Survivorship of modern total hip replacement to 30 years: systematic review, meta-analysis, and extrapolation of global joint registry data

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Summary

Background Total hip replacement is a successful operation that aims to restore function and quality of life to millions of people globally. Knowing how long a total hip replacement might last is important for patients, surgeons, and health-care institutions for planning and resource allocation. Over the past 20 years, the use of contemporary bearing surfaces for total hip replacement has substantially altered implant wear and, possibly, longevity. To date, there has been no large-scale study that examines survivorship of these modern implants. We aimed to determine the survivorship of contemporary total hip replacements and bearing materials.

Methods We focused solely on the assessment of modern bearing surfaces: highly cross-linked polyethylene versus metal or third-generation and fourth-generation ceramic heads and ceramic-on-ceramic primary total hip replacement in adult patients. We conducted a search of MEDLINE and Embase from database inception to June 13, 2024, including articles that reported a minimum of 10 years of survivorship, irrespective of fixation method or surgical approach. We then conducted a meta-analysis combining data from eight national joint registries assessing all-cause revision within the various bearing combinations. We extrapolated the extracted data to estimate survivorship to 30 years, using the multivariable random-effects model from the registry data. The primary outcome was survivorship of the hip replacement, defined as time from primary total hip replacement to first all-cause revision, expressed as a percentage of unrevised implants at specific timepoints. This study is registered with PROSPERO (CRD42024572518).

Findings We identified 1 904 237 total hip arthroplasties across 29 clinical studies (n=5203) and eight national joint registries (n=1 899 034). Pooled analysis of the included studies showed an all-cause implant survivorship of 0·97 (0·96–0·98) under the random-effects model. Survivorship estimate based on joint registry data was at 93·6% (95% CI 92·3–94·7) at 20 years. Extrapolating these data indicates a predicted survivorship of 92·8% (91·2–94·2) at 25 years and 92·1% (90·1– 93·7) at 30 years.

Interpretation The estimated 92% 30-year survivorship of contemporary total hip replacement suggests that advances in bearing surface technology have greatly improved the long-term durability of total hip replacements and might influence patient counselling, health-care planning, and device regulation.

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Introduction

Total hip replacement remains an increasingly performed,[1] cost-effective,[2,3] and clinically successful operation.[4] With the increasing incidence of total hip replacement in younger patients and the increasing lifespan in the global population,[5,6] the longevity of the implants is even more important in clinical decision making. A frequently asked and pertinent question in orthopaedic clinics around the world is: how long will my new hip replacement last? For patients, there is often anxiety about the need and timing for revision surgery, and this information is an important part of a shared decision-making process. For health-care funders, there is also a necessity for provision planning. Compared with primary total hip arthroplasty, revision surgery has a higher risk of complications, has inferior patient-reported outcomes,[7,8] and is considerably more expensive.[7,8] Therefore, avoiding revision surgery is important for patients, as well as government bodies. Answering this question is currently aided by a 2019 study from Evans and colleagues.[9] Although this article remains the gold standard for many surgeons and despite it having been published relatively recently, it had one major limitation: it relied on data from older prostheses that are largely no longer in use.

When examining factors for revision as per the 2024 report from the National Joint Registry (for England,

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See Online for appendix

Research in context

Evidence before this study

A 2019 *Lancet* publication by Evans and colleagues provides the most widely cited estimates of long-term survivorship for total hip replacements, reporting that 57·9% of implants lasted 25 years. The study synthesised evidence from national joint registries and published literature, but was limited by the inclusion of outdated bearing surfaces, such as conventional ultra-high molecular weight polyethylene and early generation ceramics. These older materials are no longer in routine clinical use due to high wear rates and risk of fracture.

We reviewed existing evidence through a search of MEDLINE and Embase from database inception to June 13, 2024, to identify studies reporting total hip replacement survivorship with contemporary bearing surfaces—specifically highly crosslinked polyethylene (XLPE) and third-generation or fourth-generation ceramics. We used search terms such as "arthroplasty", "highly cross linked polyethylene", and "survival analysis" (appendix p 1). Although individual registries have reported long-term outcomes with modern materials, no previous study has combined meta-analysed clinical data with multiple national registry datasets to model implant survivorship using these bearing surfaces. Moreover, previous lifetime risk models, such as those by Bayliss and colleagues, were also based on historical implant technologies. Although registries had begun to report improved outcomes with XLPE, these trends had not been systematically quantified or extrapolated beyond 20 years. There was a clear need to update implant survivorship estimates using modern materials reflective of current global practice.

Added value of this study

This study is the first to comprehensively estimate implant survivorship using contemporary bearing surfaces—XLPE and third-generation or fourth-generation ceramics—by combining datasets from eight national joint registries (n=1 899 034 hip arthroplasties) with a systematic review and meta-analysis of published clinical studies (n=5203 hip arthroplasties). We provide updated, long-term survivorship estimates at 10 years, 15 years, 20 years, 25 years, and 30 years. Across all bearing combinations, average survivorship exceeded 92% at 30 years. In contrast to previous studies, our findings focus on implants and tribological materials currently in widespread clinical use, thereby offering a more clinically relevant and contemporary answer to the question frequently asked by patients: how long will a modern hip replacement last?

Implications of all the available evidence

Combined with previous evidence, our findings suggest that advances in bearing surface technology have substantially improved the long-term durability of total hip replacements. Revision rates have declined, and exceeds implant survivorship exceeds 92% at 20 years and a predicted 92% at 30 years. These findings have important implications for patient counselling, informed consent, and shared decision making. For policy makers and health-care systems, the projected decline in revision burden might support the strategic centralisation of revision surgery at high-volume centres while focusing resources on expanding access to primary total hip replacement. Although our study provides population-level estimates of implant survivorship, individual patient risk profiles—including age, sex, comorbidity, and implant selection—remain key determinants of clinical outcome. In this context, our findings also support revisiting lifetime revision risk models, such as those proposed by Bayliss and colleagues, using contemporary implants to guide more accurate clinical and policy forecasting.

Wales, and Northern Ireland), aseptic loosening accounted for 45% of all revision arthroplasties.[10,11] Aseptic loosening largely occurs as a result of particulate debris from wear of bearing surfaces, typically the acetabular polyethylene liner. The particulate debris stimulates an inflammatory cascade resulting in osteolysis and subsequent implant loosening.[12] This occurrence was historically common due to the use of traditional ultra-high molecular weight polyethylene (UHMWPE) as acetabular liners or cups. However, in 1998, a newer highly crosslinked polyethylene (XLPE) was launched into the market[13,14] and widely adopted as standard care worldwide by 2008.[15] The wear rate of XLPE is up to five times less than that of UHMWPE, and in a randomised controlled trial (RCT) with 10-year follow-up, there were no cases of secondary osteolysis.[14,15] This change is reflected in the 2024 National Joint Registry report,[11] which shows that the proportion of single-stage hip revisions attributed to aseptic loosening has decreased over time from 45·4% across the entire registry period (2003–23) to 35·9% over the past 5 years (2019–23).

For surgeons who were concerned by particulate-instigated osteolysis, there was also the option of ceramic-on-ceramic bearings. Early generation ceramics had risks of implant fracture due to brittleness (>13%).[16,17] Technological advances have evolved to make third-generation and fourth-generation ceramic bearings surfaces with significantly lower fracture rates than early generation ceramics.[18]

In view of these advances in tribology, we felt that it was important to provide an update to Evans and colleagues[9] article, to establish the survivorship of contemporary total hip replacements and bearing materials.

Methods

Study design

We conducted a systematic review of the literature and a meta-analysis of data from global joint registries. This study was designed in accordance with the 2019 *Lancet* Article by Evans and colleagues[9] and compared survivorship of XLPE total hip replacements with metal or ceramic heads, and also third-generation and fourth-generation ceramic-on-ceramic combinations. Data were synthesised in three phases: (1) a systematic review and meta-analysis of published literature; (2) a meta-analysis of national joint registry data; and (3) model-based extrapolation to estimate implant survivorship at 25 years and 30 years.

Search strategy and selection criteria

A systematic search of MEDLINE and Embase was conducted from database inception to June 13, 2024, to identify RCTs, cohort studies, and case-series reporting implant survivorship in patients undergoing primary total hip replacement with contemporary bearing surfaces. The search strategy included keywords and medical subject headings terms such as "arthroplasty", "highly cross linked polyethylene", and "survival analysis" (see appendix p 1 for a complete list of search terms).

Eligible studies reported outcomes on primary hip replacement with a minimum of 10 years of follow-up for at least one of the following bearing combinations: ceramic-on-ceramic (third-generation alumina or fourth-generation alumina-zirconia), ceramic-on-XLPE, or metal-on-XLPE. Studies were included irrespective of fixation method or surgical approach. Exclusion criteria comprised revision surgery, registry-based analyses, and review articles. Conference abstracts were excluded due to insufficient data granularity. Duplicate datasets were removed by selecting the most recent or comprehensive publication. The bearing type was exclusively single bearing (excluding dual mobility and constrained articulation constructs). All study designs were included if they met inclusion criteria due to the scarcity of long-term data (particularly beyond 20 years).

Two reviewers (VP and ZT) independently screened titles, abstracts, and full texts using Covidence. Disagreements were resolved by consensus and with the aid of a senior author (AA). Full-text articles were obtained when possible; otherwise, study authors were contacted by email. The review protocol was registered with PROSPERO (CRD42024572518) and conducted following protocol in accordance with PRISMA guidelines[19] and the Cochrane Handbook.[20]

Data extraction and quality review

A standardised data extraction form was used to collect study characteristics and outcome data. Extracted variables included number of hips, implant bearing type, follow-up duration, and survivorship estimates with 95% CIs. Additional information, when available, included patient demographics, implant brand, fixation technique, surgical indication, and osteolysis rates. Weighted means were used to summarise patient characteristics.

All studies included in the systematic review were assessed with the JBI study-specific critical appraisal tools for cohort studies,[21] RCTs,[22] and case-series.[23] Quality assessment was completed independently by two reviewers (VP and ZT) and disagreements were resolved by consensus and the senior author (AA).

Data were sourced from eight joint registries, with a minimum of 10 years of follow-up for total hip replacement: the Australian Orthopaedic Association National Joint Replacement Registry; Canadian Joint Replacement Registry; Danish Hip Arthroplasty Register; Finnish Arthroplasty Register; National Joint Registry of England, Northern Ireland, and Wales; Norwegian Arthroplasty Register; Swedish Arthroplasty Register; and Kaiser Permanente National Total Joint Replacement Registry (CA, USA). National joint registry data were collected from either (1) previously published annual reports[24] where available (the Australian Joint Replacement Registry); (2) data repurposed from a previously published joint registry study (National Joint Registry);[25] or (3) bespoke data request from the joint registries (six registries).

Statistical analysis

The primary outcome of the study was the survivorship of the hip replacement. Survivorship was defined as the time from primary total hip replacement to the first all-cause revision, expressed as a percentage of unrevised implants at specific timepoints (eg, 10 years, 15 years, and 20 years). All-cause revision included removal, exchange, or addition of a new prosthetic component for any reason—infection, dislocation, fracture, aseptic loosening, or other reasons. For the meta-analysis of published cases, the survival estimates were pooled assuming that survivorship was approximated as a binary event for each timepoint, with each study weighted by the standard error of its survival estimate, as in standard fixed or common effects. For the meta-analysis of the joint registry data, we used a multivariable random-effects model on ln(-ln) transformation for the survivorship rate[26] with bearing surface and log-transformed survival year as fixed effects and random intercept by studies; details of the models are provided in the appendix (pp 8–9). Both transformations yielded unrestricted (ie, real-valued) ranges, therefore facilitating efficient fit of the model to the large datasets used in this analysis. This model represents our baseline analysis and effectively assumes that survivorship correlates across time within a study and bearing surface. Statistical clustering was accounted for at the country level and was not extended to the individual level. Additional sensitivity analyses explored the potential non-linear trend of survivorship over time and its potential interaction with bearing materials, considering linear and quadratic terms of survival time and its interaction with bearing materials. Of these models, the best fit model was selected using the Akaike information criterion.[27] The standard errors in both meta-analyses were derived from the published 95% CIs assuming normal distribution.

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	Australian Orthopaedic Association National Joint Replacement Registry (N=484 881)	Canadian Joint Replacement Registry (N=157 111)	Danish Hip Arthroplasty Register (N=115 418)	Finnish Arthroplasty Register (N=97 867)	Kaiser Permanente National Total Joint Replacement Registry (N=137 267)	National Joint Registry for England, Wales, and Northern Ireland (N=642 269)	Norwegian Arthroplasty Register (N=55 035)	Swedish Arthroplasty Register (N=209 186)	Meta-analysis of included studies (N=5203)	Total (N=1 904 237)
Age (95% CI)	67·8*	..	67·7 (11·27)	67·7*	66·6 (32·13)	66·60 (8·18)	64·40 (11·97)	67·80 (4·67)	53·6*†	67·1*†
Sex										
Female	266 685 (55·0%)	78 556 (50·0%)	64 401 (55·8%)	55 784 (57·0%)	79 334 (57·8%)	378 095 (58·9%)	33 021 (60·0%)	209 186 (57·4%)	2581 (49·6%)	1 061 660 (55·7%)
Male	218 186 (45%)	78 555 (50%)	51 017 (44·2%)	42 083 (43·0%)	57 933 (42·2%)	264 174 (41·1%)	22 014 (40·0%)	89 112 (42·6%)	2622 (50·4%)	842 577 (44·3%)
Participants who have osteoarthritis listed as primary indication for surgery	426 696 (88·0%)	108 878 (69·3%)	99 259 (86·0%)	84 166 (86·0%)	130 677 (95·2%)	586 792 (91·3%)	43 203 (78·5%)	3555 (84·0%)	1 412 944 (68·3%)	1 412 944 (74·2%)

Data are mean (SD) or n (%). *SD not available. †The weighted average by sample size was reported for the meta-analysis study and total.

Table 1: **Demographic characteristics of contributing national joint registries**

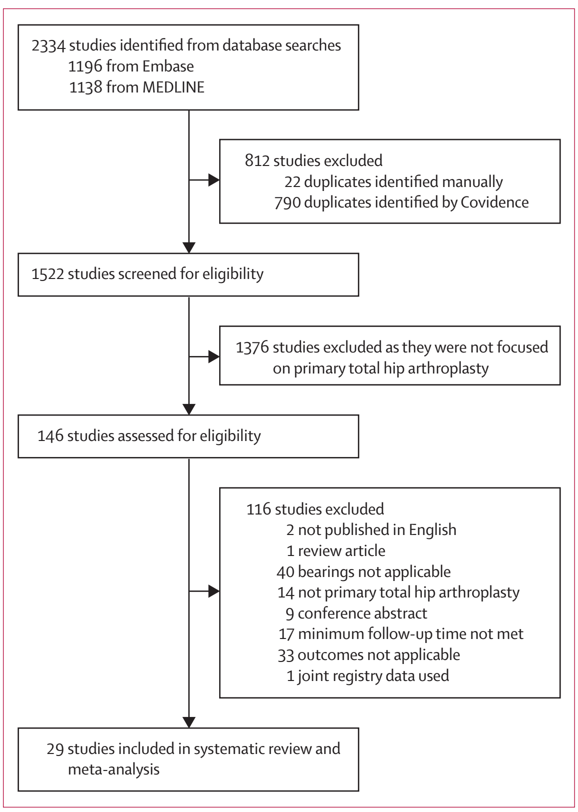

Figure 1: **PRISMA diagram of studies included in systematic review and meta-analysis**

Model-based extrapolation

To explore long-term survival of the hip replacement by bearing surface, survivorship was extrapolated to 25 years and 30 years using the multivariable random-effects model from the registry data. All the statistical analyses were conducted using R (version 4.4.2), meta[28] (version 8.0-2), and metafor[29] (version 4.8-0). Details of the statistical methods underlying the extrapolation can be found in the appendix (pp 8–9).

Role of the funding source

There was no funding source for this study.

Results

We identified 1 904 237 total hip arthroplasties across eight national joint registries (n=1 899 034) and 29 clinical studies (n=5203). Our study population represents total hip replacements completed in 18 countries across four continents. Table 1 summarises the demographic characteristics of the populations included in this study.

The systematic database searches yielded 2334 articles. After removing 812 duplicates, we screened 1522 studies, and 29 studies[30–57] met our inclusion criteria. Figure 1 illustrates the details of our study selection process and reasons for exclusion.

A total of 5203 total hip arthroplasties were included across nine RCTs,[15,30,31–37] ten cohort studies,[38–47] and ten case series.[48–57] 19 studies[15,31–34,36,38,40–48,52,53,56] (n=4755) reported a minimum follow-up of 10 years, seven studies[30,37,39,49–51,57] (n=1333) reported a minimum follow-up of 15 years, and three studies[53,54,55] (n=186) reported a follow-up of 15–20 years.

The quality of the included studies was moderate to high with case-series on average the highest quality and cohort studies the lowest quality, with scores typically decreasing as a result of not discussing confounding variables. The JBI Quality Assessment Tool results are illustrated in the appendix (p 2).

Figure 2 illustrates the pooled implant survivorship across the included studies at 10 years, 15 years, and

	Survivorship	Total	Events (95% CI)
10 years' follow-up			
Atrey et al (2017)[15]	34	34	100·00 (89·72–100·00)
Atrey et al (2017)[15]	31	32	96·88 (83·78–99·92)
Beaupre et al (2016)[31]	43	43	100·00 (91·78–100·00)
Beaupre et al (2016)[31]	40	43	93·02 (80·94–98·54)
Bonutti et al (2018)[48]	105	107	98·13 (93·41–99·77)
Blumenfeld et al (2022)[38]	102	104	98·08 (93·23–99·77)
Blumenfeld et al (2022)[38]	76	81	93·83 (86·18–97·97)
Broomfield et al (2017)[32]	11	11	100·00 (71·51–100·00)
D'Antonio et al (2012)[40]	71	73	97·26 (90·45–99·67)
D'Antonio et al (2012)[40]	68	71	95·77 (88·14–99·12)
Devane et al (2017)[33]	56	57	98·25 (90·61–99·96)
El-Sahoury et al (2023)[34]	92	92	100·00 (96·07–100·00)
Epinette et al (2014)[41]	112	120	93·33 (87·29–97·08)
Epinette et al (2014)[41]	161	163	98·77 (95·64–99·85)
Glyn-Jones et al (2015)[36]	20	20	100·00 (83·16–100·00)
Higuchi et al (2016)[42]	66	67	98·51 (91·96–99·96)
Higuchi et al (2016)[42]	78	81	96·30 (89·56–99·23)
Lachiewicz et al (2016)[43]	110	112	98·21 (93·70–99·78)
Naito et al (2021)[52]	90	93	96·77 (90·86–99·33)
Niu et al (2023)[53]	1064	1083	98·25 (97·27–98·94)
Park et al (2024)[44]	702	716	98·04 (96·74–98·93)
Park et al (2023)[44]	283	288	98·26 (96·00–99·43)
Taniguchi et al (2021)[45]	30	33	90·91 (75·67–98·08)
Taniguchi et al (2021)[45]	26	29	89·66 (72·65–97·81)
Tsukamoto et al (2017)[46]	41	41	100·00 (91·40–100·00)
Yoo et al (2019)[47]	88	90	97·78 (92·20–99·73)
Common-effect model		**3684**	**97·72 (97·18–98·16)**
Random-effects model			**97·58 (96·79–98·18)**
Heterogeneity I^2=23·4%, p=0·1408			
15 years' follow-up			
Atrey et al (2018)[30]	25	29	86·21 (68·34–96·11)
Bryan et al (2019)[39]	167	180	92·78 (87·97–96·10)
Tsukada et al (2022)[57]	65	70	92·86 (84·11–97·64)
Chatelet et al (2021)[49]	343	357	96·08 (93·51–97·84)
Coulomb et al (2022)[50]	115	125	92·00 (85·78–96·10)
Hopper et al (2018)[37]	111	116	95·69 (90·23–98·59)
Kim et al (2022)[51]	442	456	96·93 (94·90–98·31)
Common-effect model		**1333**	**95·12 (93·83–96·16)**
Random-effects model			**94·69 (92·52–96·26)**
Heterogeneity I^2=55%, p=0·0380			
20 years' follow-up			
García-Rey et al (2022)[35]	34	36	94·44 (81·34–99·32)
Orita et al (2022)[54]	32	33	96·97 (84·24–99·92)
Orita et al (2023)[55]	116	117	99·15 (95·33–99·98)
Common-effect model		**186**	**97·85 (94·41–99·19)**
Random-effects model			**97·85 (94·41–99·19)**
Heterogeneity I^2=16·6%, p=0·3014			
Common-effect model		**5203**	**97·06 (96·56–97·49)**
Random-effects model			**96·94 (96·05–97·64)**
Heterogeneity I^2=44·9%, p=0·0022			
Test for subgroup differences (common effect): χ^2_2=22·45, df=2 (p<0·0001)			
Test for subgroup differences (random effects): χ^2_2=12·40, df=2 (p=0·0020)			

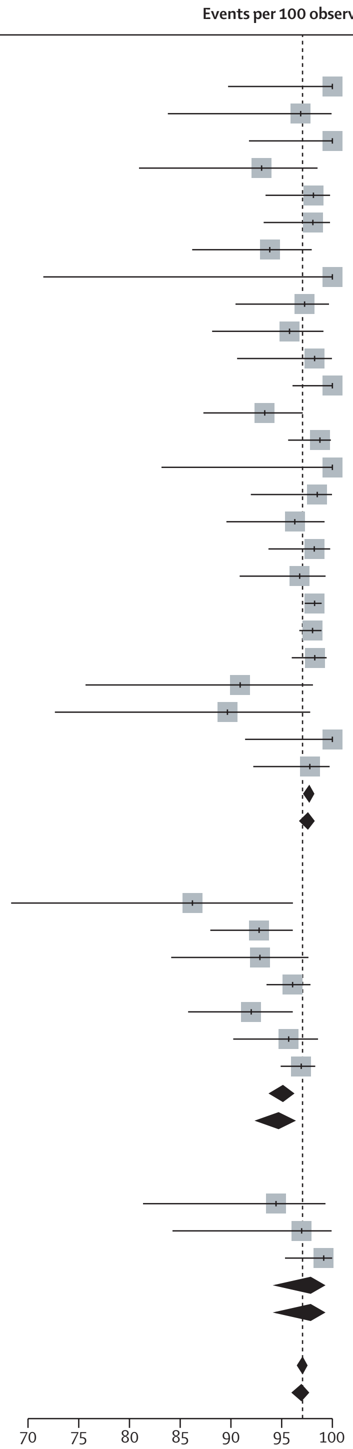

***Figure 2:* Forest plot of included studies showing Kaplan–Meier survivorship estimates (0–100%) of total hip replacement at 10 years, 15 years, and 20 years of follow-up**

Studies with multiple groups are presented and modelled separately.

20 years of follow-up. Pooled analysis of the included studies showed an all-cause implant survivorship of 0·97 (95% CI 0·97–0·97) under the fixed-effects model and 0·97 (0·96–0·98) under the random-effects model. The included studies had considerable implant heterogeneity, incorporating a range of manufacturers

	Survivorship	Total	Events (95% CI)
Metal-on-XLPE			
Atrey et al (2018)[30]	25	29	86·21 (68·34–96·11)
García-Rey et al (2022)[35]	34	36	94·44 (81·34–99·32)
Bryan et al (2019)[39]	167	180	92·78 (87·97–96·10)
Atrey et al (2017)[15]	31	32	96·88 (83·78–99·92)
Bonutti et al (2018)[48]	105	107	98·13 (93·41–99·77)
Broomfield et al (2017)[32]	11	11	100·00 (71·51–100·00)
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El-Sahoury et al (2023)[34]	92	92	100·00 (96·07–100·00)
Glyn-Jones et al (2015)[36]	20	20	100·00 (83·16–100·00)
Higuchi et al (2016)[42]	78	81	96·30 (89·56–99·23)
Hopper et al (2018)[37]	111	116	95·69 (90·23–98·59)
Lachiewicz et al (2016)[43]	110	112	98·21 (93·70–99·78)
Tsukamoto et al (2017)[46]	41	41	100·00 (91·40–100·00)
Common-effect model		**914**	**96·39 (94·96–97·42)**
Random-effects model			**97·14 (94·82–98·44)**
Heterogeneity I^2=0·7%, p=0·4386			
Ceramic-on-XLPE			
Orita et al (2022)[54]	32	33	96·97 (84·24–99·92)
Beaupre et al (2016)[31]	40	43	93·02 (80·94–98·54)
Epinette et al (2014)[41]	112	120	93·33 (87·29–97·08)
Orita et al (2023)[55]	116	117	99·15 (95·33–99·98)
Naito et al (2021)[52]	90	93	96·77 (90·86–99·33)
Common-effect model		**406**	**96·06 (93·66–97·57)**
Random-effects model			**96·29 (93·01–98·06)**
Heterogeneity I^2=22·4%, p=0·2720			
Ceramic-on-ceramic			
Tsukada et al (2022)[57]	65	70	92·86 (84·11–97·64)
Atrey et al (2017)[15]	34	34	100·00 (89·72–100·00)
Beaupre et al (2016)[31]	43	43	100·00 (91·78–100·00)
Blumenfeld et al (2022)[38]	102	104	98·08 (93·23–99·77)
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Higuchi et al (2016)[42]	66	67	98·51 (91·96–99·96)
Kim et al (2022)[51]	442	456	96·93 (94·90–98·31)
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Taniguchi et al (2021)[45]	30	33	90·91 (75·67–98·08)
Taniguchi et al (2021)[45]	26	29	89·66 (72·65–97·81)
Yoo et al (2019)[47]	88	90	97·78 (92·20–99·73)
Common-effect model		**3883**	**97·32 (96·76–97·79)**
Random-effects model			**97·05 (95·97–97·85)**
Heterogeneity I^2=55·7%, p=0·0022			
Common-effect model		**5203**	**97·06 (96·56–97·49)**
Random-effects model			**96·94 (96·05–97·64)**
Heterogeneity I^2=44·9%, p=0·0022			
Test for subgroup differences (common effect): χ^2_2=3·76, df=2 (p<0·1526)			
Test for subgroup differences (random effects): χ^2_2=0·44, df=2 (p=0·8015)			

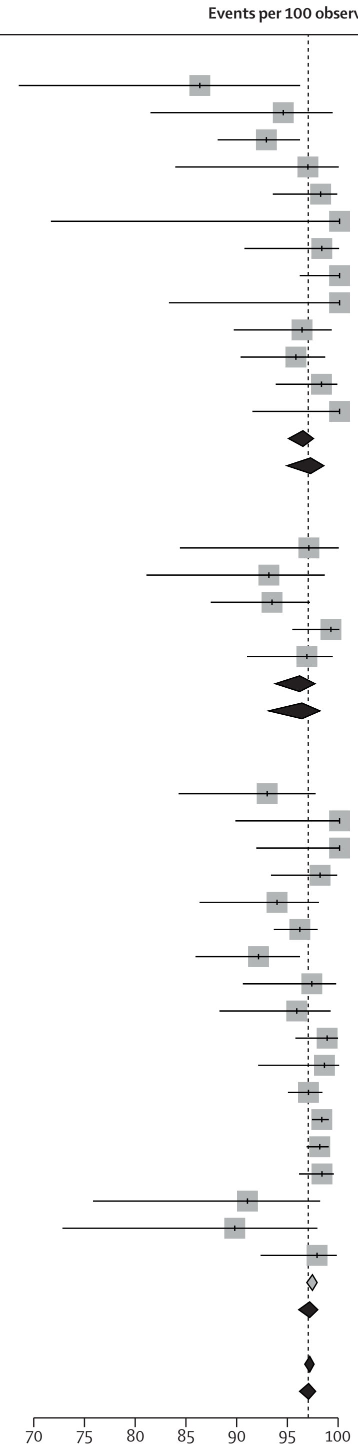

***Figure 3*: Forest plot of included studies showing Kaplan–Meier survivorship estimates (0–100%) of total hip replacement by implant bearing materials**
Studies with multiple groups are presented and modelled separately. XLPE=crosslinked polyethylene.

	Australian Orthopaedic Association National Joint Replacement Registry	Canadian Joint Replacement Registry*	Danish Hip Arthroplasty Register	Finnish Arthroplasty Register	Kaiser Permanente National Total Joint Replacement Registry	National Joint Registry for England, Wales, and Northern Ireland	Norwegian Arthroplasty Register	Swedish Arthroplasty Register
Ceramic-on-ceramic								
10 years (95% CI)	95·3 (95·1–95·4)	..	94·0 (93·3–94·7)	97·1 (99·0–99·0)	92·0 (89·4–94·2)	95·9 (95·8–96·0)	94·6 (94·0–95·1)	93·2 (91·3–95·1)
15 years (95% CI)	93·2 (93·0–93·5)	..	91·8 (90·9–92·7)	96·7 (99·0–99·0)	90·2 (87·1–92·8)	94·7 (94·5–94·9)	92·2 (93·0–91·4)	89·6 (87·0–92·2)
20 years (95% CI)	90·9 (90·4–91·3)	..	90·4 (89·2–91·5)	..	85·9 (80·7–90·4)	94·5 (94·0–94·8)	89·8 (88·6–90·9)	..
N	110 883	4301	4742	12 580	558	147 160	6442	863
Ceramic-on-XLPE								
10 years (95% CI)	96·0 (95·8–96·1)	..	93·8 (93·2–94·3)	93·3 (99·1–99·1)	97·0 (96·8–97·2)	97·6 (97·5–97·7)	94·0 (93·6–94·5)	96·3 (96·6–96·0)
15 years (95% CI)	94·5 (94·2–94·8)	..	91·8 (91·1–92·5)	93·2 (99·1–99·1)	95·9 (95·4–96·3)	97·1 (96·9–97·4)	92·5 (91·8–93·2)	94·3 (93·4–95·2)
20 years (95% CI)	93·2 (92·4–93·9)	..	90·3 (89·1–91·3)	..	95·1 (94·2–95·9)	95·4 (92·1–97·3)	..	..
N	166 184	34 577	8783	36 169	69 220	195 632	19 804	40 788
Metal-on-XLPE								
10 years (95% CI)	95·5 (95·4–95·6)	..	93·9 (93·7–94·1)	93·0 (99·1–99·1)	96·3 (96·2–96·5)	97·0 (96·9 –97·1)	94·2 (93·8–94·7)	96·0 (95·9–96·1)
15 years (95% CI)	93·9 (93·7–94·1)	..	91·9 (91·5–92·2)	92·6 (99·1–99·1)	95·3 (95·1–95·5)	96·0 (95·8–96·2)	92·8 (91·9–93·6)	94·4 (94·1–94·7)
20 years (95% CI)	92·5 (92·1–92·8)	..	89·2 (87·1 –91·1)	..	94·1 (93·6–94·6)	..	..	..
N	207 814	118 233	101 893	49 118	67 489	299 477	28 789	167 535

N=total number of patients at risk of revision at baseline. *Reported survival rate from 1 year to 9 years, and the number of patients at risk were reported after 1 year.

Table 2: **Implant survivorship estimates at 10 years, 15 years, and 20 years of follow-up by bearing material from joint registry data**

and models using the target bearing surfaces (appendix pp 3–8). Both cemented and uncemented fixation methods were represented, with most studies using cementless stems and acetabular shells.[15,31,33–40,44–57]

When stratified by bearing material, pooled analysis using a random-effects model showed survivorship estimates of 0·97 (0·95–0·98) for metal-on-XLPE, 0·96 (0·93–0·98) for ceramic-on-XLPE, and 0·97 (0·96–0·98) for ceramic-on-ceramic bearings (figure 3). Overall, survivorship estimates exceeded 94% over 15 years across all bearing types (figure 2); however, the metal-on-XLPE and ceramic-on-ceramic bearings had the highest pooled survivorship (with confidence interval overlaps between all bearings).

Data from 1 899 034 total hip replacements reported by eight national joint registries were pooled to estimate implant survivorship by bearing material, using all-cause revision as the endpoint. The 10-year, 15-year, and 20-year implant survivorship by bearing material, as reported by each national registry, are summarised in table 2 and figure 4A. The best fitting model was a multivariable random-effects model with two fixed effects—survival year and bearing material—and no interactions. The model selection process and the estimation of the parameters of the final model are presented in the appendix (pp 9–10). The estimated survivorship and 95% CI of the multivariable random-effects model are presented in table 3 and figure 4B. Ceramic-on-ceramic bearings showed survivorship of 95·5% (94·3–96·4) at 10 years, 94·4% (92·9–95·6) at 15 years, and 93·6% (91·7–95·0) at 20 years. Ceramic-on-XLPE bearings showed survivorship of 95·6% (94·5–96·5) at 10 years, 94·6% (93·2–95·7) at 15 years, and 93·8% (92·0–95·2) at 20 years. Metal-on-XLPE bearings showed survivorship of 95·3% (94·3–96·2) at 10 years, 94·3% (92·9–95·4) at 15 years, and 93·4% (91·7–94·8) at 20 years.

Survivorship estimates for each bearing material at 10 years, 15 years, and 20 years were concordant between the systematic review and registry datasets, with overlapping confidence intervals observed across sources, despite smaller sample sizes in the published studies.

The national joint registry dataset of 1 899 034 hips was used to extrapolate implant survival estimates beyond 20 years using the multivariable random-effects model. The result of this extrapolation showed that expected overall survivorship estimates across implant bearing materials were projected to reach 92·8% (91·2–94·2) at 25 years and 92·1% (90·1–93·7) at 30 years (table 3; figure 4B).

Discussion

Results from our study show that the pooled estimates for all bearing types of primary total hip replacements have a survivorship of 93·6% (95 CI% 92·3–94·7) at 20 years, 92·8% (91·2–94·2) at 25 years, and 92·1% (90·1–93·7) at 30 years. These results differ to Evans and colleagues’,[9] which reported 57·9% survivorship at 25 years. The implications of these results are substantial for patients considering surgery, guiding the decisions of surgeons, and the future planning of health systems.

Evans and colleagues[9] included outdated implants—namely, first-generation and second-generation ceramics with high brittleness[16,17] and conventional polyethylene (eg, UHMWPE), both now not used due to high revision risk. Since this study, the most transformative advances have been in bearing surfaces, particularly XLPE and contemporary ceramics.[58] XLPE shows five-fold lower wear than UHMWPE,[12,59] remains stable into the second decade after implantation, and falls below the osteolysis threshold, reducing loosening.[59] Modern ceramics, unlike their fracture-prone predecessors,[60] now have fracture rates less than 1%.[61–63] These rates are reflected in the 2024 National Joint Registry report, which reported an approximate 50% decline in revision rates from 2008 to 2023,[64] consistent with our pooled findings.

Fixation methods have changed little, aside from refinements such as fourth-generation cementing techniques[62,65,66] and surface coatings (eg, hydroxyapatite),[67] which have further improved stability.

The ideal total hip replacement bearing surface remains debated. Our data suggest survivorship remains high across all three modern bearings (table 3). This finding suggests that contemporary bearing surface material might not significantly affect implant survivorship in the long term, provided modern materials are used.

By contrast to the study by Evans and colleagues,[9] which identified discrepancies between published data and registry datasets, our analysis found concordant results across sources. At 10 years, survivorship estimates for each bearing material were similar between the systematic review and registry data, with overlapping confidence intervals despite smaller sample sizes in the systematic review studies. Although the included studies might have lower rates of loss to follow-up than registry data, they are more susceptible to patient migration bias.[68] Conversely, the majority of joint registries included in our study have near-complete (100%) data capture, with the National Joint Registry achieving more than 90% compliance, supporting their robustness.[69]

Although the previous study by Evans and colleagues[9] acknowledged that many implants assessed were no

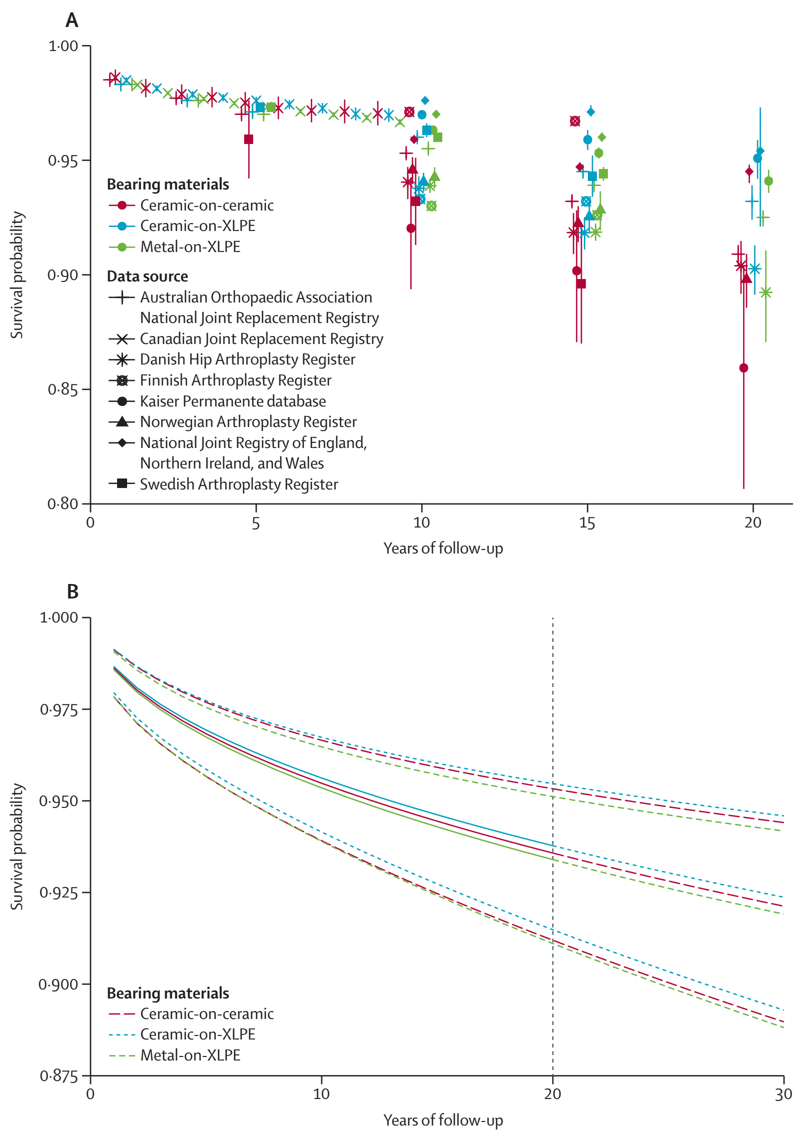

Figure 4: **Implant survivorship by bearing materials over time, using data from national joint registries**
(A) Reported survivorship with 95% CI. (B) Estimated survivorship (solid lines) with 95% CI (dotted lines). The black dotted vertical line indicates time with observed data and the dashed lines of all bearing materials beyond this line indicates extrapolated survivorship. XLPE=crosslinked polyethylene.

	10 years (95% CI)	15 years (95% CI)	20 years (95% CI)	25 years (95% CI)	30 years (95% CI)
Ceramic-on-ceramic	95·5 (94·3–96·4)	94·4 (92·9–95·6)	93·6 (91·7–95·0)	92·8 (90·6–94·5)	92·1 (89·6–94·1)
Ceramic-on-XLPE	95·6 (94·5–96·5)	94·6 (93·2–95·7)	93·8 (92·0–95·2)	93·0 (90·9–94·7)	92·4 (89·9–94·3)
Metal-on-XLPE	95·3 (94·3–96·2)	94·3 (92·9–95·4)	93·4 (91·7–94·8)	92·6 (90·5–94·3)	91·9 (89·4–93·8)

Survivorships beyond 20 years are extrapolated estimates. XLPE=crosslinked polyethylene.

Table 3: **Estimated survivorship of bearing surfaces from pooled joint registry data using a random-effects model**

longer in use (with only four case-series implants remaining in practical use), our updated review reflects contemporary practice more closely. Of the 29 studies in our systematic review, only two[31,32] used retired femoral stems. However, even in these implants, the bearing surfaces and acetabular components remain in circulation.

With the proven longevity benefits of XLPE and modern ceramics, our strict inclusion criteria increase clinical relevance. However, as innovation continues and new designs and materials for implants arise in the future, our results should not be extrapolated to novel implant materials not included in our dataset.

Bayliss and colleagues[70] previously showed that lifetime risk of revision is inversely related to age at implantation. Their model, based on historical data and implants, showed that younger patients (anyone who underwent total hip arthroplasty before age 70 years) face a significantly higher cumulative risk of revision. Our findings suggest that with contemporary materials, this lifetime risk is likely lower. However, to confirm this reduction, our planned follow-up study will use individual-level longitudinal data, which are linked to national death registries across all eight countries. This approach will allow for competing risk survival analysis stratified by age and sex.

Interpretation of lifetime revision risk should also consider the implications of undergoing revision. Although the absolute risk of revision has declined, the outcomes of revision—particularly re-revision—remain inferior to those of primary total hip replacement.

Extrapolation beyond the observed data should be performed with caution as it depends on the data quality and volume and the model adequacy. Particularly, the fact that our fitted models show satisfactory fit to the data does not necessitate that the same trends will continue into the future. However, our research is based on a large dataset and the extrapolation period is shorter than the observation period. Additionally, the projections appear robust when varying the model structure. Furthermore, there is broad compatibility between estimates of different countries with overlapping credible intervals within each bearing material, suggesting that reasonable confidence might be attributed to those estimates.

The fact that survivorship between actual 20-year data and survivorship at 30 years is not substantially different is potentially due to the low wear rates of bearing surfaces. Although conventional polyethylene has showed time-dependent exponential wear rates, XLPE has maintained low and linear wear rates.[71]

Limitations of this study are divided between two issues: the restraints of registry data and the generalisability of the results. Most of our data were derived from joint registries. Approximately 60% of the hip implants included in this study were drawn from either the National Joint Registry or the Australian Orthopaedic Association National Joint Replacement Registry. Although these registries—as well as four Scandinavian registries and the Kaiser Permanente National Total Joint Replacement Registry— have well established data validation protocols and almost 100% completeness of case reporting to registries, the same level of audit and mandatory reporting might not apply uniformly across all contributing registries, which might introduce potential for bias. Limitations of registry data include that we were unable to differentiate between the indications for total hip replacement (other than stipulating arthritis) or to stratify according to sex, age, or fixation method. Additionally, registry datasets do not have information on patient-reported outcomes such as pain or satisfaction, and only confirm that the implant remains in situ.

A further limitation of joint registry data is the under-reporting of periprosthetic fractures when treated by open reduction and internal fixation or osteosynthesis, or for patients in whom a debridement and implant retention are done for infection with only exchange of modular implants. These cases are not always documented as a revision, although might reflect failure of the hardware or its implantation. There is also heterogeneity in revision definitions between registries, including the potential exclusion of non-component-exchanging procedures. There might be patients who are clinically indicated for revision of a primary total hip replacement who are unable to receive the surgery due to competing factors, such as frailty, access barriers, or extended waiting times for surgery, as seen during the COVID-19 pandemic—these patients would not be captured in registry data, which might introduce survivorship bias by underestimating the true burden of implant failure.

All registries handle death in survivorship analyses by ending follow-up at the time of death. In this framework, it is the performance of the device that is being assessed rather than the lifetime risk of revision—ie, how long does the implant last before it is revised? This approach is standard across registry Kaplan–Meier analyses and is an appropriate method for assessing implant survivorship. Accordingly, our analysis treats deaths as the end of observation rather than as competing events. Although this approach is accepted and considered appropriate, it might lead to modest overestimation of implant failure risk in older populations.[72]

Although the generalisability of our data is reassuring at a population level, it might not reflect individual risk. Patient-specific factors such as age, comorbidities, and bone quality, as well as surgical techniques used, will continue to influence outcomes. Furthermore, our results concern implants with long-term follow-up only and should not be extrapolated to newly introduced devices, or even devices using similar bearing surfaces. Similarly, these results do not account for variation between individual stem or cup designs. For patients with older implants, such as those with conventional polyethylene or earlier generation ceramics, the 2019 article from Evans and colleagues[9] remains the most accurate estimate of survivorship.

Results from our study show that primary total hip replacements with contemporary bearing surfaces have a survivorship of 93·6% (95 CI% 92·3–94·7) at 20 years, 92·8% (91·2–94·2) at 25 years, and 92·1% (90·1–93·7) at 30 years. This percentage is much higher than has been previously reported. The transition to bearing surfaces with lower wear rates has likely been the driver for this improvement in survivorship. Regarding bearing surfaces, we found no statistically significant difference between the three contemporary combinations, which is beneficial for patients and surgeons who might need these data for the shared informed consent process.

Although the demand for primary hip replacement will continue to increase, whether this demand translates into a proportional increase in revision surgery remains uncertain.

Contributors

VP and ZT: independently screened studies for selection, extracted all study data, contributed to the writing of the original draft of the manuscript, and participated in revisions of the final draft of the manuscript. AD and ND: served as advisors on study design, completed all statistical analyses for the study, contributed to the writing of the original draft, and participated in revisions of the final draft of the manuscript. LE, AMF, ONF, NH, TBK, KM, SO, EP, HP, MR, OR, CV, TV, and MW: contributed to curation, analysis, and interpretation of data; the writing of the original manuscript draft; and the review and editing of the manuscript. EB, DC, GH, AK, JK, BR, and JPW: contributed to the conception of the study premise and participated in the revisions of the final draft of the manuscript. AA: was the senior author, conceived the premise of the study, supervised all phases of the project, contributed to the writing of the original draft, and participated in revisions of the final draft of the manuscript. VP and ZT had full access to all the data in the study and had final responsibility for the decision to submit for publication. AA and VP directly accessed and verified the data underlying the study.

Declaration of interests

EB reports receiving payment or honoraria for lectures, presentations, speakers' bureaus, manuscript writing, or educational events from Stryker; support for attending meetings and travel from DePuy; leadership or fiduciary roles with the Canadian Joint Replacement Registry (Chair, Advisory Committee); the International Society of Arthroplasty Registries (President); and the Canadian Arthroplasty Society (President); and institutional educational support from Smith & Nephew and DePuy. DC reports royalties or licences from Smith & Nephew for revision component design; holding leadership or fiduciary roles as Chair of the Glenelg Hospital Medical Advisory Committee and as a Review Panel Member for the National Joint Replacement Registry; and holding stock or stock options in Austofix Orthopaedics.
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Data sharing

All data used in the production of this paper, including population-level demographic data and Kaplan–Meier survival estimates of total hip replacements from each national joint registry, are available on request from the corresponding author. All data from the systematic review and meta-analysis of the literature are publicly available. The statistical analysis plan and data files are similarly available on request from the corresponding author.

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