Reduced Risk of Revision with Computer-Guided Versus Non-Computer-Guided THA

An Analysis of Manufacturer-Specific Data from the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man

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Background: Computer-assisted total hip arthroplasty (THA) is known to improve implantation precision, but clinical data demonstrating an improvement in survivorship and patient-reported outcome measures (PROMs) are lacking. Our aim was to compare the risk of revision, PROMs, and patient satisfaction between cohorts who underwent THA with and without the use of computer guidance.

Methods: We used the data set and linked PROM data of the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man. Our sample included THAs performed for osteoarthritis using cementless acetabular components from a single manufacturer (cementless and hybrid THAs). An additional analysis was performed limiting the sample size to cementless-only THAs. The primary end point was revision (any component) for any reason. Kaplan-Meier survivorship analysis and an adjusted Cox proportional-hazards model were used.

Results: There were 41,683 non-computer-guided and 871 (2%) computer-guided cases included in our analysis of the cementless and hybrid group. There were 943 revisions in the non-computer-guided group and 7 in the computer-guided group. The cumulative revision rate at 10 years was 3.88% (95% confidence interval [CI]: 3.59% to 4.18%) for the non-computer-guided group and 1.06% (95% CI: 0.45% to 2.76%) for the computer-guided group. The Cox proportional-hazards model yielded a hazard ratio of 0.45 (95% CI: 0.21 to 0.96; p = 0.038). In the analysis of the cementless-only group, the cumulative revision rate at 10 years was 3.99% (95% CI: 3.62% to 4.38%) and 1.20% (95% CI: 0.52% to 3.12%) for the 2 groups, respectively. The Cox proportional-hazards model yielded a hazard ratio of 0.47 (95% CI: 0.22 to 1.01; p = 0.053). There was no significant difference in the 6-month Oxford Hip Score, the EuroQol-5 Dimension (EQ-5D) and EQ-VAS (Visual Analogue Scale) scores, and patient-reported success rates. Patient satisfaction (single-item satisfaction outcome measure) was higher in the computer-guided group, but this finding was limited by a reduced number of responses.

Conclusions: In our analysis, the use of computer-guided surgery was associated with a lower rate of revision at mean follow-up of 5.6 years. This finding was upheld when the sample was restricted to cementless-only THAs. Causality cannot be inferred in view of the observational nature of the study, and additional studies are recommended to validate these findings.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Computer-guided surgery has been used in arthroplasty for over 2 decades; the first clinical report, to our knowledge, on the use of an active robot and image-based guidance was published in the early 1990s1. Since its introduction, the technology has evolved, and different iterations of computer-guided surgery have been employed.

Disclosure: The Disclosure of Potential Conflicts of Interest forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A304).

Disclaimer: The data used for this analysis was obtained from the National Joint Registry (“NJR”), part of the Healthcare Quality Improvement Partnership (“HQIP”). HQIP, the NJR and/or its contractor, Northgate Public Services (U.K.) Limited (“NPS”) Limited (“NPS”) take no responsibility (except as prohibited by law) for the accuracy, currency, reliability and correctness of any data used or referred to in this report, nor for the accuracy, currency, reliability and correctness of links or references to other information sources and disclaim all warranties in relation to such data, links and references to the maximum extent permitted by legislation including any duty of care to third party readers of the data analysis.

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including active robotic systems use, image-based computer navigation, imageless navigation, and more recently, haptic robotic-arm-assisted hip arthroplasty. Proponents of computer-guided surgery cite the improved precision in component placement and, therefore, the reduction in component-positioning outliers. Opponents, however, raise the issues of increased capital expenditure, increased operative time, the need for training, and the lack of difference in functional outcome scores or survival in studies.

Higher-level evidence on computer-guided total hip arthroplasty (THA) remains scarce, with a frequently cited study in THA navigation consisting of 60 patients randomized to computer-navigated or conventional THA using a Watson-Jones approach. Ten-year follow-up revealed no differences in radiograph-measured wear or patient-reported outcome measures (PROMs). Large data sets have more recently been used to assess the outcomes of THAs performed with computer navigation. A recent large database study reported a significant reduction in the risk of dislocation and revision of the acetabular component at short-term follow-up. A large percentage of early THA failures are considered avoidable, and suboptimal positioning of the acetabular component was reported as the most common avoidable factor in a large academic-center retrospective study.

The aim of the current study was to assess the effect of computer guidance on the survival of THA and patient satisfaction using the data set and linked PROM data of the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man (NJR).

Our hypothesis was that computer-guided surgery is associated with improved survival and improved PROMs when compared with THAs performed without computer guidance.

Materials and Methods

NJR Data Set

NJR primary THA records from April 3, 2003, to February 8, 2020, were analyzed. The NJR collects data on whether computer-guided surgery was used (yes/no) but not on the type of system used. As a result, our analysis does not include information on the system used for computer guidance. All THAs involving the use of cementless acetabular components by a single manufacturer (Smith & Nephew) were eligible for analysis. THAs with metal-on-metal bearing surfaces were excluded from the analysis because of unique failure mechanisms associated with this bearing. Polyethylene-based bearings and ceramic-on-ceramic THAs were included. THAs performed for indications other than osteoarthritis were excluded. The primary end point was revision of any component. Reasons for revisions were selected by the surgeon at the time of surgery from a predetermined list. Multiple reasons can be selected per case. The details of the included cups are available in the full text of the NJR Bespoke Implant Report.

Restricted Sample: Cementless-Only THAs

Previous work using the NJR data set has revealed a significant association between stem fixation and prosthetic joint survival. In order to eliminate the effect of stem fixation on our analysis, we restricted the sample size to THAs utilizing cementless stems from the same manufacturer. Details of the types of stems included in the analysis are available in the full text of the NJR Bespoke Implant Report.

PROMs

PROMs are recorded by NHS Digital for patients undergoing inpatient elective surgery funded by the National Health Service (NHS) in England. Patients are asked to complete preoperative and postoperative questionnaires to assess improvement in health as perceived by the patients themselves. Condition-specific measures and general health measures are used. For patients undergoing THA, the measures used are the Oxford Hip Score (OHS), the EuroQol-5 Dimension (EQ-5D) Index, and the EQ-Visual Analogue Scale (EQ-VAS). The minimal important change (MIC) in the OHS was defined as 11 points, and the minimal detectable change (MDC), 5 points.

As different organizations may treat patients of differing complexity or case mix, PROMs are adjusted using statistical models to account for this. Adjusted scores in our analysis correspond to the NHS Digital version 3 case-mix-adjustment model. This includes patient variables from PROMs, Hospital Episode Statistics, and the Index of Multiple Deprivation.

Patients were also asked in their postoperative questionnaires how they would describe the results of their operation by answering 2 questions: (1) “Overall, how are your problems now compared with before your operation?” (single-item success measure), and (2) “How would you describe the results of your operation?” (single-item satisfaction measure). The patients provide a response to those 2 questions on a 5-point scale, from poor to excellent.

Statistical Analysis

Survival analysis was performed using a Kaplan-Meier product limit estimator. In addition, a Cox proportional-hazards model was built for the risk of revision between the computer-guided and non-computer-guided groups. The proportional-hazards assumption was tested using scaled Schoenfeld residuals and was met. The hazard ratio reported is a simple average hazard ratio, which is the geometric average of the hazard ratios at all revision times and is not weighted by numbers of individuals at risk. The Cox model was adjusted for sex, American Society of Anesthesiologists (ASA) group, approach, prosthesis head size, year cohort, age group, body mass index (BMI) group, and bearing.

PROM health gains were analyzed using a Mann-Whitney U test (since data were not normally distributed). An analysis of the success and satisfaction measures was performed by plotting each of 5 possible responses for both the computer-guided and non-computer-guided THAs. These responses were not case-mix adjusted. A chi-square test was used to test the significance of any difference in response pattern between the 2 groups.

The statistical analysis was performed independently of the authors of the manuscript as part of a bespoke report through the National Joint Registry Supplier Feedback framework. An NJR data-sharing request for the bespoke
reports was approved by the Healthcare Quality Improvement Partnership (HQIP). The full reports are available online.\textsuperscript{18,19}

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The study was funded through a restricted grant by Smith & Nephew. Multiple authors are employees of Smith & Nephew. The funding body had no access to the data or the statistical analysis, which was performed independently of the authors of the manuscript.

### Results

**Cementless and Hybrid THAs**

Computer-guided surgery was used in 871 (2%) of 42,554 cases. There were a total of 943 revisions in the non-computer-guided group and 7 revisions in the computer-guided group. Patient demographics and implant-usage details are shown in Table I. The reasons for revision in both groups are shown in Table II.

Kaplan-Meier survival analysis revealed a significantly lower cumulative revision rate at 10 years in the computer-guided group compared to the non-computer-guided group. The survival rates were 91.5% and 83.2%, respectively.

### Table I: Patient Demographics and Procedure Details\textsuperscript{*}

|                        | Cementless and Hybrid THAs | Cementless-Only THAs |
|------------------------|----------------------------|-----------------------|
|                        | Computer-Guided | Non-Computer-Guided | Computer-Guided | Non-Computer-Guided |
| Total no. of procedures | 871            | 41,683               | 761             | 29,785               |
| Total no. of patients  | 799            | 37,956               | 699             | 27,018               |
| Demographics           |               |                       |                 |                       |
| Age                    |               |                       |                 |                       |
| Mean (yr)              | 66.8          | 67.4                  | 66.8            | 65.5                  |
| <50 yr                 | 5.9%          | 5.2%                  | 6.6%            | 6.6%                  |
| 50-59 yr               | 16.4%         | 16.9%                 | 18.5%           | 20.6%                 |
| 60-69 yr               | 34.7%         | 33.0%                 | 35.9%           | 36.1%                 |
| 70-79 yr               | 34.0%         | 33.2%                 | 32.5%           | 28.7%                 |
| ≥80 yr                 | 9.1%          | 11.9%                 | 6.6%            | 7.9%                  |
| BMI                    |               |                       |                 |                       |
| Median (kg/m\textsuperscript{2}) | 28     | 29                     | 28              | 29                     |
| % BMI information available | 71.8% | 67.2%                   | 70.7%           | 67.5%                  |
| Underweight (BMI <18.5 kg/m\textsuperscript{2}) | 0.2% | 0.7%                   | 0.2%            | 0.5%                   |
| Normal (18.5 ≤ BMI <25 kg/m\textsuperscript{2}) | 17.0% | 17.5%                 | 15.1%           | 16.7%                  |
| Overweight (25 ≤ BMI <30 kg/m\textsuperscript{2}) | 44.0% | 39.2%                 | 44.2%           | 39.0%                  |
| Obese I (30 ≤ BMI <35 kg/m\textsuperscript{2}) | 31.0% | 27.8%                 | 32.2%           | 28.4%                  |
| Obese II (35 ≤ BMI <40 kg/m\textsuperscript{2}) | 6.6%  | 11.1%                | 7.2%            | 11.5%                  |
| Obese III (BMI ≥40 kg/m\textsuperscript{2}) | 1.3%  | 3.7%                | 1.1%            | 3.9%                   |
| Sex                    |               |                       |                 |                       |
| % male                 | 45.6%         | 42.8%                 | 48.8%           | 45.9%                  |
| ASA grade              |               |                       |                 |                       |
| P1 - fit and healthy   | 16.3%         | 15.9%                 | 17.5%           | 17.7%                  |
| P2 - mild disease, not incapacitating | 78.6% | 69.4%                 | 77.8%           | 69.0%                  |
| P3 - incapacitating systemic disease | 5.1%  | 14.4%                | 4.7%            | 13.0%                  |
| P4/P5                  | 0.0%          | 0.4%                  | 0.0%            | 0.3%                   |
| Indications            |               |                       |                 |                       |
| Osteoarthritis         | 100.00%       | 100.00%               | 100%            | 100%                   |
| Implant usage          |               |                       |                 |                       |
| First usage in the NJR | Sep. 9, 2003  | Apr. 3, 2003          | Apr. 2, 2005    | Apr. 3, 2003          |
| Last usage in this data set | Jan. 27, 2020 | Feb. 8, 2020         | Jan. 27, 2020   | Feb. 8, 2020          |
| Max. implantation time (yr) | 15.7 | 16.9                 | 14.9            | 16.8                   |
| Mean implantation time (yr) | 5.6   | 5.2                 | 5.6             | 4.9                    |
| Centers (no.)          | 26            | 200                  | 20              | 179                    |
| Surgeons (no.)         | 36            | 956                  | 27              | 745                    |

\*ASA = American Society of Anesthesiologists, BMI = body mass index, NJR = National Joint Registry, and THA = total hip arthroplasty. The complete NJR Bespoke Implant Reports are available online.\textsuperscript{18,19}
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guided group (1.06% [95% confidence interval (CI): 0.45% to 2.76%]) compared with the non-computer-guided group (3.88% [95% CI: 3.59% to 4.18%]) (Fig. 1-A). A Cox model that was adjusted for sex, ASA group, approach, prosthesis head size, year cohort, age group, BMI group, and bearing revealed a hazard ratio of 0.45 (95% CI: 0.21 to 0.96). This was significant (p = 0.038).

Cementless-Only THAs

Computer-guided surgery was used in 761 (2.5%) of 30,546 cases. There were a total of 648 revisions in the non-computer-guided group and 7 revisions in the computer-guided group. The cumulative incidence of revision at 10 years was 1.20% (95% CI: 0.52% to 3.12%) in the computer-guided group and 3.99% (95% CI: 3.62% to 4.38%) in the non-guided group (Fig. 1-B). The adjusted Cox model revealed a hazard ratio of 0.47 (95% CI: 0.22 to 1.01). This did not reach significance (p = 0.053).

**PROMs and Single-Item Responses**

The analysis of PROMs revealed clinically notable improvements in the postoperative scores of all measures recorded in both the hybrid and cementless group and the cementless-only group (Table III). Both the computer-guided and non-guided groups exceeded the MIC of 11 points in the OHS. The mean difference in the 6-month OHS between groups did not reach the MDC of 5 points. The comparison of the adjusted health gain between the computer-guided and non-guided groups did not reveal a significant difference in the OHS, the EQ-5D, or the EQ-VAS (Table III). Patient-reported success rates at the 6-month postoperative point (single question) did not differ between the 2 groups (chi-square test, p = 0.123 in

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**TABLE II Reasons for Revision and Components Revised**

| Reason for revision | Cementless and Hybrid THAs* Revised† (% of All Cases) | Non-Computer-Guided Revised† (% of All Cases) | Cementless-Only THAs* Revised† (% of All Cases) | Non-Computer-Guided Revised† (% of All Cases) |
|---------------------|-------------------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| Unexplained pain    | 1 (0.11%)                                             | 121 (0.29%)                                 | 1 (0.13%)                                   | 94 (0.32%)                                  |
| Dislocation/subluxation | 1 (0.11%)                                       | 203 (0.49%)                                 | 1 (0.13%)                                   | 121 (0.41%)                                 |
| Adverse soft-tissue reaction | 0                                             | 26 (0.06%)                                  | 0                                           | 18 (0.06%)                                  |
| Infection           | 1 (0.11%)                                             | 156 (0.37%)                                 | 1 (0.13%)                                   | 100 (0.34%)                                 |
| Aseptic loosening: stem | 2 (0.23%)                                     | 206 (0.49%)                                 | 2 (0.26%)                                   | 174 (0.58%)                                 |
| Aseptic loosening: socket | 0                                                | 79 (0.19%)                                  | 0                                           | 51 (0.17%)                                  |
| Periprosthetic fracture: stem | 2 (0.23%)                                   | 132 (0.32%)                                 | 2 (0.26%)                                   | 86 (0.29%)                                  |
| Periprosthetic fracture: socket | 0                                                | 7 (0.02%)                                   | 0                                           | 5 (0.02%)                                   |
| Malalignment: stem   | 0                                                    | 31 (0.07%)                                  | 0                                           | 26 (0.09%)                                  |
| Malalignment: socket | 1 (0.11%)                                             | 63 (0.15%)                                  | 1 (0.13%)                                   | 46 (0.15%)                                  |
| Wear of acetabular component | 0                                               | 79 (0.19%)                                  | 0                                           | 51 (0.17%)                                  |
| Lysis: stem          | 0                                                    | 40 (0.10%)                                  | 0                                           | 22 (0.07%)                                  |
| Lysis: socket        | 0                                                    | 32 (0.08%)                                  | 0                                           | 14 (0.05%)                                  |
| Implant fracture: stem | 0                                                  | 21 (0.05%)                                  | 0                                           | 10 (0.03%)                                  |
| Implant fracture: socket | 0                                                  | 15 (0.04%)                                  | 0                                           | 13 (0.04%)                                  |
| Implant fracture: head | 0                                                 | 7 (0.02%)                                   | 0                                           | 5 (0.02%)                                   |
| Dissociation of liner | 0                                                  | 12 (0.03%)                                  | 0                                           | 9 (0.03%)                                   |
| Other/reason not recorded | 1 (0.11%)                                 | 29 (0.07%)                                  | 1 (0.13%)                                   | 23 (0.08%)                                  |
| **Total revised**    | **7 (0.8%)**                                         | **943 (2.26%)**                             | **7 (0.92%)**                               | **648 (2.18%)**                             |
| Components revised   |                                                      |                                             |                                             |                                             |
| Femoral only         | 2 (28.6%)                                            | 271 (28.7%)                                 | 2 (28.6%)                                   | 212 (32.7%)                                 |
| Acetabular only      | 0                                                    | 176 (18.7%)                                 | 0                                           | 125 (19.3%)                                 |
| Both femoral and acetabular revision recorded‡ | 4 (57.1%)                                             | 357 (37.9%)                                 | 4 (57.1%)                                   | 223 (34.4%)                                 |
| Neither femoral nor acetabular revision recorded‡ | 1 (14.3%)                                             | 139 (14.7%)                                 | 1 (14.3%)                                   | 88 (13.6%)                                  |

*THA = total hip arthroplasty. †Multiple reasons may be listed for 1 revision procedure. ‡Includes isolated head and/or liner exchange. The complete NJR Bespoke Implant Reports are available online18,19.
the full analysis and $p = 0.173$ in the cementless-only analysis). However, the satisfaction rate was significantly higher in the computer-guided group (chi-square test, $p = 0.003$ and $p = 0.039$, respectively).

**Discussion**

Our study revealed a lower rate of revision in THAs performed with computer guidance; this reached significance in our analysis of the group with cementless and hybrid THAs. In the analysis of our cementless-only THA group, the effect was of similar magnitude but did not reach significance in this smaller sample size. Our PROM analysis was limited by the low number of responses in the computer-guided groups. No significant difference was seen between the groups in the comparison of adjusted health gain, leading us to reject our hypothesis on PROMs. Patients who underwent computer-guided surgery had better satisfaction scores for the question “How would you describe the results of your operation?”

The strength of our study is the use of a national joint registry with long and comparable follow-up for both the computer-guided group (mean, 5.6 years; maximum, 15.7 years) and non-computer guided group (mean, 5.2 years; maximum, 16.9 years). To our knowledge, this is the first study using the NJR data set to investigate the effect of computer-guided THA on implant survivorship. Furthermore, our sample included computer-guided cases performed by a total of 36 surgeons (and 27 when the analysis was restricted to the cementless THA group), which makes our results more generalizable than those of some clinical trials. The results of the cementless-only group analysis confirmed that the effect seen was not associated with stem-fixation discrepancies between the groups. Finally, the use of a fully adjusted Cox proportional-hazards model, controlling for a range of confounding variables, yielded a hazard ratio that confirmed the significantly reduced risk of revision for the computer-guided group.

The finding of a reduced risk of revision surgery is in agreement with a recent study by Bohl et al., who used the 100% Medicare Part A claims data set for their analysis. The authors identified a significantly lower risk of aseptic acetabular component revision in navigated cases (1.03% versus 1.55%; adjusted hazard ratio, 0.75 [95% CI: 0.64 to 0.88]). The hazard ratio in our study was lower and the confidence interval was wider (hazard ratio for cementless and hybrid, 0.45 [95% CI: 0.21 to 0.96]), possibly reflecting the smaller sample size. The proportion of patients who underwent computer-guided surgery in our study (2%) was similar to that in the study by Bohl et al. (1.81%). Our study included patients of all ages, while the study by Bohl et al. was limited to patients ≥65 years of age who are covered by Medicare. We believe that the inclusion of all age groups makes the results more generalizable, as it includes higher-demand younger patient groups.

In another large database study (Nationwide Readmission Database), Gausden et al. reported that computer-guided navigation was associated with reduced complication and readmission rates at 90 days using an adjusted model. The authors did not identify a significant difference in readmissions that involved revision surgery at 90 days post-surgery (odds ratio, 0.84 [95% CI: 0.67 to 1.05]; $p = 0.13$). The longer follow-up durations in our study (mean, 5.6 and 5.2 years) might explain our ability to capture a difference in revision rates.

Our findings are not in agreement with some commonly cited clinical trials. Parratte et al. reported on 10-year follow-up of a randomized controlled trial comparing 30 computer-guided THAs and 30 THAs implanted with conventional instrumentation. The authors reported no difference between the groups in the Short Form (SF)-12, the Harris hip score, and the Hip injury and Osteoarthritis Outcome Score or the revision rate at 10 years. We believe that the small sample size of
their study makes it difficult to identify a difference in survival. Most clinical trials on computer-guided surgery and robotic-assisted THA in the literature have sample sizes of <200 cases. In order to identify a difference in prosthetic joint survival with clinical trials, the sample size would have to be large. National database and registry studies are more likely to have the power to identify smaller differences in survivorship as the sample analyzed is much larger.

Our study failed to identify a significant difference in PROMs between the groups analyzed. The sample of patients with recorded PROMs in our study was smaller than the survivorship cohort, with 317 patients (286 in the cementless-only analysis) submitting pre- and postoperative EQ-VAS scores. This raises the possibility of the cohort being insufficiently powered to identify a difference in PROMs. Computer-guided surgery and robotic-arm haptic-system guidance have been shown to improve the precision of implantation of the acetabular component within a safe zone and restoration of the native center of rotation and combined offset. Whether this translates to improved PROMs, and to what extent, remains a topic for ongoing research. In addition to the PROMs recorded, NHS Digital records a single-item satisfaction measure using wording and response scales consistent with the International Society of Arthroplasty Registries PROMs Working Group recommendations. In our study, the response to the single-item satisfaction question was significantly higher in the computer-guided group.

Our study has several limitations. The type of computer-guidance system used during the study period was not recorded by the registry and therefore not included in our analysis. We did not have access to component-orientation data, and thus, we cannot comment on orientation differences between groups. The observational nature of registry data raises the possibility of unaccounted-for confounders, despite the statistical modeling. The number of surgeons in the computer-guided group was small and may represent a group of surgeons with characteristics different from the surgeons in the non-guided group, such as being concentrated in academic centers or receiving additional manufacturer support. In addition, the non-guided group was more likely to represent more varied (and hence representative) surgical expertise and skill.

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**TABLE III Comparison of Patient-Reported Outcome Measures**

| Patient-Reported Outcome Measure | Cementless and Hybrid THAs | Cementless-Only THAs |
|----------------------------------|---------------------------|---------------------|
|                                  | Computer-Guided | Non-Computer-Guided | P Value† | Computer-Guided | Non-Computer-Guided | P Value† |
| Oxford Hip Score (0 to 48)       |               |                     |         |               |                     |         |
| Paired records (no.)             | 355           | 10,454              |          | 316           | 7,681               |          |
| Preop. score                     | 19.4 (18.6-20.2) | 18.2 (18.1-18.4)   |          | 19.7 (18.8-20.6) | 18.6 (18.4-18.7)   |          |
| 6-mo score                       | 41.3 (40.5-42.2) | 39.9 (39.7-40.1)   |          | 41.5 (40.5-42.4) | 40.3 (40.1-40.5)   |          |
| 6-mo score, adjusted             | 40.5 (39.7-41.2) | 39.7 (39.6-39.9)   |          | 40.4 (39.6-41.2) | 39.8 (39.7-40.0)   |          |
| Health gain                      | 21.9 (20.9-22.9) | 21.7 (21.5-21.9)   | 0.11     | 21.8 (20.7-22.8) | 21.8 (21.5-22.0)   |          |
| Health gain, adjusted            | 22.4 (21.7-23.2) | 21.7 (21.5-21.8)   | 0.11     | 22.4 (21.6-23.2) | 21.8 (21.7-22.0)   | 0.27     |
| Score improved                   | 97.2%          | 97.2%               |          | 97.2%          | 97.3%               |          |
| EQ-SD Index (−0.59 to 1.00)      |               |                     |         |               |                     |         |
| Paired records (no.)             | 329           | 9,643               |          | 297           | 7,119               |          |
| Preop. score                     | 0.396 (0.362-0.430) | 0.363 (0.357-0.369) |          | 0.405 (0.368-0.441) | 0.373 (0.366-0.380) |          |
| 6-mo score                       | 0.829 (0.804-0.854) | 0.802 (0.797-0.807) |          | 0.830 (0.803-0.858) | 0.808 (0.803-0.814) |          |
| 6-mo score, adjusted             | 0.814 (0.791-0.836) | 0.798 (0.793-0.802) |          | 0.811 (0.787-0.835) | 0.799 (0.794-0.804) |          |
| Health gain                      | 0.433 (0.398-0.467) | 0.439 (0.432-0.446) |          | 0.426 (0.389-0.462) | 0.435 (0.427-0.443) |          |
| Health gain, adjusted            | 0.459 (0.437-0.481) | 0.443 (0.438-0.447) | 0.3       | 0.456 (0.433-0.480) | 0.444 (0.439-0.450) | 0.41     |
| Score improved                   | 92.1%          | 89.7%               |          | 91.6%          | 89.7%               |          |
| EQ-VAS (0 to 100)                |               |                     |         |               |                     |         |
| Paired records (no.)             | 317           | 9,212               |          | 286           | 6,817               |          |
| Preop. score                     | 68.3 (66.0-70.6) | 65.4 (64.9-65.8)   |          | 68.8 (66.3-71.2) | 65.6 (65.1-66.1)   |          |
| 6-mo score                       | 79.7 (77.9-81.4) | 77.9 (77.5-78.2)   |          | 79.5 (77.6-81.4) | 78.6 (78.2-79.0)   |          |
| 6-mo score, adjusted             | 78.0 (76.5-79.6) | 77.6 (77.2-77.9)   |          | 77.7 (76.0-79.3) | 77.9 (77.5-78.3)   |          |
| Health gain                      | 11.3 (9.0-13.6) | 12.5 (12.1-13.0)   | 0.92     | 10.8 (8.4-13.1) | 13.0 (12.5-13.6)   |          |
| Health gain, adjusted            | 13.0 (11.5-14.6) | 12.5 (12.2-12.9)   | 0.92     | 12.6 (11.0-14.3) | 12.9 (12.5-13.3)   | 0.42     |
| Score improved                   | 67.2%          | 67.5%               |          | 66.1%          | 68.4%               |          |

*Values are given as the mean and 95% CI, except as indicated. Adjusted scores correspond to the NHS Digital version 3 case-mix-adjustment model. This includes patient variables from PROMs, Hospital Episode Statistics, and the Index of Multiple Deprivation data. THA = total hip arthroplasty. †Mann-Whitney U test. The complete NJR Bespoke Implant Reports are available online.
Computer-Guided Versus Non-Computer-Guided THA

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Conclusions

The use of computer-guided surgery was associated with a reduced rate of revision in this manufacturer-specific analysis of registry data at a mean follow-up of 5.6 years. The response to the single-item satisfaction measure was higher in the computer-guided group, although the patients were not blinded. Causality cannot be inferred, as our study was observational in nature and cannot account for unmeasured confounders. If confirmed, the reduced risk of revision is valuable information for future health economics studies investigating the cost-effectiveness of the technology. We recommend further clinical trials and database/registry studies to investigate the effects of computer-guided surgery on prosthetic joint survival. Areas of interest for future research include patients at high risk for dislocation, such as patients identified through spinopeval assessment. Computer-guided surgery should also be evaluated against new and increasingly popular technologies, such as dual-mobility bearings or large-head THA components.

small number of revisions in the computer-guided group (7) limited our ability to further analyze reasons for revision. Satisfaction rates (single-item satisfaction measure) were higher in the computer-guided group. As with all PROMs in our analysis, patients were not blinded to the technology used, and this should be considered when interpreting the results. When surgeons use both computer-guided and non-guided surgery, selection bias applies. In addition, the threshold to revise THAs may be different when computer guidance was used at the time of the primary procedure. We have analyzed THAs using components by a single manufacturer, and therefore the results might not be generalizable to all THAs in the independent nature of the reports on which our manuscript is based meant that the methodology was decided a priori, and subsequent analyses were not possible. We believe that further analysis of the complete NJR data set and other registries is justified to validate our findings.

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