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Cost-Effectiveness Analysis for Implants of Knee Replacement Surgery in the UK: Discrete-Time Cohort Markov Economic Model

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Objective and background

- Objective: Identify the most cost-effective prosthetic knee implant for total knee replacement (TKR) patients of different age and sex strata, using a Markov mode-based cost-effectiveness analysis of 12 knee implant types.
- Prices of TKR implants vary widely.
- Implant types are defined by key features: fixation to the bone (cemented, uncemented or hybrid), constraint (cruciate-retaining vs posterior-stabilized), bearing materials (metal-on-polyethylene and oxinium coated), and bearing mobility (fixed vs mobile).
- Cemented, cruciate retaining, metal-on-polyethylene, fixed bearing implant constructs are the most common, but it is not known which combination is most cost-effective.

Results

- No evidence that any implant is better than the cemented, cruciate-retaining, metal-on-polyethylene, fixed construct implant (MoP Cem CR_Fix) in any age or gender cohort.
- The second most cost-effective implant is the posterior-stabilized version for all patients except men aged 75-84.
- Top three implant types have all similar costs and QALY gains and overlapping credible intervals, with not much differentiating between them.
- High uncertainty, all implants having low probabilities of being the most cost-effective choice.
- In females 65-74 years old, uncertainty in mid-term revision rates have greatest impact on the decision, with highest EVPPI (up to £38 million).

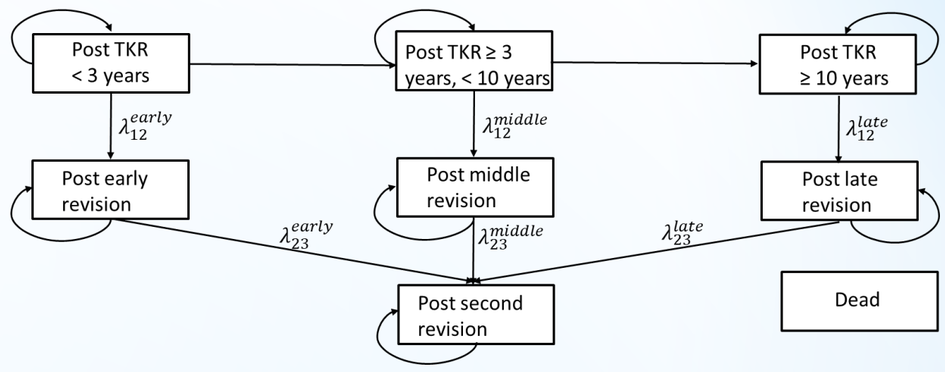
EVPPI results for female 55-64

Parameters	Per person (£)	Population (£)
Total	1 315	231 440 969
1st revision probabilities <3	88	15 539 592
1st revision probabilities 3-10	217	38 261 027
1st revision probabilities >10	106	18 668 877
2nd and higher revision probabilities	18	3 111 444
primary utilities	0	0
revision utilities	2	346 022

Methods

Model structure

- We conducted a Markov model using tunnel states to model outcomes after total knee replacement.



- We stratified the population into adult male and females aged ≤55, 55-64, 65-74, 75-84, and 85+ years old.
- This economic evaluation model had a cycle length of one year and a life-time horizon up to 100 years old, with 3.5% discount rate to reflect societal time preferences.
- The model was fully probabilistic, and 1000 samples were simulated to ensure stability of results.

Statistical analysis

Transition probabilities

- Transition probabilities were based on estimated using data from the National Joint Registry (NJR) from 2017 to 2018. (e.g. The largest group, female patients aged 65-74, has 243,479 patients, and the smallest group, male patients aged 85+, has 17,363 patients.)
- Mortality rate: depends on both current time as it will increase with age as in the Office of National Statisticians' life tables, and death directly from surgery.

Costs

- Implant costs from NJR price benchmark database (2019 prices).
- NHS 2020 reference costs to estimate the total cost of revision surgery.

QALYs

- Freely available anonymized individual patient utility values reported in the finalised Patient Reported Outcome Measures (PROMS) database for the last 5 years (2016-2020). Used PROMS casemix adjustment.
- Combined the utility and disutility of revision.

Expected Value of Partial Perfect Information (EVPPI)

- We estimated per population and per person EVPPI using gaussian process regression to measure the decision uncertainty associated with imperfect information in sets of input parameters
- The parameters chosen for EVPPI are first revision probabilities, second and higher revision probabilities and utilities.
- In 2019/20, for reasons of osteoarthritis, there are 92,185 primary total joint surgery surgeries from the NJR.
- EVPPIs for each patient groups were estimated over a 10 year technology horizon.

Implants with 1st and 2nd highest net monetary benefit (NMB) with 95% credible intervals

Gender	Age	1st highest NMB	NMB (£GBP)	2nd highest NMB	NMB (£GBP)
Female	0-55	MoP Cem CR_Fix	234 165 (217 647, 245 314)	MoP Cem PS_Fix	228 861 (2e+05, 244 156)
	55-64	MoP Cem CR_Fix	214 955 (209 029, 220 617)	MoP Cem PS_Fix	212 849 (2e+05, 219 249)
	65-74	MoP Cem CR_Fix	83 162 (-1 374, 170 965)	MoP Cem PS_Fix	82 536 (-1 531, 169 670)
	75-84	MoP Cem CR_Fix	111 715 (108 856, 114 475)	MoP Cem PS_Fix	111 315 (108 391, 114 218)
	85+	MoP Cem CR_Fix	28 005 (-1 408, 58 149)	MoP Cem PS_Fix	27 867 (-1 507, 58 007)
Male	0-55	MoP Cem CR_Fix	231 560 (212 176, 243 744)	MoP Cem PS_Fix	220 997 (182 718, 240 466)
	55-64	MoP Cem CR_Fix	213 539 (207 739, 219 151)	MoP Cem PS_Fix	210 895 (2e+05, 217 838)
	65-74	MoP Cem CR_Fix	166 397 (162 102, 170 238)	MoP Cem PS_Fix	164 885 (160 590, 169 152)
	75-84	MoP Cem CR_Fix	111 399 (108 709, 114 208)	MoP Cem CR_Fix Mono	111 040 (106 227, 114 696)
	85+	MoP Cem CR_Fix	56 512 (54 774, 58 100)	MoP Cem PS_Fix	56 289 (53 847, 58 127)

* MoP: Metal bearings on conventional or highly cross-linked polyethylene trays; OX: oxinium, CR: cruciate retaining; PS: posterior stabilized, Cem: cemented, Unc: uncemented, Mob: mobile, Mono: monobloc (all others are modular).

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Conclusions

- Most implant constructs have similar cost and QALY profiles, with no evidence that any are better than the most common combination in the UK (the cemented, cruciate retaining, metal-on-polyethylene, fixed implant).
- Uncertainty about the probability of patients having the first revision after 10 years has a very significant impact on decision-making and could represent a valuable target for further research.

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