Predictors of clinical outcome in total hip and knee replacement : a methodological appraisal of implants and patient factors

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Which Implant should we use for Primary Total Hip Replacement?

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Abstract

Background Many total hip implants are currently available on the market worldwide. We aimed to estimate the probability of revision surgery at ten years for each individual total hip implant and to compare these estimates with the National Institute for Health and Care Excellence (NICE) benchmark.

Methods We performed a meta-analysis of cohort studies. The methodological quality was assessed with use of the Assessment of Quality in Lower Limb Arthroplasty (AQUILA) checklist. We searched PubMed, EMBASE, Web of Science and the Cochrane Library. Additionally, National Joint Registries that were full members of the International Society of Arthroplasty Registers (ISAR) were hand searched. Studies in which the authors reported the survival probability for either the acetabular or the femoral component of primary total hip replacements, with at least 100 implants at baseline, and in which at least 60% of the patients had primary osteoarthritis were eligible for inclusion.

Results The search strategy revealed 5513 papers describing survival probabilities for thirty-four types of acetabular components and thirty-two types of femoral components. Eight types of acetabular cups and fifteen types of femoral stems performed better than the NICE benchmark.

Conclusions We recommend the surgeons performing a primary total hip replacement use an implant that outperforms the NICE benchmarks.

Introduction

Total Hip Replacement (THR) is an effective surgical intervention to alleviate pain, restore functionality of the hip and improve the quality of life of patients with end-stage degeneration of the hip joint.[1, 21, 27, 28]. Currently, a wide variety of Total Hip Implants (THI) is available to orthopaedic surgeons worldwide.[29] Many factors, such as the cost of the implant, familiarity with the design and instruments and ease of use, influence the choice for a particular THI. Arguably, from both a patient and a societal perspective, the most important factor is the clinical performance of the total hip implant

and the probability of revision surgery during a given period of time. Revision hip arthroplasty is technically challenging with a higher complication rate, a longer hospital stay, and a higher cost than primary total hip replacement and can lead to disability and death.[30–34] Clearly, choosing a total hip implant that is associated with the lowest rate of revision surgery can prevent harm and reduce long-term health-care costs. Recently, the National Institute for Health and Care Excellence (NICE) suggested a ten-year revision rate of $\leq$10% as an acceptable benchmark performance of a primary total hip implant, which was loosely based on an earlier report by Murray et al.[29, 35]

The objective of our study was to systematically search and appraise the literature to estimate the probability of revision surgery at ten years for each individual type of total hip implant. Additionally, we sought to compare the estimates of the probability of revision surgery for each total hip implant to with NICE benchmark.

Materials and Methods

Protocol and registration This systematic review and meta-analysis was performed from March 2011 to February 2013, with use of the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement for development of the study protocol and reporting the results of our study.[36]

Eligibility criteria The NICE Technology Appraisal Guidance states: "The evidence used in support of any prosthesis . . . should relate to data on 10 or more years follow up from a number of centers, obtained via adequately sized, well conducted observational studies (preferably with consecutive patients from non-selected populations) or randomised controlled trials. Such evidence should have been published or be available for peer review".[35] Studies in which the authors reported the survival probability (i.e. the Kaplan-Meier estimate) for either the acetabular or the femoral component of a primary total hip replacement with use of revision for any reason or for aseptic loosening at ten years as the end point were eligible for inclusion. We considered studies to be of adequate size when there were at least 100 implants at baseline, and we defined a study

population as representative of the general population at large when at least 60% of the patients had primary osteoarthritis. Studies with fewer than 100 implants at baseline and in which $<$60% of the patients had primary osteoarthritis were excluded. Studies were also excluded when the authors described the outcomes of multiple (sub)types of implants without reporting the outcomes for each (sub)type separately. Articles written in any language other than English, Dutch, German, French, Spanish or Italian were not eligible for inclusion. In order to limit the extent of publication bias, no publication status restrictions were imposed.

Information sources On March 22, 2011, an experienced independent information specialist (JWS) searched four electronic databases: PubMed, EMBASE, Web of Science and the Cochrane Library. We also performed implant-specific PubMed searches for all primary total hip implants registered in the first annual report of the Dutch Arthroplasty Register (Landelijke Registratie Orthopaedische Implantaten [LROI]).[8] Finally, National Joint Registries that were full members of the International Society of Arthroplasty Registers (ISAR, www.isarhome.org) were hand searched.

Search strategy The following search terms were applied to Pubmed and adapted for all other databases:
(tha[tw] OR “total hip” OR “total hips” OR ((“total joint” OR “total joints”) AND (hips OR hip)) OR (total hip AND (prosthesis OR prosthetic OR endoprosthesis OR endoprostheses OR endoprosthetic OR arthroplasty OR arthroplasties OR replacement [tiab])) OR (Hip Replacement Arthroplasty AND total [tiab]) OR Hip Replacement Arthroplasty OR hip arthroplasty OR hip replacement OR Hip Prosthesis) AND (Osteoarthritis OR Osteoarthritides OR osteoarthriti* OR Osteoarthrosis[tiab] OR Osteoartroses OR athrosis[tw] OR arthroses OR “Degenerative Arthritis”) NOT (early[tw] OR initial[tw] OR preliminary[tw] OR “short follow-up”[tw] OR “Letter”[Publication type] OR “Case Reports”[Publication Type])

Study Selection Two authors (JFM & SDM) independently screened the titles and abstracts of the search results using pre-specified eligibility criteria, as stated above.

Two other authors (JCK & FRvT) screened the full text of the remaining articles using the same eligibility criteria. Disagreements between authors were resolved by consensus.

Data collection process and data items Data collection was performed by two authors (JCK & FRvT) independently using predefined data extraction sheets. Inconsistencies between the two authors were resolved by consensus. When data were not reported numerically, but were presented graphically in Kaplan-Meier curves, the estimated observations of both authors were averaged. The brand name and manufacturer of the implant, the Kaplan-Meier estimate at ten years, and its standard error and 95% confidence interval were extracted from each included study.

Risk of bias in individual studies The methodological quality of all included studies was assessed using the Assessment of Quality in Lower Limb Arthroplasty (AQUILA) checklist, a tool specifically designed to appraise the quality of observational studies concerning total hip replacement and total knee replacement.[37] Two authors (JCK & FrvT) independently assessed the quality of all included studies, using predefined data extraction sheets. Inconsistencies between the two authors were resolved by consensus.

Summary measures and Synthesis of results The principal summary measure was the survival probability for each implant at 10 years with use of revision for any reason as the end point. The secondary summary measure was the survival probability for each implant at 10 years with use of revision for aseptic loosening as the end point. Estimates of the survival probability in different studies on the same implant were pooled with use of inverse variance weighting. When no estimate of the variance or standard error of the survival probability at 10 years was presented, we deduced the missing standard error from the confidence interval of the survival probability. When the study did not provide an estimate of the variance or standard error, or a confidence interval, we imputed the missing standard error from the mean standard error of all other studies.[38, 39] When $>$50% of all standard errors were missing, we imputed the missing standard errors with single imputation on the basis of the survival estimate and the number of

implants at baseline. We chose this approach instead of a more elaborate modelling approach[40–42] for two reasons. First, we were interested in the survival probability at only one specific point in time. Second, the majority of studies that did not provide the standard error also did not give enough information to allow modelling of the survival probability.

In order to test whether each implant performed better than the NICE benchmark, we calculated the confidence interval for each implant survival estimate. The 10-year revision rate of 10% for a total hip implant corresponds with a survival probability of 90% for a THI. Therefore, the survival probability of a cup or stem should exceed 90%. Assuming independence of the survival probability for either the cup or the stem, we can summarise the minimal survival probability with the formula: $p_{cup} * p_{stem} \geq 0.9$. When it is assumed that $p_{cup} = p_{stem}$, then the minimal survival probability for the cup is $p_{cup}^2 = 0.9$, leading to a minimal cup survival probability of $\sqrt{0.9}$, which is rounded to 95%. Therefore, the survival probability of either the cup or the stem should exceed 95%. When both the survival estimate and the lower limit of the confidence interval were $>$95%, we concluded that that particular implant performed significantly better than the NICE benchmark. When both the survival estimate and the upper limit of the confidence interval were $<$95%, we concluded that that particular implant performed significantly worse than the NICE benchmark. In all other cases, we concluded that there was insufficient evidence to suggest that the particular implant performs better or worse than the NICE benchmark.

All analyses were performed with use of R, version 2.15.2.[43]

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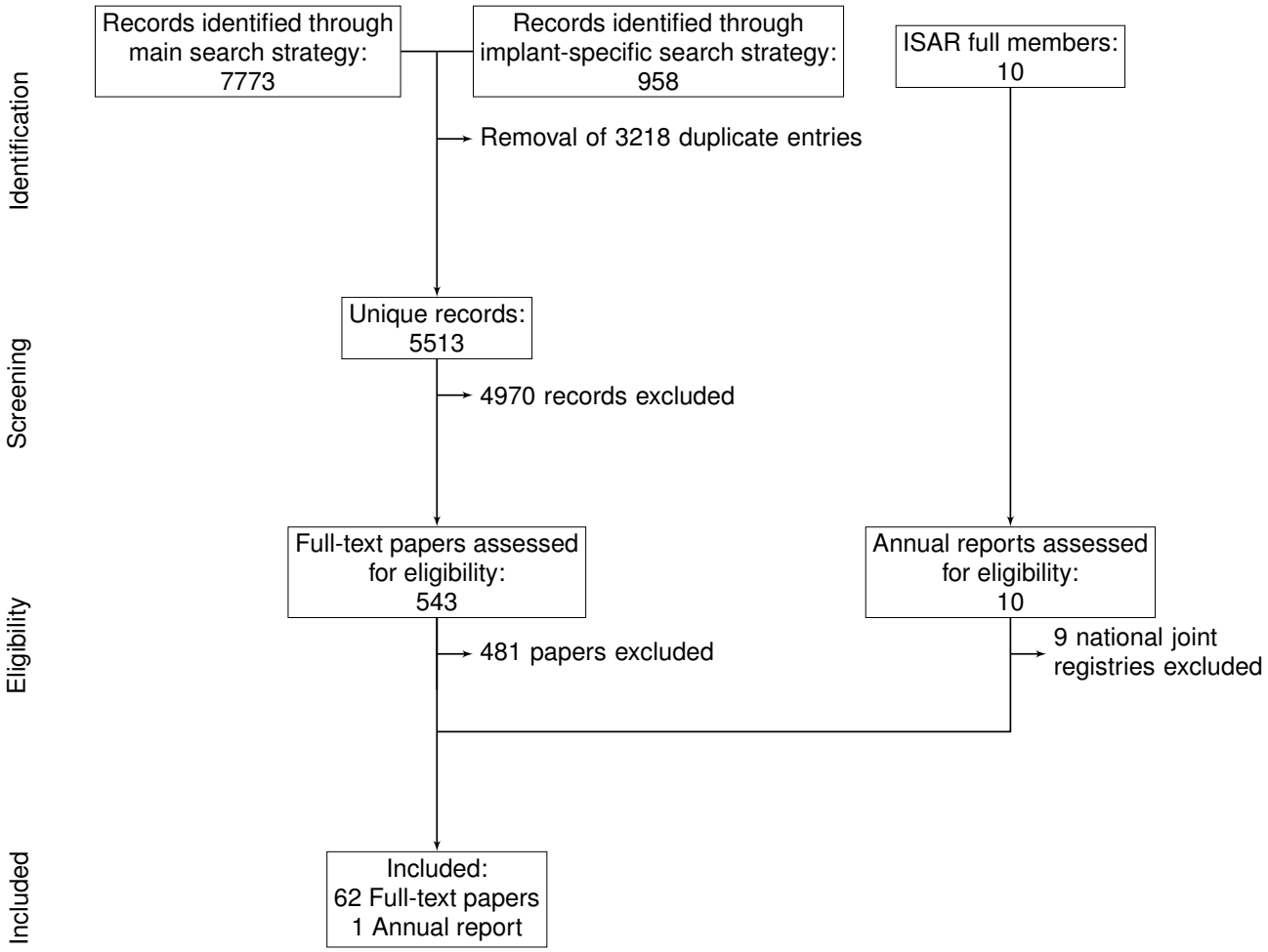

Figure 2.1: **Flow-chart of study inclusion.**

Results

Study selection Our search strategy revealed 8731 hits: the main search strategy yielded 7773 hits and the implant-specific search yielded an additional 958 hits (Fig. 2.1). After removal of duplicate entries, 5513 unique papers remained, and their titles and abstracts were screened. 4970 papers were excluded, leaving 543 papers eligible for inclusion. Further assessment of eligibility based on the full-text papers led to the exclusion of 481 papers: 259 papers did not report the survival probability of a cup or stem at ten years, and 222 papers did not provide separate results for cups or stems. Of all national joint registries that were full members of ISAR, only the Swedish Hip Arthroplasty Register reported separate results for cups and stems at ten years with revision for any reason as the end point.[44] This left 63 papers for further analysis.

Study characteristics and Risk of bias Tables 2.1 (p. 22) and 2.2 (p. 23) provide an overview of the characteristics of all included studies in which the end point was revision for any reason, and tables 2.3 (p. 24) and 2.4 (p. 25) provide such an overview for the studies in which the end point was revision for aseptic loosening. The methodological quality of the studies in which revision for any reason was the end point is shown in tables 2.5 (p. 26) and 2.6 (p. 27), and the methodological quality of the studies in which the end point was revision for aseptic loosening is shown in tables 2.7 (p. 28) and 2.8 (p. 29). We found 41 cohorts for which the ten-year survival probability of an acetabular cup was described with revision for any reason as the end point. These studies included a total of 34 different acetabular implants: ABG 1,[45, 46] ABG 2 HA,[44] ACS Triloc+,[47] Arthopor,[47] ATLAS II,[48] ATLAS III,[48] Charnley,[44, 49] Charnley Elite,[44] CLS Spotorno,[44] Conserve Plus,[50] Exeter All-Polyethylene,[51] Exeter Duration,[44] Fitmore,[52] Harris Design 2,[53] Harris-Galante I,[54] Harris-Galante II,[45] Hofer-Imhof,[55] JRI Threaded Cup,[56] Lubinus,[44] Lubinus Eccentric,[57] Mallory-Head Cementless,[45, 58] Miami Orthopaedic Surgical Clinic: All Polyethylene,[49] Miami Orthopaedic Surgical Clinic: Metal Backed,[49] Morscher Press Fit,[59, 60] Mueller,[49] Novae,[61] PCA Pegged,[45] Plasmacup,[62] RM,[63] Romanus,[45] T28,[49, 64] Trilogy HA,[44] Universal,[45, 65] Zweymuller-Alloclassic Screw Cup.[66, 67]

42 papers described the ten-year survival probability of 32 different femoral stem implants with revision for any reason as the end point: ABG 1,[44–46] Anatomic Mesh,[45] Bicontact,[68] Bi-Metric,[45, 69, 70] Charnley,[44, 71] CLS Spotorno,[44, 45] Conserve Plus,[50] Corail,[72] Exeter Polished,[44] Exeter Universal,[73] Freeman Cementless,[74] Furlong,[56] Harvard Femoral Stem,[75] Heritage,[76] Iowa polished,[76] Lord Madreporique,[45, 77] Lubinus IP,[57, 78] Lubinus SP,[57, 78] Lubinus SPII,[44] Mallory Head Cemented,[79] Mallory Head Cementless,[58, 80] MS-30,[59] Omnifit Cemented,[71] Osteonics Cementless,[81] PCA,[45] Profile Porous,[45] R-B Interlok,[71] SBG,[82] Stanmore Custom Made,[83] Taperloc,[84] Triumph,[76] Zweymuller SL.[66]

39 papers described the ten-year survival probability of 31 different acetabular cup implants with revision for aseptic loosening as the end point: ABG 1,[45] ACS Triloc+,[47] Arthopor,[47] Brunswik,[85] Charnley,[49, 85–87] Charnley All-Polyethylene,[88] Conserve Plus,[50] Elite Ogee,[73] Exeter,[87] Exeter All-Polyethylene,[51] Fitmore,[52] Harris Design-2 All-Polyethylene,[89] Harris-Galante II,[45] Hofer-Imhof,[55, 90] JRI Threaded Cup,[56] Link,[87] Lord Threaded,[77] Mallory-Head Cementless,[45] Miami Orthopaedic Surgical Clinic: All Polyethylene,[49] Miami Orthopaedic Surgical Clinic: Metal Backed,[49] Morscher Press Fit,[59, 60] Mueller,[49] PCA Pegged,[45] Romanus,[45] Spectron,[87] T-28,[49, 64] Titan,[87] Trabecular Metal Monoblock Acetabular Component System,[91] Universal,[45, 65] Weber Hemispheric,[92] Zweymuller-Alloclassic Screw Cup.[93, 94]

Finally, we found 52 cohorts in which the ten-year survival probability of 37 different femoral stem implants was assessed with revision for aseptic loosening as the end point: ABG 1,[45, 46] Anatomic Mesh,[45] Bi-Metric,[45, 69, 70] Charnley,[71, 87, 95] Charnley Elite-Plus,[96, 97] Charnley Flat-back,[97] CLS Spotorno,[45] Corail,[72] Exeter,[87] Exeter Matt,[97] Exeter Universal,[73, 97, 98] Freeman Cemented,[99, 100] Freeman Cementless,[74, 101] Furlong,[56] Harris Design 2,[89] Harvard Femoral Stem,[75] Interlok,[97] ITH,[87] Lord Madreporique,[45, 77] Lubinus IP,[97] Lubinus SP II,[97] Mallory Head Cementless,[58, 80] MS-30,[59] Muller Straight Protasul-10 Cobalt-Nickel-Chromium,[97, 102, 103] Muller Straight Protasul-100 Titanium,[104] Muller Style Titanium,[105] Omnifit Cemented,[71] Osteonics Cemented,[106] Osteonics Cementless,[81] PCA,[45] Profile Porous,[45] R-B Interlok,[71] SBG,[82] Stanmore Custom Made,[83] Taperloc,[65, 84] Titan,[87] Zweymuller Alloclassic.[94]

Synthesis of results An overview of the survival probability for the different implants is presented in figures 2 through 5. With use of revision for any reason as the end point, the following acetabular cups performed better than the NICE benchmark: JRI Threaded Cup, Conserve Plus, Zweymuller-Alloclassic Screw Cup, Charnley Elite, Lubinus, Exeter Duration, Charnley, T28 (fig. 2.2 (p. 30)). With use of revision for any reason as the end point, the following femoral stems performed better than the NICE benchmark:

Stanmore Custom Made, MS-30, Iowa Polished, RB Interlok, Taperloc, Corail, Furlong, SBG, Zweymuller SL, CLS Spotorno, Mallory-Head Cementless, Osteonics Cementless, Lubinus SPII, ABG 1, Exeter Polished (fig. 2.3 (p. 31)). With use of revision for aseptic loosening as the end point, the following acetabular cups performed better than the NICE benchmark: Weber Hemispheric, Trabecular Metal Monoblock Acetabular Component System, JRI Threaded Cup, Fitmore, Conserve Plus, Morscher Press Fit, Zweymuller-Alloclassic Screw Cup, Arthropor, ACS Trilok+, Charnley, Titan, Spectron, Charnley All-polyethylene, Exeter (fig. 2.4 (p. 32)). With use of revision for aseptic loosening as the end point, the following femoral stems performed better than the NICE benchmark: ABG 1, Osteonics Cementless, RB Interlok, Zweymuller Alloclassic, Freeman Cementless, Stanmore Custom Made, MS-30, Corail, Profile Porous, Bimetric, Mallory-Head Cementless, Taperloc, Omnifit Cemented, Furlong, CLS Spotorno, Harris Design II, Exeter, Exeter Universal, Titan, Osteonics Cemented, Freeman Cemented, Charnley, Muller Straight Protasul-10 Cobalt-Nickle-Chromium (fig. 2.5 (p. 33)).

Discussion

In this systematic review and meta-analysis, we estimated the probability of revision surgery at ten years for 34 types of acetabular cups and 32 types of femoral stems that were available on the market with published results. Of these implants, 8 acetabular cups and 15 femoral stems performed better than the NICE benchmark.
Most studies were of low methodological quality: the majority of studies consisted of non-consecutive cohorts, with more than 5% of the hips lost to follow-up and no worst-case analysis.

In the past decades, numerous efforts have been made to improve the survival probability of primary total hip implants. Some efforts, such as the addition of antibiotics to bone cement,[107] have led to an improvement in survival probability. Others, such as the introduction of Boneloc® cement or the 3M Capital Hip System have led to unprecedented failures, which could have been prevented by phased introduction of new implants and techniques.[108, 109] Despite subsequent calls for stricter regulation

of new total hip implants,[29, 110] few actions were taken, facilitating the recent disaster with the ASR hip prosthesis.[111] In providing an overview of all implants that perform better or worse than the NICE benchmark, we aid practising orthopaedic surgeons in choosing safe, time-proven implants for primary total hip replacement. Additionally, our study documents that an astonishing limited number of publications are currently available.

There are a number of limitations to this study. The description of the type of implant used in a specific total hip replacement cohort was often limited to the specific brand name. Some studies, such as the well described one by Franklin et al,[112] included the results of multiple subtypes of implants, which had undergone major changes in design, summarized in one survival estimate at 10 years. We excluded studies which did not specify separate survival estimates for subtypes with substantial changes in design. In all other papers, we assumed that a single subtype of implant was used for all patients. Additionally, the NICE benchmarks were poorly defined, leaving much room for interpretation.[35] The recommendation to use a ten-year revision rate of 10% as a threshold does not specify a particular end point — e.g. aseptic loosening or revision for any reason. Additionally, it is unclear whether this revision rate should include the acetabular or femoral component or both implants. Furthermore, no guidance is given regarding the statistical methods to use for outlier detection. Finally, the guidelines do not define “adequately sized” or “well conducted” studies. In order to err on the side of caution, we chose revision for any reason instead of revision for aseptic loosening as the primary outcome measure. Aseptic loosening is considered the principal mechanism of failure at the time of long-term follow-up, is slowly progressive and causes disabling pain.[113] Especially in the case of focal osteolysis, an implant might appear solidly fixed at revision surgery, despite moving up to 1 mm relative to the surrounding bone.[114] In order to minimise the risk of misclassification bias (e.g. misclassifying cases of aseptic loosening as cases revised for persistent pain after joint replacement), we chose to use revision for any reason as the principal outcome measure.[115] On the basis of our clinical judgement, we defined the revision rate of 10% as referring to the combination of

both implants and defined “adequately sized” as a minimum of 100 implants at baseline. No competing risk analyses were performed in any of the included cohorts. It is highly unlikely that no competing events, such as the death of a patient, have taken place within 10 years after primary THR. Disregarding these competing events leads to an underestimation of the survival probability.[116] Therefore, some implants might outperform the NICE benchmark in reality but not appear to do so on the basis of their survival estimates because of unrealistic statistical assumptions.

In our analyses, we assumed that the case mix of all studies was similar. Regarding one of the most important characteristics— namely, the indication for joint replacement— this was certainly the case, as this was one of the inclusion criteria. Other characteristics, such as age, sex, physical activity, and number of co-morbidities were not recorded and might have differed among the cohorts. Some patient characteristics, such as age and sex, are easily identified in most studies. Others, such as physical activity and number of co-morbidities are not uniformly measured if they are measured at all. Because there is no current consensus on relevant case-mix variables,[37] we decided to omit these variables from this systematic review.

Finally, the majority of the survival estimates were based on a single study, performed in a single center. This raises the question of whether the survival rates presented in this meta-analysis represent the actual survival rates of these implants. In the unlikely case of extreme publication bias, an implant might appear to outperform the NICE benchmark in the only published study, while performing worse in the unpublished reality. Extreme negative publication bias is also theoretically possible. Surgeons who notice poor results using a certain prosthesis might be more inclined to report their results, as a general warning, than are surgeons who notice acceptable results. In the case of extreme negative publication bias, an implant might appear to perform worse than the NICE in the only published study, while performing better in the unpublished reality. It is difficult to study the effect of publication bias in this meta-analysis. Conventional methods such as funnel plots would fail in this case, as it would be pointless to make a funnel plot for an implant for which there was only one estimate and therefore only one

point. A sensible approach is to interpret estimates based on the experience at a single center with more caution, especially if those centers were involved in the design of the implant.[117]

A wide variety of implants is available to orthopaedic surgeons worldwide, but there is a very limited amount of evidence for some of these implants. In the European Union, there is a single organisation for the approval of drugs— the European Medicines Agency, which demands evidence of safety and efficacy in controlled trials. In contrast, for medical devices such as an orthopaedic implant, it is only necessary to obtain a European Conformity (Conformité Européenne (CE)) mark, which requires limited or no evidence of clinical efficacy.[118] Since the introduction of Charnley's total hip replacement in the late 1950s, new successful total hip replacement implants have been designed, lowering the probability of revision surgery. However, recent problems with several hip prostheses have illustrated that patient safety can be at risk when new total hip replacement implants are developed.[119, 120] We encourage the development of new implants but not at the cost of patient safety.[121] Therefore, the development of new implants should take place in the setting of comparative clinical studies. Ideally, results of experimental implants should be compared with results of implants that outperform the NICE benchmark. To provide access to innovative treatments while ensuring evidence is collected, health-care funders need to implement a payment-with-evidence-development approach.[122]

The use of optimally performing total hip implants is possible despite older and more recent disasters with certain hip implants. It is the surgeon who has to decide which implant will provide the best quality for his or her specific patient. The current study underscores that there is evidence in the literature, but that evidence has to be used.

Cup	Ref.	Manufacturer	Country of Study Origin	n at baseline
ABG 1	[45]	Howmedica	Finland	108
ABG 1	[46]	Howmedica	Wales	100
ABG II HA	[44]	n.s.	Sweden	213
ACS Triloc+	[47]	DePuy	USA	394
Arthopor	[47]	Joint Medical Products	USA	433
ATLAS II	[48]	n.s.	France	171
ATLAS III	[48]	n.s.	France	126
Charnley	[49]	Thackrey	USA	238
Charnley	[44]	n.s.	Sweden	23272
Charnley Elite	[44]	n.s.	Sweden	9456
CLS Spotorno	[44]	n.s.	Sweden	1169
Conserve Plus	[50]	Wright Medical Technology	USA	100
Exeter All-Polyethylene	[51]	Stryker	UK	263
Exeter Duration	[44]	n.s.	Sweden	11712
Fitmore	[52]	Sulzer	UK	119
Harris Design 2	[53]	Howmedica	Sweden	126
Harris-Galante I	[54]	Zimmer	Denmark	324
Harris-Galante II	[45]	Zimmer	Finland	277
Hofer-Imhof	[55]	n.s.	Austria	678
JRI Threaded Cup	[56]	JRI	UK	112
Lubinus	[44]	n.s.	Sweden	76047
Lubinus Eccentric	[57]	Waldemar-Link	Finland	444
Mallory-Head Cementless	[45]	Biomet	Finland	110
Mallory-Head Cementless	[58]	Biomet	Canada	307
MOSC[1]: All Polyethylene	[49]	Biomet	USA	100
MOSC[1]: Metal Backed	[49]	Biomet	USA	134
Morscher Press Fit	[59]	Zimmer	Switzerland	124
Morscher Press Fit	[60]	Sulzer	New Zealand	125
Mueller	[49]	Depuy International Ltd	USA	141
Novae	[61]	SERF	France	135
PCA Pegged	[45]	Howmedica	Finland	122
Plasmacup	[62]	B Braun Ltd	UK	318
RM	[63]	Mathys	Netherlands	630
Romanus	[45]	Biomet	Finland	114
T28	[49]	Zimmer	USA	559
T28	[64]	Zimmer	USA	132
Trilogy HA	[44]	n.s.	Sweden	1196
Universal	[45]	Biomet	Finland	898
Universal	[65]	Biomet	USA	114
ZA[2] Screw Cup	[66]	Sulzer	Germany	320
ZA[2] Screw Cup	[67]	Sulzer	Germany	139

Table 2.1: **Study Characteristics of all included Studies, describing the Survival Probability of Acetabular Cups for Revision Any Reason.** n.s.: not specified.
1: Miami Orthopaedic Surgical Clinic. 2: Zweymuller-Alloclassic.

Stem	Ref.	Manufacturer	Country of Study Origin	n at baseline
ABG 1	[45]	Stryker	Finland	390
ABG 1	[46]	Howmedica	UK	100
ABG 1	[44]	n.s.	Sweden	370
Anatomic Mesh	[45]	Zimmer	Finland	135
Bicontact	[68]	B.Braun-Aesculap	Germany	250
Bi-Metric	[69]	Biomet	Sweden	115
Bi-Metric	[45]	Biomet	Finland	1982
Bi-Metric	[70]	Biomet	USA	129
Charnley	[71]	Johnson & Johnson	USA	160
Charnley	[44]	n.s.	Sweden	23272
CLS Spotorno	[45]	Sulzer-medica	Finland	108
CLS Spotorno	[44]	n.s.	Sweden	1169
Conserve Plus	[50]	Wright Medical Technology	USA	100
Corail	[72]	DePuy	France	120
Exeter Polished	[44]	n.s.	Sweden	11712
Exeter Universal	[73]	Howmedica	UK	230
Freeman Cementless	[74]	Finsbury Instruments	UK	100
Furlong	[56]	JRI	UK	134
Harvard Femoral Stem	[75]	Harvard Health Care	UK	269
Heritage	[76]	Zimmer	USA	283
Iowa polished	[76]	Zimmer	USA	120
Lord Madreporique	[45]	Benoist Girard	Finland	286
Lord Madreporique	[77]	Benoist Girard	Norway	116
Lubinus IP	[78]	Waldemar Link	Finland	280
Lubinus IP	[57]	Waldemar Link	Finland	257
Lubinus SP	[78]	Waldemar Link	Finland	263
Lubinus SP	[57]	Waldemar Link	Finland	185
Lubinus SPII	[44]	n.s.	Sweden	76047
Mallory Head Cemented	[79]	Biomet	USA	102
Mallory Head Cementless	[80]	Biomet	USA	2000
Mallory Head Cementless	[58]	Biomet	Canada	307
MS-30	[59]	Zimmer	Switzerland	124
Omnifit Cemented	[71]	Osteonics	USA	305
Osteonics Cementless	[81]	Stryker	USA	226
PCA	[45]	Howmedica	Finland	111
Profile Porous	[45]	Depuy	Finland	115
R-B Interlok	[71]	Biomet	USA	235
SBG	[82]	Plus Orthopaedics	Austria	230
Stanmore Custom Made	[83]	Depuy	Italy	129
Taperloc	[84]	Biomet	USA	129
Triumph	[76]	Zimmer	USA	148
Zweymuller SL	[66]	Zimmer	Germany	320

Table 2.2: **Study Characteristics of all included Studies, describing the Survival Probability of Femoral Stems for Revision Any Reason.** n.s.: not specified.

Cup	Ref.	Manufacturer	Country of Study Origin	n at baseline
ABG 1	[45]	Howmedica	Finland	108
ACS Triloc+	[47]	DePuy	USA	394
Arthopor	[47]	Joint Medical Products	USA	433
Brunswik	[85]	n.s.	Sweden	151
Charnley	[86]	DePuy	Norway	9186
Charnley	[85]	n.s.	Sweden	204
Charnley	[87]	n.s.	Norway	14842
Charnley	[49]	Thackrey	USA	238
Charnley All-Polyethylene	[88]	Zimmer	USA	193
Conserve Plus	[50]	Wright Medical Technology	USA	100
Elite Ogee	[73]	DePuy	UK	218
Exeter	[87]	n.s.	Norway	3934
Exeter All-Polyethylene	[51]	Stryker	UK	263
Fitmore	[52]	Sulzer	UK	119
Harris Design-2 All-Polyethylene	[89]	Howmedica	Canada	195
Harris-Galante II	[45]	Zimmer	Finland	277
Hofer-Imhof	[90]	Smith and Nephew	Austria	100
Hofer-Imhof	[55]	n.s.	Austria	678
JRI Threaded Cup	[56]	JRI	UK	134
Link	[87]	n.s.	Norway	413
Lord Threaded	[77]	Benoist Girard	Norway	116
Mallory-Head Cementless	[45]	Biomet	Finland	110
MOSC[1]: All Polyethylene	[49]	Biomet	USA	100
MOSC[1]: Metal Backed	[49]	Biomet	USA	134
Morscher Press Fit	[59]	Zimmer	Switzerland	124
Morscher Press Fit	[60]	Sulzer	New Zealand	125
Mueller	[49]	Depuy	USA	141
PCA Pegged	[45]	Howmedica	Finland	122
Romanus	[45]	Biomet	Finland	114
Spectron	[87]	n.s.	Norway	2019
T-28	[64]	Zimmer	USA	132
T-28	[49]	Zimmer	USA	559
Titan	[87]	n.s.	Norway	3205
Trabecular Metal Monoblock ACS[2]	[91]	Zimmer	Greece	156
Universal	[45]	Biomet	Finland	898
Universal	[65]	Biomet	USA	123
Weber Hemispheric	[92]	Hoechst	Netherlands	315
ZA[3] Screw Cup	[93]	Zimmer	Netherlands	135
ZA[3] Screw Cup	[94]	Sulzer	France	200

Table 2.3: **Study Characteristics of all included Studies, describing the Survival Probability of Acetabular Cups for Revision Aseptic Loosening.** n.s.: not specified. 1: Miami Orthopaedic Surgical Clinic. 2: Acetabular Component System. 3: Zweymuller-Alloclassic.

Stem	Ref.	Manufacturer	Country of Study Origin	n at baseline
ABG 1	[45]	Stryker	Finland	390
ABG 1	[46]	Howmedica	UK	100
Anatomic Mesh	[45]	Zimmer	Finland	135
Bimetric	[69]	Biomet	Sweden	104
Bimetric	[45]	Biomet	Finland	1982
Bimetric	[70]	Biomet	USA	105
Charnley	[95]	Thackray	Japan	405
Charnley	[87]	n.s.	Norway	14842
Charnley	[71]	Johnson & Johnson	USA	160
Charnley Elite-Plus	[96]	Depuy	Sweden	114
Charnley Elite-Plus	[97]	Johnson & Johnson	Finland	885
Charnley Flat-back	[97]	Johnson & Johnson	Finland	925
CLS Spotorno	[45]	Sulzer-medica	Finland	108
Corail	[72]	DePuy, France	France	120
Exeter	[87]	n.s.	Norway	3934
Exeter Matt	[97]	Stryker	Finland	876
Exeter Universal	[97]	Stryker	Finland	10620
Exeter Universal	[73]	Howmedica	UK	230
Exeter Universal	[98]	Howmedica	UK	142
Freeman Cemented	[99]	Finsbury Instruments	UK	92
Freeman Cemented	[99]	Finsbury Instruments	UK	97
Freeman Cemented	[100]	Finsbury Instruments	Australia	202
Freeman Cementless	[101]	Finsbury Instruments	UK	100
Freeman Cementless	[74]	Finsbury Instruments	UK	100
Furlong	[56]	JRI	UK	134
Harris Design 2	[89]	Howmedica	Canada	195
Harvard Femoral Stem	[75]	Harvard Health Care	UK	269
Interlok	[97]	Biomet	Finland	581
ITH	[87]	n.s.	Norway	2019
Lord Madreporique	[45]	Benoist Girard	Finland	286
Lord Madreporique	[77]	Benoist Girard	Norway	116
Lubinus IP	[97]	Link	Finland	5790
Lubinus SP II	[97]	Link	Finland	10634
Mallory Head Cementless	[80]	Biomet	USA	2000
Mallory Head Cementless	[58]	Biomet	Canada	307
MS-30	[59]	Zimmer	Switzerland	124
Muller S PCNC[1]	[97]	Zimmer	Finland	2309
Muller S PCNC[1]	[102]	Protek	Switzerland	112
Muller S PCNC[1]	[103]	n.s.	Switzerland	161
Muller S T[2]	[104]	Protek	Germany	203
Muller Style Titanium	[105]	Lima	Slovenia	170
Omnifit Cemented	[71]	Osteonics	USA	305
Osteonics Cemented	[106]	Osteonics	USA	215
Osteonics Cementless	[81]	Stryker	USA	262
PCA	[45]	Howmedica	Finland	111
Profile Porous	[45]	Depuy	Finland	115
R-B Interlok	[71]	Biomet	USA	235
SBG	[82]	Plus Orthopaedics	Austria	230
Stanmore Custom Made	[83]	Depuy	Italy	129
Taperloc	[65]	Biomet	USA	123
Taperloc	[84]	Biomet	USA	129
Titan	[87]	n.s.	Norway	3205
Zweymuller Alloclassic	[94]	Sulzer-medica	France	200

Table 2.4: **Study Characteristics of all included Studies, describing the Survival Probability of Femoral Stems for Revision Aseptic Loosening.** n.s.: not specified. 1: Muller Straight Protasul-10 Cobalt-Nickel-Chromium. 2: Muller Straight Protasul-100 Titanium.

Cup	Ref.	Primary research question	Cohorts construction	Adequacy follow-up	Follow-up performed	n at risk at follow-up	Worst case or comp. risk analysis
ABG 1	[45]	Yes	NC	U	U	≥20	No
ABG 1	[46]	Yes	U	FC	P	<20	Yes
ABG II HA	[44]	Yes	NC	U	P	≥20	No
ACS Triloc+	[47]	Yes	NC	U	U	≥20	No
Arthopor	[47]	Yes	NC	U	U	≥20	No
ATLAS II	[48]	Yes	NC	>5% lost	U	U	No
ATLAS III	[48]	Yes	NC	>5% lost	U	U	No
Charnley	[49]	Yes	NC	U	U	≥20	No
Charnley	[44]	Yes	NC	U	P	≥20	No
Charnley Elite	[44]	Yes	NC	U	P	≥20	No
CLS Spotorno	[44]	Yes	NC	U	P	≥20	No
Conserve Plus	[50]	No	NC	5% lost	P	≥20	No
Exeter All-Poly[1]	[51]	Yes	U	≤5% lost	P	≥20	Yes
Exeter Duration	[44]	Yes	NC	U	P	≥20	No
Fitmore	[52]	Yes	NC	≤5% lost	NP	≥20	No
Harris Design 2	[53]	Yes	C	>5% lost	P	≥20	No
Harris-Galante I	[54]	Yes	NC	≤5% lost	U	≥20	No
Harris-Galante II	[45]	Yes	NC	U	U	≥20	No
Hofer-Imhof	[55]	Yes	U	>5% lost	P	≥20	No
JRI Threaded Cup	[56]	Yes	C	>5% lost	P	≥20	Yes
Lubinus	[44]	Yes	NC	U	P	≥20	No
Lubinus Eccentric	[57]	Yes	U	FC	NP	≥20	No
Mallory-Head[2]	[45]	Yes	NC	U	U	≥20	No
Mallory-Head[2]	[58]	Yes	NC	≤5% lost	P	≥20	No
MOSC: All Poly[3]	[49]	Yes	NC	U	U	≥20	No
MOSC: MB[4]	[49]	Yes	NC	U	U	≥20	No
Morscher Press Fit	[59]	No	NC	FC	P	≥20	No
Morscher Press Fit	[60]	Yes	NC	≤5% lost	P	≥20	No
Mueller	[49]	Yes	NC	U	U	≥20	No
Novae	[61]	Yes	NC	≤5% lost	U	≥20	No
PCA Pegged	[45]	Yes	NC	U	U	≥20	No
Plasmacup	[62]	Yes	NC	>5% lost	NP	≥20	No
RM	[63]	Yes	U	≤5% lost	U	U	Yes
Romanus	[45]	Yes	NC	U	U	≥20	No
T28	[49]	Yes	NC	U	U	≥20	No
T28	[64]	Yes	NC	≤5% lost	P	≥20	No
Trilogy HA	[44]	Yes	NC	U	P	≥20	No
Universal	[45]	Yes	NC	U	U	≥20	No
Universal	[65]	Yes	NC	≤5% lost	P	≥20	No
ZA Screw Cup[5]	[66]	Yes	NC	>5% lost	NP	≥20	No
ZA Screw Cup[5]	[67]	No	U	≤5% lost	U	≥20	No

Table 2.5: **Study Quality of all included Studies, describing the Survival Probability of Acetabular Cups for Revision Any Reason.** U: Unknown. C: Consecutively, NC: Non-Consecutively. FC: Fully Completed. P: Predefined, NP: Non-Predefined.
1: Exeter All-Polyethylene; 2: Mallory-Head Cementless; 3: Miami Orthopaedic Surgical Clinic, All Polyethylene; 4: Miami Orthopaedic Surgical Clinic, Metal Backed; 5: Zweymuller-Alloclassic Screw Cup.

Stem	Ref.	Primary research question	Cohorts construction	Adequacy follow-up	Follow-up performed	n at risk at follow-up	Worst case or comp. risk analysis
ABG 1	[45]	Yes	NC	U	NP	≥20	No
ABG 1	[46]	Yes	U	FC	P	<20	Yes
ABG 1	[44]	Yes	NC	U	P	≥20	No
Anatomic Mesh	[45]	Yes	NC	U	NP	≥20	No
Bicontact	[68]	Yes	U	≤5% lost	NP	≥20	No
Bi-Metric	[69]	Yes	U	≤5% lost	NP	≥20	No
Bi-Metric	[45]	Yes	NC	U	NP	≥20	No
Bi-Metric	[70]	Yes	U	≤5% lost	P	≥20	Yes
Charnley	[71]	Yes	C	>5% lost	NP	≥20	Yes
Charnley	[44]	Yes	NC	U	P	≥20	No
CLS Spotorno	[45]	Yes	NC	U	NP	≥20	No
CLS Spotorno	[44]	Yes	NC	U	P	≥20	No
Conserve Plus	[50]	Yes	NC	≤5% lost	P	≥20	No
Corail	[72]	Yes	U	≤5% lost	NP	≥20	No
Exeter Polished	[44]	Yes	NC	U	P	≥20	No
Exeter Universal	[73]	Yes	U	≤5% lost	P	≥20	Yes
Freeman Cementless	[74]	Yes	U	>5% lost	P	≥20	Yes
Furlong	[56]	Yes	C	≤5% lost	P	≥20	Yes
Harvard Femoral Stem	[75]	Yes	U	≤5% lost	NP	≥20	No
Heritage	[76]	Yes	NC	U	P	≥20	No
Iowa polished	[76]	Yes	NC	U	P	≥20	No
Lord Madreporique	[45]	Yes	NC	U	NP	≥20	No
Lord Madreporique	[77]	Yes	C	≤5% lost	NP	≥20	No
Lubinus IP	[78]	Yes	NC	≤5% lost	P	≥20	No
Lubinus IP	[57]	Yes	NC	FC	NP	≥20	No
Lubinus SP	[78]	Yes	NC	>5% lost	P	≥20	No
Lubinus SP	[57]	Yes	NC	FC	NP	≥20	No
Lubinus SPII	[44]	Yes	NC	U	P	≥20	No
Mallory Head Cemented	[79]	Yes	NC	≤5% lost	NP	≥20	No
Mallory Head Cementless	[80]	Yes	U	>5% lost	NP	≥20	No
Mallory Head Cementless	[58]	Yes	NC	≤5% lost	P	≥20	No
MS-30	[59]	Yes	U	FC	P	≥20	No
Omnifit Cemented	[71]	Yes	NC	>5% lost	NP	≥20	Yes
Osteonics Cementless	[81]	Yes	U	U	NP	≥20	No
PCA	[45]	Yes	NC	U	NP	≥20	No
Profile Porous	[45]	Yes	NC	U	NP	≥20	No
R-B Interlok	[71]	Yes	NC	>5% lost	NP	≥20	Yes
SBG	[82]	Yes	U	>5% lost	NP	≥20	No
Stanmore Custom Made	[83]	Yes	NC	FC	P	≥20	No
Taperloc	[84]	Yes	U	≤5% lost	P	≥20	Yes
Triumph	[76]	Yes	NC	U	P	≥20	No
Zweymuller SL	[66]	Yes	NC	>5% lost	NP	≥20	No

Table 2.6: **Study Quality of all included Studies, describing the Survival Probability of Femoral Stems for Revision Any Reason.** U: Unknown. C: Consecutively; NC: Non-Consecutively. FC: Fully Completed. P: Predefined; NP: Non-Predefined.

Cup	Ref.	Primary research question	Cohorts construction	Adequacy follow-up	Follow-up performed	n at risk at follow-up	Worst case or comp. risk analysis
ABG 1	[45]	Yes	NC	U	U	≥20	No
ACS Triloc+	[47]	Yes	NC	U	U	≥20	No
Arthopor	[47]	Yes	NC	U	U	≥20	No
Brunswik	[85]	Yes	NC	FC	NP	≥20	No
Charnley	[86]	No	C	≤5% lost	NP	≥20	No
Charnley	[85]	Yes	NC	FC	NP	≥20	No
Charnley	[87]	Yes	NC	≤5% lost	NP	≥20	No
Charnley	[49]	Yes	NC	U	U	≥20	No
Charnley All-Poly	[88]	No	NC	>5% lost	U	≥20	No
Conserve Plus	[50]	No	NC	≤5% lost	P	≥20	No
Elite Ogee	[73]	No	NC	≤5% lost	U	U	Yes
Exeter	[87]	Yes	NC	≤5% lost	NP	≥20	No
Exeter All-Poly	[51]	Yes	U	≤5% lost	P	≥20	Yes
Fitmore	[52]	Yes	NC	≤5% lost	NP	≥20	No
Harris Design-2 All-Polyethylene	[89]	Yes	U	≤5% lost	P	≥20	No
Harris-Galante II	[45]	Yes	NC	U	U	≥20	No
Hofer-Imhof	[90]	Yes	NC	FC	P	≥20	No
Hofer-Imhof	[55]	Yes	U	>5% lost	P	≥20	No
JRI Threaded Cup	[56]	Yes	C	>5% lost	P	≥20	Yes
Link	[87]	Yes	NC	≤5% lost	NP	≥20	No
Lord Threaded	[77]	Yes	C	U	P	≥20	Yes
Mallory-Head Cementless	[45]	Yes	NC	U	U	≥20	No
MOSC[1]: All Poly	[49]	Yes	NC	U	U	≥20	No
MOSC[1]: Metal Backed	[49]	Yes	NC	U	U	≥20	No
Morscher Press Fit	[59]	No	NC	FC	P	≥20	No
Morscher Press Fit	[60]	Yes	NC	≤5% lost	P	≥20	No
Mueller	[49]	Yes	NC	U	U	≥20	No
PCA Pegged	[45]	Yes	NC	U	U	≥20	No
Romanus	[45]	Yes	NC	U	U	≥20	No
Spectron	[87]	Yes	NC	≤5% lost	NP	≥20	No
T-28	[64]	Yes	NC	≤5% lost	P	≥20	No
T-28	[49]	Yes	NC	U	U	≥20	No
Titan	[87]	Yes	NC	≤5% lost	NP	≥20	No
Trabecular Metal Monoblock ACS[2]	[91]	Yes	NC	FC	NP	≥20	No
Universal	[45]	Yes	NC	U	U	≥20	No
Universal	[65]	Yes	NC	≤5% lost	P	≥20	No
Weber Hemispheric	[92]	Yes	U	>5% lost	U	≥20	Yes
ZA[3] Screw Cup	[93]	Yes	U	≤5% lost	P	≥20	Yes
ZA[3] Screw Cup	[94]	Yes	NC	U	P	≥20	Yes

Table 2.7: **Study Quality of all included Studies, describing the Survival Probability of Acetabular Cups for Revision Aseptic Loosening.** U: Unknown. C: Consecutively; NC: Non-Consecutively. FC: Fully Completed. P: Predefined; NP: Non-Predefined.
1: Miami Orthopaedic Surgical Clinic. 2: Acetabular Component System. 3: Zweymuller-Alloclassic.

Stem	Ref.	Primary research question	Cohorts construction	Adequacy follow-up	Follow-up performed	n at risk at follow-up	Worst case or comp. risk analysis
ABG 1	[45]	Yes	NC	U	NP	≥20	No
ABG 1	[46]	Yes	U	FC	P	<20	Yes
Anatomic Mesh	[45]	Yes	NC	U	NP	≥20	No
Bimetric	[69]	Yes	U	≤5% lost	NP	≥20	No
Bimetric	[45]	Yes	NC	U	NP	≥20	No
Bimetric	[70]	Yes	U	≤5% lost	P	≥20	Yes
Charnley	[95]	No	U	U	NP	≥20	No
Charnley	[87]	Yes	NC	U	P	≥20	No
Charnley	[71]	Yes	C	>5% lost	NP	≥20	No
Charnley Elite-Plus	[96]	Yes	NC	U	P	≥20	No
Charnley Elite-Plus	[97]	Yes	NC	U	NP	≥20	No
Charnley Flat-back	[97]	Yes	NC	U	NP	≥20	No
CLS Spotorno	[45]	Yes	NC	U	NP	≥20	No
Corail	[72]	Yes	U	≤5% lost	NP	≥20	No
Exeter	[87]	Yes	NC	U	P	≥20	No
Exeter Matt	[97]	Yes	NC	U	NP	≥20	No
Exeter Universal	[97]	Yes	NC	U	NP	≥20	No
Exeter Universal	[73]	Yes	U	≤5% lost	P	≥20	Yes
Exeter Universal	[98]	Yes	U	FC	NP	≥20	No
Freeman Cemented	[99]	No	U	≤5% lost	P	≥20	No
Freeman Cemented	[99]	No	U	≤5% lost	P	≥20	No
Freeman Cemented	[100]	Yes	U	≤5% lost	NP	<20	No
Freeman Cementless	[101]	Yes	U	≤5% lost	P	≥20	Yes
Freeman Cementless	[74]	Yes	U	>5% lost	P	≥20	Yes
Furlong	[56]	Yes	C	≤5% lost	P	≥20	No
Harris Design 2	[89]	Yes	U	≤5% lost	P	≥20	No
Harvard Femoral Stem	[75]	Yes	U	≤5% lost	NP	≥20	No
Interlok	[97]	Yes	NC	U	NP	≥20	No
ITH	[87]	Yes	NC	U	P	≥20	No
Lord Madreporique	[45]	Yes	NC	U	NP	≥20	No
Lord Madreporique	[77]	Yes	C	≤5% lost	NP	≥20	No
Lubinus IP	[97]	Yes	NC	U	NP	≥20	No
Lubinus SP II	[97]	Yes	NC	U	NP	≥20	No
Mallory Head Cementless	[80]	Yes	U	>5% lost	NP	≥20	No
Mallory Head Cementless	[58]	Yes	NC	≤5% lost	P	≥20	No
MS-30	[59]	Yes	U	FC	P	≥20	No
Muller Straight CNC[1]	[97]	Yes	NC	U	NP	≥20	No
Muller Straight CNC[1]	[102]	Yes	NC	≤5% lost	NP	≥20	No
Muller Straight CNC[1]	[103]	Yes	U	≤5% lost	P	≥20	No
Muller Straight Ti[2]	[104]	Yes	NC	>5% lost	NP	≥20	No
Muller Style Titanium	[105]	Yes	NC	≤5% lost	P	≥20	No
Omnifit Cemented	[71]	Yes	C	>5% lost	NP	≥20	No
Osteonics Cemented	[106]	Yes	C	>5% lost	NP	≥20	No
Osteonics Cementless	[81]	Yes	U	U	NP	≥20	No
PCA	[45]	Yes	NC	U	NP	≥20	No
Profile Porous	[45]	Yes	NC	U	NP	≥20	No
R-B Interlok	[71]	Yes	C	>5% lost	NP	≥20	No
SBG	[82]	Yes	U	>5% lost	NP	≥20	No
Stanmore Custom Made	[83]	Yes	NC	FC	P	≥20	No
Taperloc	[65]	Yes	NC	≤5% lost	P	≥20	No
Taperloc	[84]	Yes	U	≤5% lost	P	≥20	Yes
Titan	[87]	Yes	NC	U	P	≥20	No
Zweymuller Alloclassic	[94]	Yes	NC	U	P	≥20	Yes

Table 2.8: **Study Quality of all included Studies, describing the Survival Probability of Femoral Stems for Revision Aseptic Loosening.** 1: Muller Straight Protasul-10 Cobalt-Nickel-Chromium; 2: Muller Straight Protasul-100 Titanium.

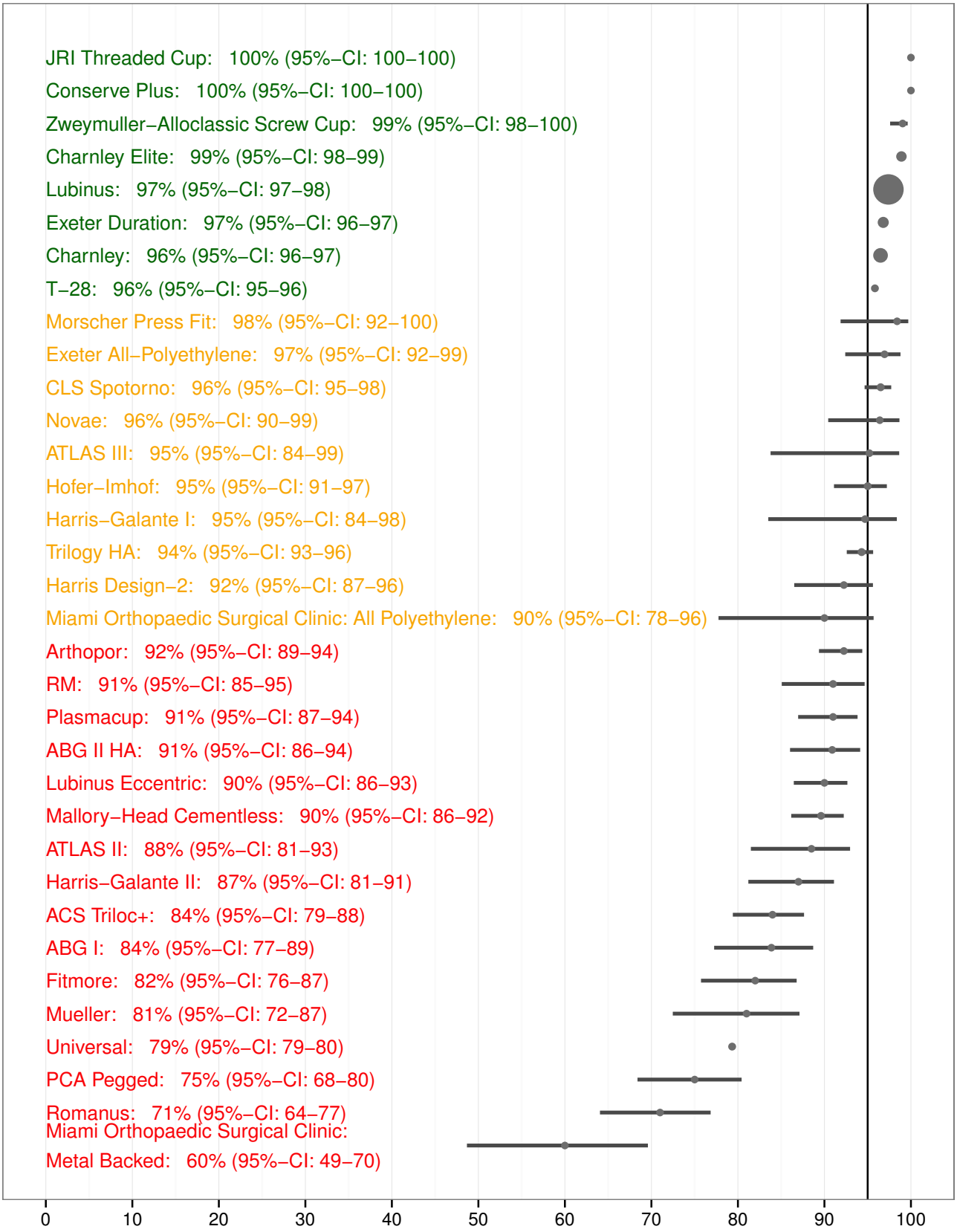

Figure 2.2: **Cumulative Survival and 95% Confidence Intervals of Acetabular Cups at 10 years follow-up, using the endpoint Revision for Any reason.** The vertical line indicates the NICE benchmark; the color of the text indicates whether an implant performs significantly better (green) or worse (red) than the NICE benchmark. The size of the points indicates the sample size on which the estimates are based.

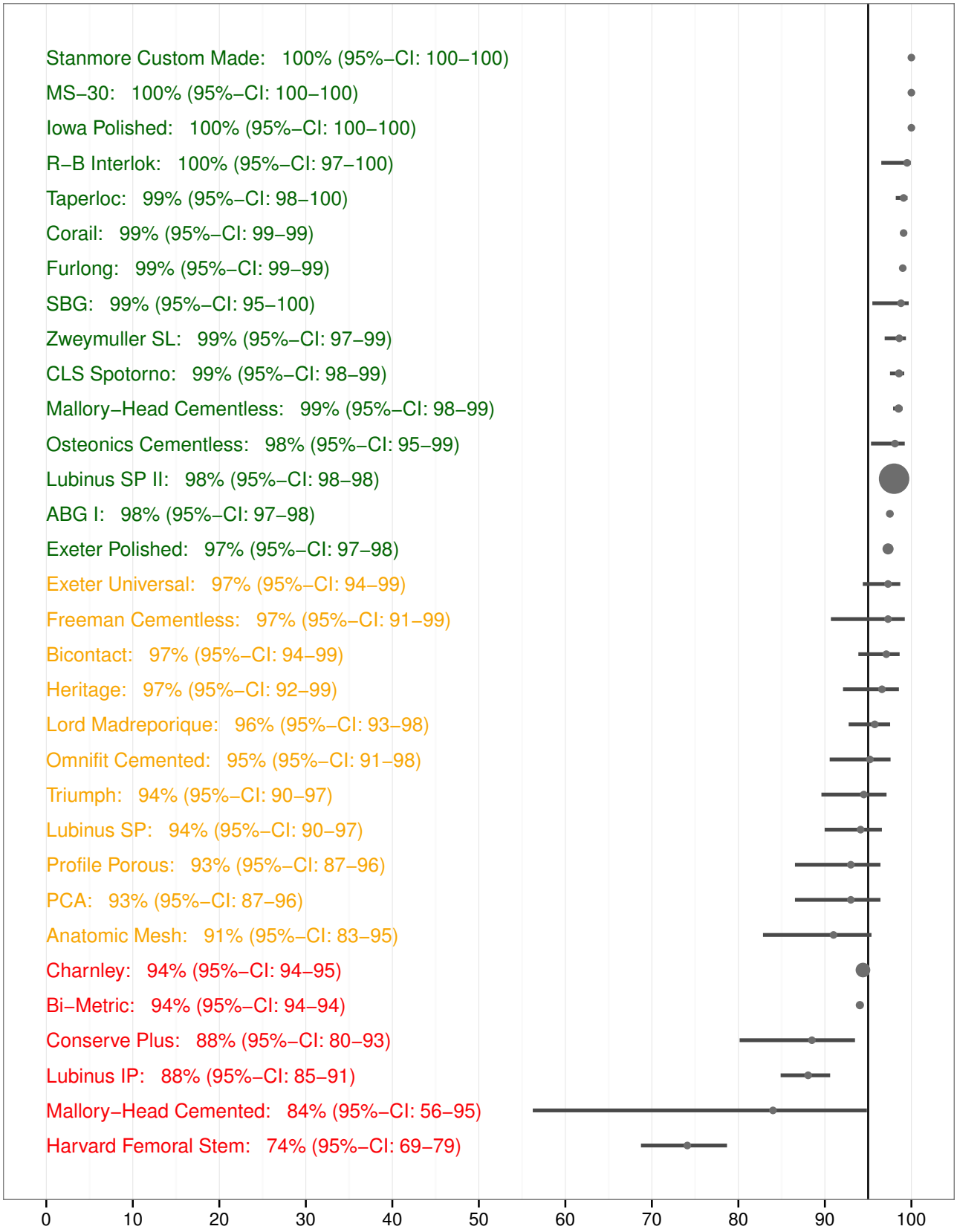

Figure 2.3: **Cumulative Survival and 95% Confidence Intervals of Femoral Stems at 10 years follow-up, using the endpoint Revision for Any reason.** The vertical line indicates the NICE benchmark; the color of the text indicates whether an implant performs significantly better (green) or worse (red) than the NICE benchmark. The size of the points indicates the sample size on which the estimates are based.

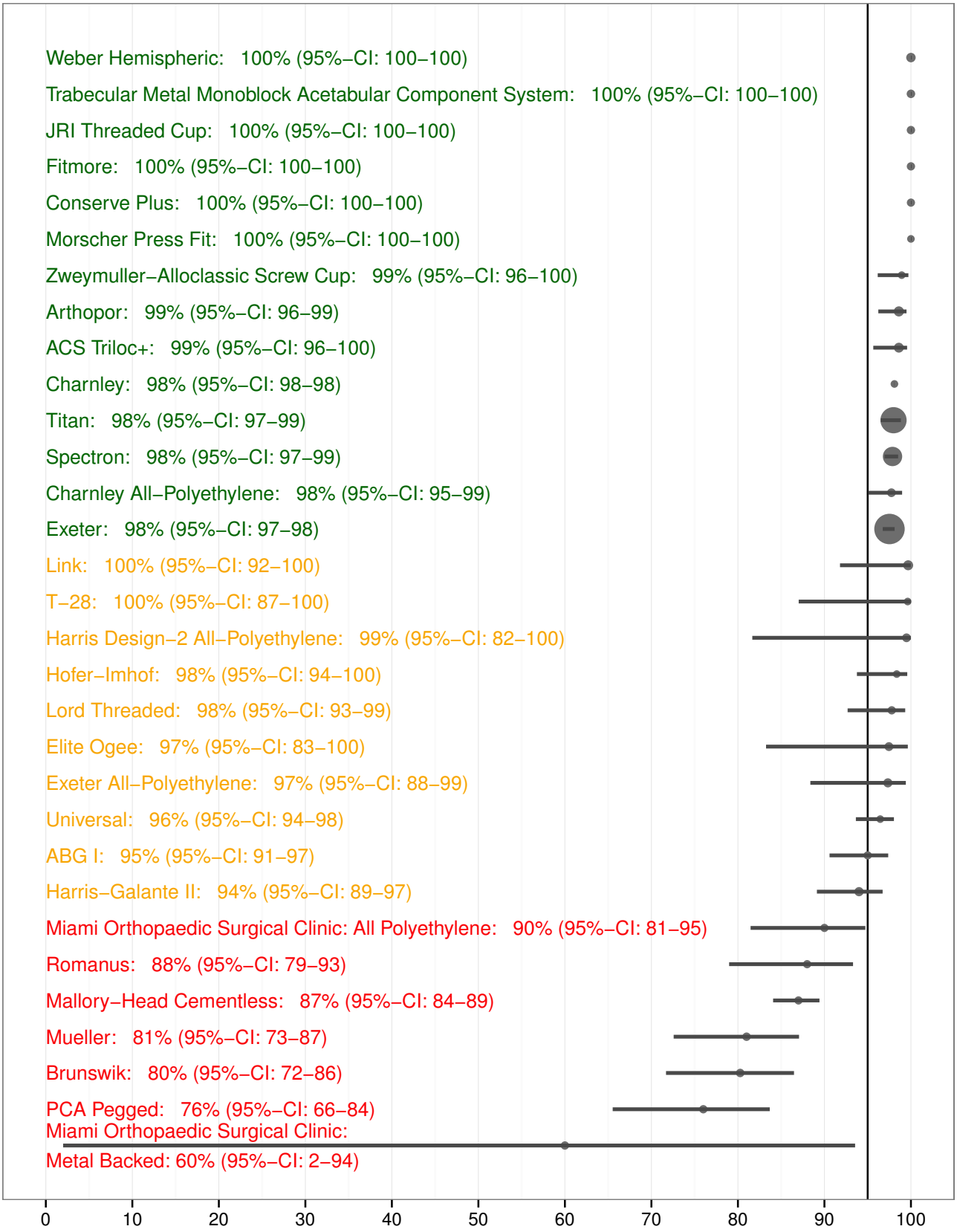

Figure 2.4: **Cumulative Survival and 95% Confidence Intervals of Acetabular Cups at 10 years follow-up, using the endpoint Revision for Aseptic Loosening.** The vertical line indicates the NICE benchmark; the color of the text indicates whether an implant performs significantly better (green) or worse (red) than the NICE benchmark. The size of the points indicates the sample size on which the estimates are based.

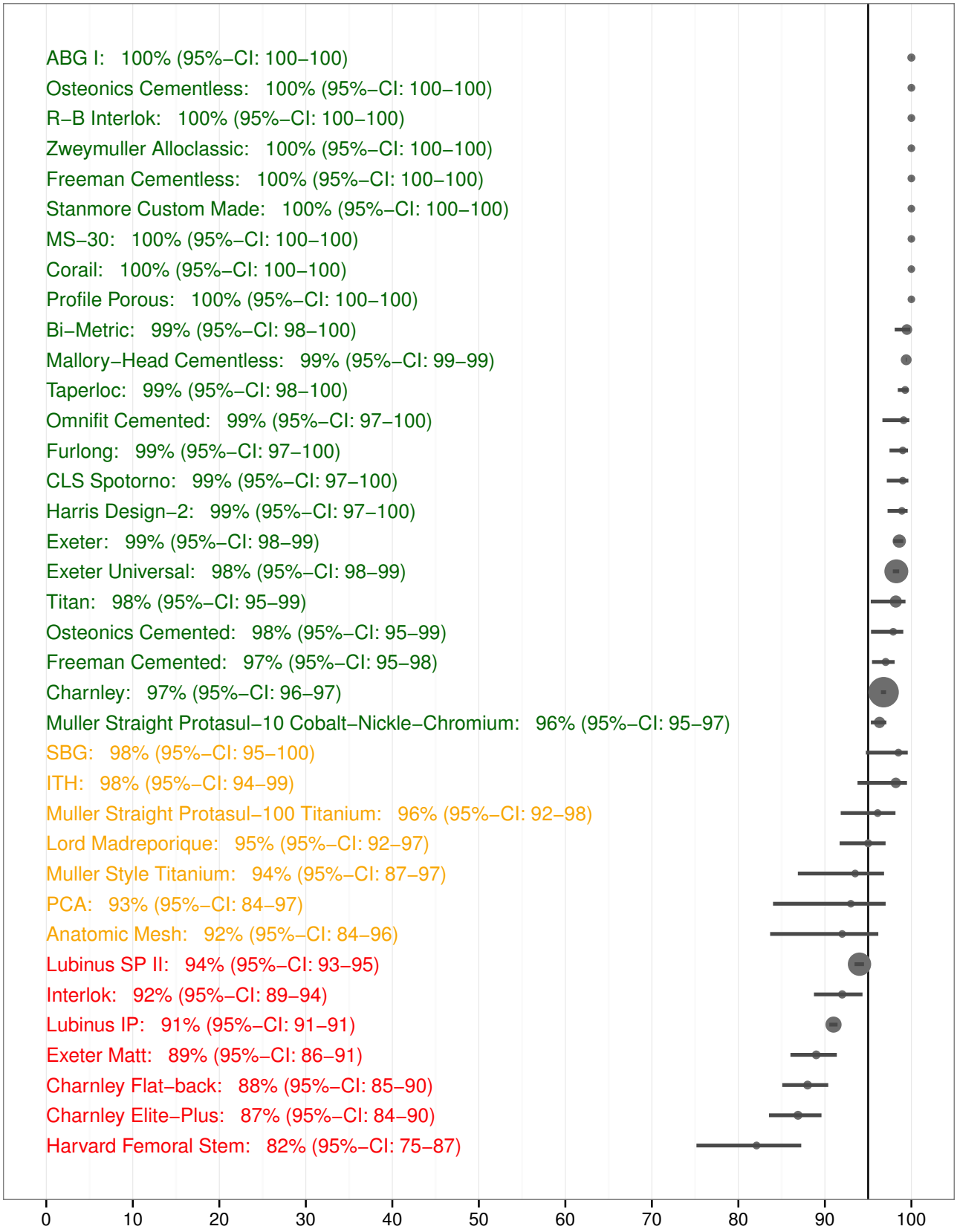

Figure 2.5: **Cumulative Survival and 95% Confidence Intervals of Femoral Stems at 10 years follow-up, using the endpoint Revision for Aseptic Loosening.** The vertical line indicates the NICE benchmark; the color of the text indicates whether an implant performs significantly better (green) or worse (red) than the NICE benchmark. The size of the points indicates the sample size on which the estimates are based.