingness-to-pay threshold was increased to $100,000 per QALY, 70.0% of the trials were to the right of this threshold.

TABLE E-1 Glossary of Common Terminology in Decision Analysis

Terminology	Explanation
Decision analytics	This is a popular discipline used in the financial, engineering, and project management fields to formally analyze important decisions. Decision analysis is especially useful in analyzing decisions with unknown variables and uncertainty in events. Predictive and prescriptive analytics have emerged from this discipline, using forecasting, optimization, and simulation techniques. Decision analytics in medicine is a growing field with techniques being utilized in cost-effectiveness studies.
Health utility	This is a common term used in health economics to reflect an individual's preference for different health outcomes. Most health utility scales range from 0 to 1 with 0 reflecting death and 1 reflecting perfect health. While there are different methods to calculate health utility, including the rating scale method, standard gamble method, and time trade-off method, most health economic evaluations use multi-attribute utility systems (MAUS). Examples of MAUS are the EuroQol-5D, Short Form-6D (which is calculated from the Short Form-12 or Short Form-36), and Health Utilities Index. Quality-adjusted life-years are calculated from this health utility by combining the utility value with the quantity of time in a health state.
Discount rate	This is a financial term used to capture the present value of future cash flows. The financial definition refers to the interest rate expected for a loan from a financial institution. The discount rate considers the time value of money as 1 dollar now being more valuable than 1 dollar in the future. In cost-effectiveness studies, the discount rate is used not only for monetary costs, but also for health utility. The discount rate used for health utility relies on the principle that a perfectly healthy year now is more valuable than a perfectly healthy year in the future.
Markov model	Also known as the Markov method. This is a stochastic method used to model transition states. The principle of Markov modeling depends only on the current state and not on the prior states. The probability of transitioning from 1 state to another state can vary according to a predetermined distribution. Markov modeling is often used in cost-effectiveness analyses to capture the value of different health states over time.
Monte Carlo simulation	Also known as the Monte Carlo method or Monte Carlo experiments. This is a computational algorithm that relies on repeated random sampling to obtain numerical results. This decision analytic tool is especially powerful when there are uncertain variables that can be modeled according to a distribution. This tool is often used in managing risk as it calculates not only the average value of each decision, but also the percentage of iterations in which a certain strategy is more valuable than another strategy.
Rollback analysis	Also known as foldback analysis. This is an iterative algorithm used to determine the value of each node. The terminal node is calculated first while working backward to the initial decision node. The value of each decision is calculated by using the weighted average of the probability of events and the value of each decision tree branch. This analysis is commonly used in decision analytics and game theory.
Strategy tables	This is a 2-way sensitivity analysis technique that shows how the optimal strategy changes in response to 2 simultaneously changing parameters. This is a particularly useful tool in decision analytics when there is uncertainty in the probability of events, value of an outcome, or cost of a decision.
Tornado chart	Also known as a tornado plot or tornado diagram. These diagrams are useful in sensitivity analysis, showing the importance of each variable in the decision model. The sensitive variable is modeled as an uncertain value, while other variables are held at baseline value. This shows how important this variable is in the decision model.

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TABLE E-2 Summary of Published Studies Used to Build the Decision Model

Study	Level of Evidence	Study Design	No. of Patients (Op./Nonop.)	Age Criteria *(yr)*	Plate Technique*	Nonop. Intervention
Canadian Orthopaedic Trauma Society[8], 2007	I	Prospective randomized	111 (62/49)	16-60	Superior	Sling
S Thyagarajan et al.[29], 2009	III	Retrospective cohort	34 (17/17)	None	NA	Sling
Kulshrestha et al.[10], 2011	II	Prospective cohort	68 (43/25)	20-50	Superior	Sling
Mirzatolooei[31], 2011	I	Prospective randomized	50 (26/24)	18-65	Superior	Sling
Virtanen et al.[13], 2012	I	Prospective randomized	51 (26/25)	18-70	Anterior	Sling
Robinson et al.[12], 2013	I	Prospective randomized	178 (86/92)	16-60	NA	Collar and cuff
Althausen et al.[18], 2013	III	Retrospective cohort	149 (66/83)	None	Superior	Sling or shoulder immobilizer
Jones et al.[27], 2014	II	Retrospective cohort	65 (24/41)	None	NA	NA
Khorami et al.[28], 2014	II	Prospective cohort	65 (35/30)	18-60	NA	Figure-of-8 bandage
Eden et al.[26], 2015	II	Prospective cohort	78 (41/37)	None	Superior	Rucksack bandage
van der Ven Denise et al.[14], 2015	II	Prospective cohort	78 (38/40)	16-70	Anterior	Sling
Melean et al.[30], 2015	I	Prospective randomized	76 (34/42)	>18	NA	Sling
Dhakad et al.[11], 2016	II	Prospective randomized	50 (25/25)	16-60	Superior	Figure-of-8 brace and sling
Naveen et al.[24], 2017	II	Prospective cohort	60 (30/30)	20-50	Superior	Figure-of-8 brace
Shetty et al.[25], 2017	II	Prospective randomized	30 (16/14)	20-50	NA	Clavicle brace and arm pouch
Woltz et al.[9], 2017	I	Prospective randomized	148 (83/65)	18-60	Mixed	Sling
Naimark et al.[37], 2016	III	Retrospective cohort	73 (op.)	18-70	Superior	None
van der Linde et al.[38], 2017	III	Retrospective cohort	101 (op.)	16-65	NA	None
Tutuhatunewa et al.[39], 2017	III	Retrospective cohort	278 (128/150)	18-65	NA	Sling or collar and cuff

*NA = not available.

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TABLE E-3 Health Utility Values for Nonoperative and Delayed Operative Treatment

Study	Health State	Time Frame *(yr)*	MAUS*	No. of Patients	MAUS Value*	Mapping Study to Convert to EQ-5D	Final Converted EQ-5D Value
Robinson et al.[12]	Nonop.	>1	SF-12	92	54.9 (SF-12 mental score), 52.9 (SF-12 physical score)	Sullivan and Ghushchyan (CLAD†)[40]	0.95
Woltz et al.[9]	Nonop.	<1	SF-36	74	54.9 (SF-36 mental score), 53.4 (SF-36 physical score)	Hanmer[41]	0.82
Woltz et al.[9]	Nonop.	>1	SF-36	74	52.2 (SF-36 mental score), 56.1 (SF-36 physical score)	Hanmer[41]	0.82
Tutuhatunewa et al.[39]	Nonop.	>1	EQ-5D	88	0.90	None	0.90
Canadian Orthopaedic Trauma Society[8]	Nonop.	<1	SF-6D	32	0.71	Brazier et al.[42]	0.67
Canadian Orthopaedic Trauma Society[8]	Nonop.	>1	SF-6D	31	0.84	Brazier et al.[42]	0.80
van der Linde et al.[38]	Delayed op.	>1	EQ-5D	25	0.83	None	0.83
Compiled value	Nonop.	<1		106			0.77
Compiled value	Nonop.	>1		285			0.88
Compiled value	Delayed op.	>1		25			0.83

*MAUS = multi-attribute utility system. †CLAD = censored least absolute deviations.

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TABLE E-4 Health Utility Values for Implant Removal

Study	Time Frame *(yr)*	MAUS*	No. of Patients	MAUS Value*	Mapping Study to Convert to EQ-5D	Final Converted EQ-5D Value
Tutuhatunewa et al.[39]	>1	EQ-5D	40	0.92	None	0.92
Naimark et al.[37]	>1	EQ-5D	11	0.78	None	0.78
Canadian Orthopaedic Trauma Society[8]	>1	SF-6D	5	0.75	Brazier et al.[42]	0.71
Compiled value	>1		56			0.87

*MAUS = multi-attribute utility system.

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TABLE E-5 Health Utility Values for Operative Treatment

							Implant Removal		
Study	Time Frame *(yr)*	MAUS*	No. of Patients	MAUS Value*	Mapping Study to Convert to EQ-5D	Converted EQ-5D Value	No.	EQ-5D Score	Final Converted EQ-5D Score
Robinson et al.[12]	>1	SF-12	86	56.6 (SF-12 mental score), 54.3 (SF-12 physical score)	Sullivan and Ghushchyan (CLAD†)[40]	0.97	10	0.87	0.98
Woltz et al.[9]	<1	SF-36	86	53.6 (SF-36 mental score), 53.5 (SF-36 physical score)	Hanmer[41]	0.86	14	0.87	0.84
Woltz et al.[9]	>1	SF-36	86	52.6 (SF-36 mental score), 55.2 (SF-36 physical score)	Hanmer[41]	0.86	14	0.87	0.84
Naimark et al.[37]	>1	EQ-5D	61	0.91	None	‡	‡	‡	0.91
van der Linde et al.[38]	>1	EQ-5D	101	0.89	None	0.89	62	0.87	0.93
Tutuhatunewa et al.[39]	>1	EQ-5D	81	0.91	None	‡	‡	‡	0.91
Canadian Orthopaedic Trauma Society[8]	<1	SF-6D	47	0.76	Brazier et al.[42]	‡	‡	‡	0.72
Canadian Orthopaedic Trauma Society[8]	>1	SF-6D	52	0.86	Brazier et al.[42]	‡	‡	‡	0.81

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Compiled value	<1 yr		133						0.80
Compiled value	>1 yr		467						0.91

*MAUS = multi-attribute utility system. Since several studies combined the MAUS score for implant removal and successful operative treatment, we used a correction factor for the health utility of implant removal to correct for this discrepancy. †CLAD = censored least absolute deviations. ‡The study had separate health utility values for implant removal and successful operative treatment.

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TABLE E-6 Societal Costs of Nonoperative and Delayed Operative Treatment

	Nonop. Treatment		Delayed Operative Treatment			Nonop. and Delayed Op. Treatment		
Median Weekly Income per Bureau of Labor Statistics	Fracture Billing	Avg. No. of Work Weeks Missed	% of Patients	Health-Care Costs	Avg. No. of Work Weeks Missed	Combined Health-Care Costs	Combined Loss of Wages	Total Societal Cost of Nonop. Treatment
$849	$227	12.2	9.3	$9,414	10.2	$1,229	$11,147	$12,377

Table E-7 Societal Costs of Operative Treatment

Health-Care Costs of Op. Treatment and Complications from Op. Treatment	Avg. No. of Work Weeks Missed with Op. Treatment	Median Weekly Salary per Bureau of Labor Statistics	Combined Loss of Wages with Op. Treatment and Complications from Op. Treatment	Total Societal Cost of Op. Treatment
$8,568	10.2	$849	$8,852	$17,420