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# Patient-reported outcome measures, complication rates, and re-revision rates are not associated with the indication for revision total hip arthroplasty

## A PROSPECTIVE EVALUATION OF 647 CONSECUTIVE PATIENTS

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### Aims

**The aim of this study was to explore the relationship between reason for revision total hip arthroplasty (rTHA) and outcomes in terms of patient-reported outcome measures (PROMs).**

### Methods

**We reviewed a prospective cohort of 647 patients undergoing full or partial rTHA at a single high-volume centre with a minimum of two years' follow-up. The reasons for revision were classified as: infection; aseptic loosening; dislocation; structural failure; and painful THA for other reasons. PROMs (modified Oxford Hip Score (mOHS), EuroQol five-dimension three-level health questionnaire (EQ-5D-3L) score, and visual analogue scales for pain during rest and activity), complication rates, and failure rates were compared among the groups.**

### Results

**The indication for revision influenced PROMs improvement over time. This finding mainly reflected preoperative differences between the groups, but diminished between the first and second postoperative years. Preoperatively, patients revised due to infection and aseptic loosening had a lower mOHS than patients with other indications for revision. Pain scores at baseline were highest in patients being revised for dislocation. Infection and aseptic loosening groups showed marked changes over time in both mOHS and EQ-5D-3L. Overall complications and re-revision rates were 35.4% and 9.7% respectively, with no differences between the groups (p = 0.351 and p = 0.470, respectively).**

### Conclusion

**Good outcomes were generally obtained regardless of the reason for revision, with patients having the poorest preoperative scores exhibiting the greatest improvement in PROMs. Furthermore, overall complication and reoperation rates were in line with previous reports and did not differ between different indications for rTHA.**

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### Introduction

During the past 15 years, the number of primary total hip arthroplasties (THAs) has increased, and thus the requirement for revision THA (rTHA) has increased too.[1] Projections estimate that procedure numbers will double by the year 2030 compared with the level in 2005.[2] rTHA is more technically demanding than primary THA, and is associated with higher complication rates and a longer hospital stay.[3,4] Furthermore, rTHA results in approximately 35% higher costs to the healthcare system compared to primary THA.[3–5] The main reasons for revision are aseptic loosening, instability or dislocation, structural failure, and infection. Other less well-defined diagnoses, such as unexplained pain, psoas impingement, and malposition, are also reported.[6–11]

The scientific literature regarding the outcome of rTHA lacks prospective data about the relationship between patient-reported outcome measures

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**Table I.** Definitions of revision reasons.

| Reason | Definition |
|---|---|
| Infection | All patients treated with either a two-stage or single-stage reimplantation based on a preoperative evaluation performed and interpreted according to the MSIS criteria.[38] This group also included patients with two or more unexpected intraoperative positive cultures for the same microorganism which was considered as "unexpected periprosthetic joint infection". |
| Aseptic loosening | Loosening without signs of infection due to a poor cementation technique (in case of cemented THA), inadequate initial fixation, and/or mechanical loss of fixation over time. |
| Dislocation | Dislocation was the presence of permanent loss of congruity between the head of the femoral component and the acetabular component. This group also included patients who complained about recurrent/multiple episodes of dislocations previously treated non-surgically with closed reduction. |
| Structural failure (as in Henderson classification)[37] | A: Implant breakage or wear (poly and/or metal wear with or without pseudotumour)<br>B: Fracture around of one or both the prosthesis components (according to the UCPF)[39] that occurred after surgery and lead to revision. We excluded intraoperative fracture that was treated like a revision procedure (e.g. with a revision stem or an acetabular cage) |
| Painful THA with uncommon causes | Painful THA without a clear diagnosis as stated above. It includes multiple/heterogenous, and not fully understood causes of pain. |

MSIS, Musculoskeletal Infection Society; THA, total hip arthroplasty; UCPF, Unified Classification System for Periprosthetic Fractures.

(PROMs) and the indication for surgery. Generally, it consists of data from large national registries or retrospective case series with mid- to long-term follow-up, both lacking the potential to evaluate patients' expectations and (dis)satisfaction. National registries focus on estimating implant-specific revision risks, and although these data may be useful for surgeons in decision-making about implants and techniques,[12] they are less helpful in guiding patient-specific decision-making.[13,14] Moreover, most registries do not administer PROMs. Retrospective case series about specific techniques or implants in rTHA can provide an overview on complication and implant survival rates, as well as mortality and clinical and radiological results.[15–23] These types of studies, however, have not focused on the relationship between the reasons for rTHA and their outcomes. Only a few articles have tried to compare outcomes,[24–32] and even fewer have studied the reason for rTHA as a predictor of outcomes.[33–36] These reports draw various, inconclusive, and sometimes conflicting conclusions.

For these reasons, we designed a study to follow a cohort of patients receiving either a full or a partial (femoral or acetabular) rTHA at a single high-volume centre. We used a predefined flowchart for consistent categorization of the preoperative reason for revision. We set out a prospective study to answer the following research question: do PROMs, complication rates, and re-revision rates differ between different indications for rTHA at two-year follow-up?

## Methods

**Patient selection.** Characteristics, surgical details, and outcomes of all rTHA patients treated at a single institution (Sint Maartenskliniek, Nijmegen, the Netherlands) were prospectively registered in a database. From this database, we extracted and reviewed all patients who underwent rTHA in our hospital between January 2013 and December 2017, resulting in a sample of 697 patients. A total of 13 patients died due to reasons not related to the index surgery, and 37 were withdrawn before reaching the minimum of two years of follow-up: three developed advanced dementia and could not complete the questionnaires, and 34 were lost to follow-up. Therefore, a total of 647 patients were analyzed in the present study. Following a specific preoperative diagnostics flowchart, every patient was assigned to one of five categories of reason for revision: infection, aseptic loosening, dislocation, structural failure, or painful THA with uncommon causes.[37,38] The definitions applied are shown in Table I.

In 119 patients, more than one reason for failure might have been considered during the preoperative assessment. To resolve any doubt about the main reason for revision, our study group of orthopaedic hip surgeons (JHMG, GvH; see Acknowledgements) discussed each of those patients and reached a unanimous decision. This main failure mechanism was then used for further analysis.

Perioperatively, a total of six intraoperative tissue cultures were taken for microbiological analysis. If two or more intraoperative cultures were unexpectedly positive for the same microorganism, we considered the revision as an unexpected periprosthetic joint infection (PJI).[40,41] These cases were included in the 'Infection' group. These patients received antibiotic treatment for three months.

Intraoperatively, surgeons recorded whether the patient underwent a full rTHA or a partial rTHA (isolated femoral component or acetabular component exchange).

All patients accepted the proposed treatment and follow-up after adequate information and written consent. The study and follow-up, respecting the criteria of the Declaration of Helsinki,[42] were approved by our hospital medical ethical review board.

**Demographic and clinical assessment.** Demographic and surgical characteristics, such as age, sex, and American Society of Anesthesiologists grade,[43] were recorded preoperatively, along with the following questionnaires: modified Oxford Hip Score (mOHS),[44] EuroQol five-dimension three-level health questionnaire (EQ-5D-3L),[45] and a 100 mm visual analogue score (VAS) for pain during rest and during activity (0 = excellent)[46] (Tables II and III). In the mOHS, the score ranges between 14 and 70, and the lower scores indicate better function. The EQ-5D-3L was scored using the Dutch value set,[39] to obtain EQ-5D-3L summary index values standardized from 0 (equivalent to death) to 1 (equivalent to full health), with a negative value representing a state worse than death. All patients were then evaluated postoperatively at three, 12, and 24 months with the use of the same questionnaires.

**Table II.** General patient and surgical characteristics.

| Variable | Infection | Aseptic loosening | Dislocation | Structural failure | Painful THA | p-value |
|---|---|---|---|---|---|---|
| Patients, n | 65 (18 uPJI) | 252 | 125 | 132 | 73 | |
| Mean age at surgery, yrs (SD) | 65 (12.4) | 67 (12) | 67.8 (11.9) | 68 (11) | 62.7 (11.1) | 0.233* |
| Female, n (%) | 27 (42) | 159 (63) | 94 (75) | 88 (67) | 54 (74) | < 0.001† |
| **ASA grade, n (%)** | | | | | | 0.374† |
| 0 | 0 (0) | 0 (0) | 0 (0) | 1 (1) | 0 (0) | |
| 1 | 15 (23) | 63 (25) | 26 (21) | 29 (22) | 25 (34) | |
| 2 | 39 (60) | 159 (63) | 85 (68) | 83 (63) | 44 (60) | |
| 3 | 11 (17) | 30 (12) | 12 (10) | 17 (13) | 4 (6) | |
| 4 | 0 (0) | 0 (0) | 2 (1) | 0 (0) | 0 (0) | |
| Missing | 0 (0) | 0 (0) | 0 (0) | 2 (1) | 0 (0) | |
| **Type of revision, n** | | | | | | < 0.001† |
| Full revision | 62 | 63 | 6 | 44 | 11 | |
| Femoral component only | 1 | 62 | 6 | 8 | 9 | |
| Acetabular component only | 2 | 127 | 113 | 80 | 53 | |

*One-way analysis of variance.
†Chi-squared test.
ASA, American Society of Anesthesiologists; SD, standard deviation; THA, total hip arthroplasty; uPJI, unexpected periprosthetic joint infection.

**Table III.** Baseline patient-reported outcome measures.

| Mean baseline value (SE) | Infection | Aseptic loosening | Dislocation | Structural failure | Painful THA |
|---|---|---|---|---|---|
| mOHS | 48.3 (3.7) | 45.3 (3.3) | 38.1 (3.3) | 39.7 (3.3) | 39.5 (3.5) |
| EQ-5D-3L | 0.40 (0.09) | 0.46 (0.08) | 0.54 (0.08) | 0.55 (0.08) | 0.56 (0.09) |
| VAS pain (rest) | 36.0 (9.7) | 41.9 (8.7) | 26.5 (8.8) | 35.8 (8.8) | 32.7 (9.3) |
| VAS pain (activity) | 62.3 (9.1) | 69.3 (8.1) | 43.0 (8.2) | 61.5 (8.2) | 56.8 (8.8) |

EQ-5D-3L, EuroQol five-dimension three-level health questionnaire; mOHS, modified Oxford Hip Score; SE, standard error; THA, total hip arthroplasty; VAS, visual analogue scale.

Complications, both intra- and postoperatively, were defined as any type of negative event related to functioning of the revision implant, including nonoperative and operative treatments. The follow-up time was always calculated as the time since the index rTHA. Reoperations consisted of any complication requiring a surgical treatment other than removal of the fixed parts of the prosthesis, such as a debridement, antibiotics and implant retention with mobile part exchange. Revisions were defined as any reoperation in which at least one fixed component was exchanged (acetabular component and/or stem).

**Statistical analysis.** Demographic data, clinical status, and baseline PROMs of the different revision groups were compared using one-way analysis of variance (ANOVA) for continuous variables and chi-squared tests for categorical variables. Differences in the PROM scores among revision groups were tested using linear mixed models with the PROM outcome as dependent-variable, reason for revision (five levels), time (three levels: baseline (T0), 12 months (T1), 24 months (T2)), the interaction of reason for revision by time as independent factors, sex, age, BMI, and ASA grade as covariates, and patient identification code as a random factor. Estimated marginal means were reported from these models. Logistic regression models were built to test differences in the rate of complications and failures, adding sex, age, BMI, and ASA score as covariates. Statistical analysis was performed in RStudio (v. 1.2.5001; R Foundation for Statistical Computing, Austria) using the lmerTest v. 3.1 and emmeans v. 1.7 packages. Post-hoc pairwise comparisons were conducted using Tukey correction for multiple comparisons. Significance level was set at a p-value < 0.05.

## Results

**Baseline and surgical comparisons.** The demographic details of the study cohort are summarized in Table II. Both sex ($p < 0.001$, chi-squared test) and type of revision surgery (partial or full rTHA; $p < 0.001$, chi-squared test)) were significantly different between the groups. Female patients and isolated acetabular component revision were more prevalent in every revision group except for the infected group. No group differences were found regarding the ASA grade ($p = 0.374$, chi-squared test). In the dislocation group, the mean number of dislocations before proceeding with revision was 3.2 (1 to 6). In the structural failure group, 13 patients presented with a periprosthetic fracture: two UCPF grade IV.6 B (two loose acetabular component, poor bone, defect; pelvic discontinuity); 11 IV.3 B (eight loose stem, good bone; three loose stem, poor bone, defect).[47] The mean follow-up was 4.8 years (standard deviation (SD) 1.2).

**PROMs.** Detailed outcomes of the ANOVA and linear mixed models for PROMs are presented in Supplementary Table i. Absolute values of preoperative PROMs are presented in Figure 1 and descriptive data of preoperative PROMs are reported in Table III.

We observed statistically significant differences in PROMs among different reasons for revision preoperatively. Detailed differences are shown in Figure 1. When we corrected

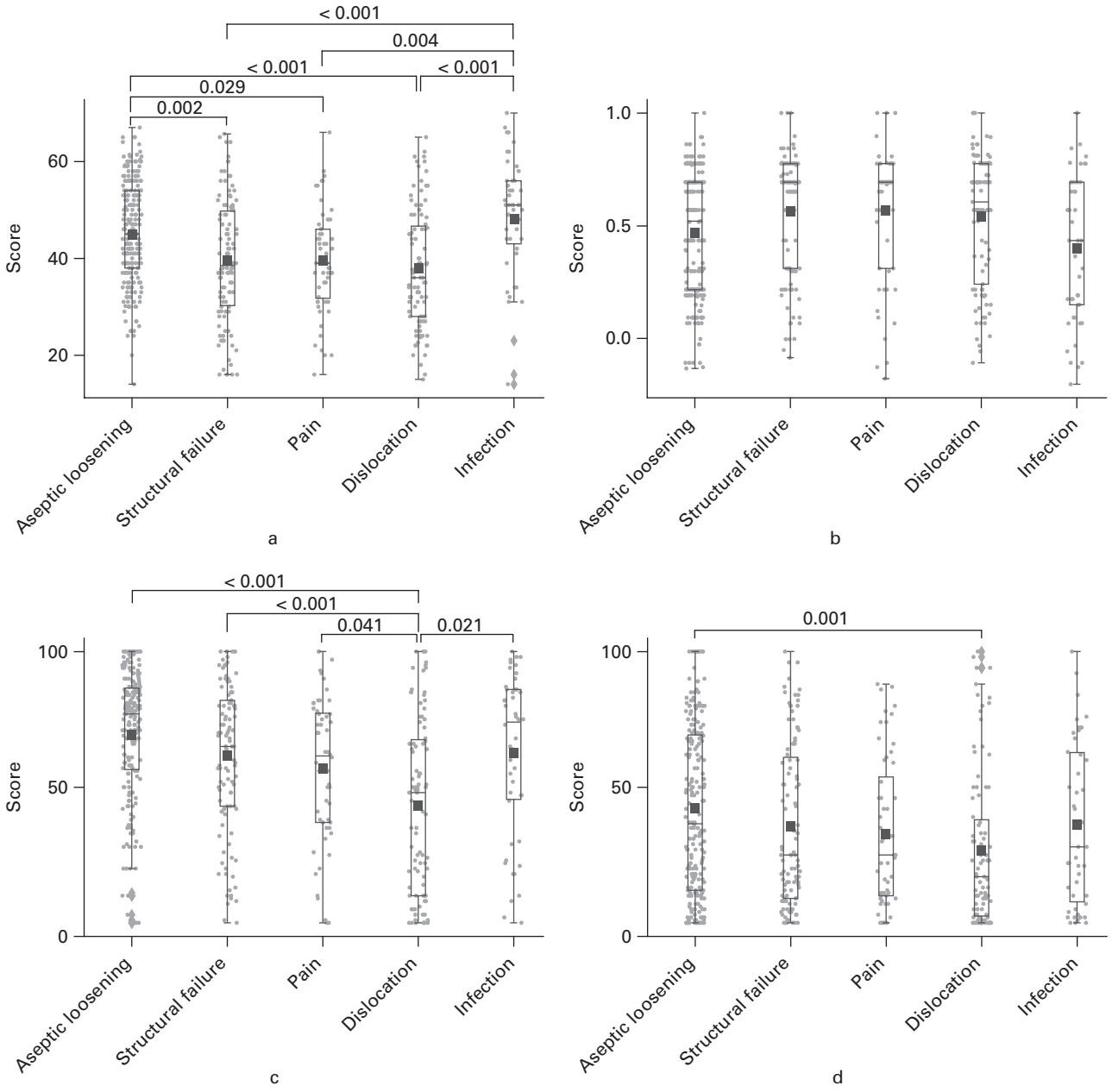


Fig. 1

Preoperative box plots of each indication for revision reported by each mode of assessment. a) modified Oxford Hip Score, b) EuroQol five-dimension three-level health questionnaire, c) visual analogue scale (VAS) pain (activity), and d) VAS pain (rest) at baseline per reason for revision group. Box plots with means (circles), medians (horizontal lines), interquartile ranges, and outliers (diamond shapes) are shown. Significant differences between groups, adjusted for covariates age, sex, BMI, and American Society of Anesthesiologists grade, are denoted by horizontal lines in the upper part of the plot; relative p-values are reported within the figures. p-values were derived from post-hoc pairwise comparisons between groups after one-way analysis of variance models were run.

for covariates, all main effects of the different PROMs remained significant.

Pairwise comparisons are detailed in Figure 1. For the mOHS, the aseptic loosening and infection group scored higher than the other groups. For the EQ-5D-3L, no pairwise comparisons remained significant. Pain during activity scores were lowest for the dislocation group, compared to all other groups. No other between-group differences were observed. Regarding pain during rest, the only significant between-group difference was found for aseptic loosening: this group scored higher than the dislocation group.

To evaluate differences in PROMs over time, we observed a significant interaction of time and reason for revision for all PROMs. As illustrated in Figure 2, these interaction effects were driven by differences in improvement rates from T0 to T1. Specifically, this result was due to baseline differences between

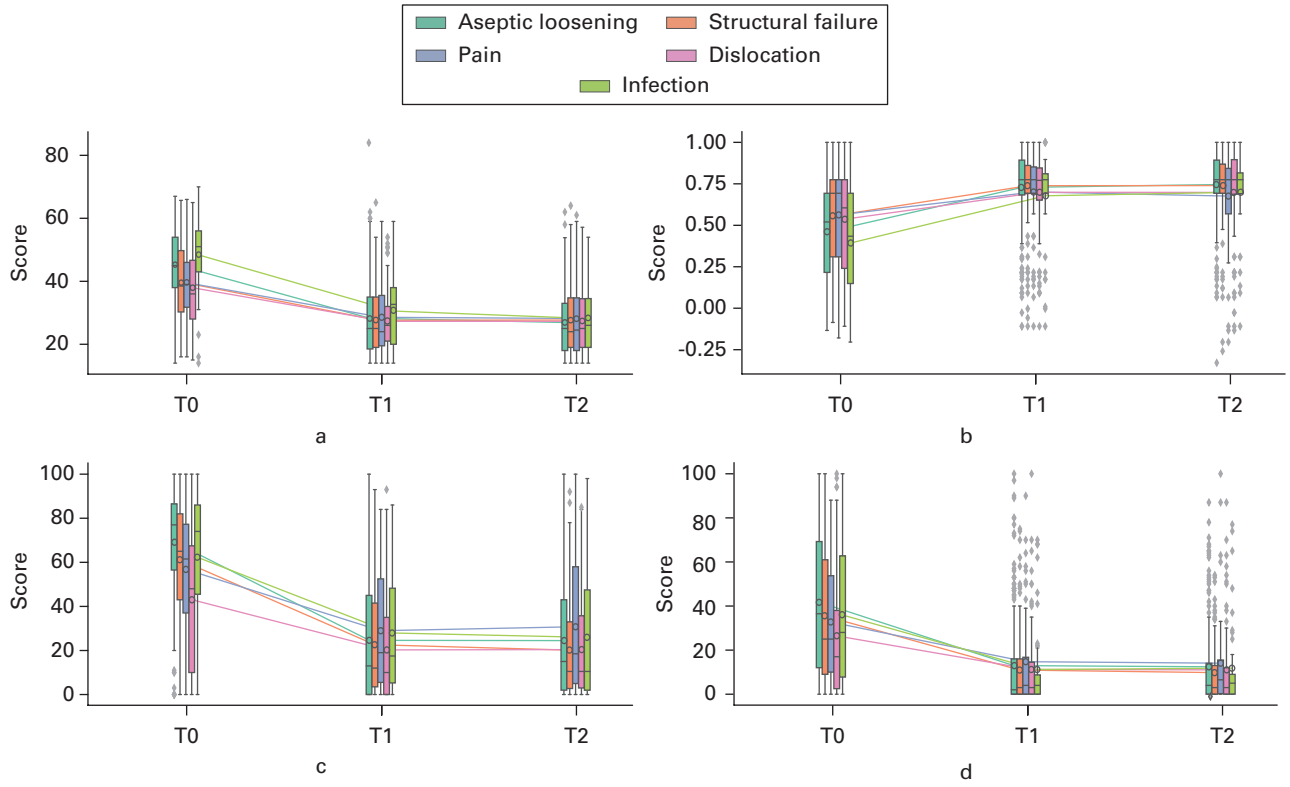


Fig. 2

Box plots to illustrate of a) modified Oxford Hip Score, b) EuroQol five-dimension three-level health questionnaire, c) visual analogue scale (VAS) pain (activity), and d) VAS pain (rest) by reason for revision over time from preoperatively (T0) to one-year (T1) and two-year (T2) follow-up. Box plots with means (circles), medians (horizontal lines), interquartile ranges, and outliers (diamonds) are shown.

**Table IV.** Reason for revision-related complications.

| Variable | Infection | Aseptic loosening | Dislocation | Structural failure | Painful THA | p-value* |
|---|---|---|---|---|---|---|
| Patients, n | 65 | 252 | 125 | 132 | 73 | |
| Patients with complications, n (%) | 26 (40) | 97 (38) | 40 (32) | 41 (31) | 25 (34) | 0.351 |
| Complications, n | 36 | 128 | 54 | 58 | 25 | |
| **Type of complication, n (%)** | | | | | | 0.004 |
| Soft-tissue-related pain | 5 (14) | 26 (20) | 11 (20) | 13 (22) | 11 (44) | |
| Deep infection | 13 (36) | 24 (19) | 13 (24) | 10 (17) | 4 (16) | |
| Instability/dislocation | 0 (0) | 20 (16) | 13 (24) | 7 (12) | 0 (0) | |
| Wound problems (leakage/dehiscence) | 6 (17) | 9 (7) | 2 (4) | 10 (17) | 2 (8) | |
| Aseptic loosening | 1 (3) | 20 (16) | 2 (4) | 5 (9) | 1 (4) | |
| Periprosthetic fracture | 5 (14) | 8 (6) | 3 (6) | 4 (7) | 1 (4) | |
| Intrasurgical complications | 1 (3) | 3 (2) | 0 (0) | 3 (5) | 2 (8) | |
| Non-surgical related complications | 5 (14) | 18 (14) | 10 (18) | 6 (10) | 4 (16) | |
| Reoperations other than re-revision, n (%) | 8 (13) | 20 (8) | 7 (6) | 10 (8) | 5 (7) | 0.629 |
| Re-revisions, n (%) | 5 (8) | 28 (11) | 15 (12) | 11 (8) | 4 (5) | 0.470 |

*Chi-squared test.
THA, total hip arthroplasty.

groups, which disappeared at T1. The infection and aseptic loosening groups had the highest change over time (starting from lowest point) for EQ-5D-3L. Aseptic loosening group reported the largest drop for VAS pain during rest.

No significant differences in PROMs between groups were observed both at T1 and T2 (Figure 2; Supplementary Table i).

**Complications and re-revisions.** The complication, reoperation, and re-revision rates are presented in Table IV. A total of 229 patients (35.4%) reported 301 complications (one single complication in 178 patients; two in 32; three in 16; and four in three patients). Complication rates did not differ between the revision groups (p = 0.351, chi-squared test).

A reoperation was needed in 50 patients (7.7%) and 63 (9.7%) underwent a re-revision THA. When comparing the number of both subsequent reoperations and re-revision THA, there was no difference between the revision groups ($p = 0.629$ and $p = 0.470$, respectively, both chi-squared test). No differences were found when adding sex, age, BMI, and ASA grade as covariates for complications ($p = 0.372$, logistic regression analysis) or re-revisions ($p = 0.367$, logistic regression analysis).

The types of complication were different between the revision groups ($p = 0.004$, chi-squared test). The most common complications seemed directly related to the initial reason for revision: deep infection was most common in the infection group, instability/dislocation in the dislocation group, and soft-tissue-related pain in the painful THA with uncommon causes group.

A detailed report on the complications with their relative treatments is provided in Supplemenary Table ii.

## Discussion

In this study, we investigated differences in PROMs, complications, and re-revision rates between patients undergoing rTHA for different reasons. As stated by Cuckler,[48] no surgeon should revise a THA unless an underlying cause is sufficiently clear. In our prospective cohort of patients, we did not find differences at two-year follow-up in PROMs, complication rates, or re-revision rates between the different indications for either a full or a partial rTHA.

We did find a significant difference in preoperative PROMs between revision groups, with the infection and aseptic loosening groups scoring significantly worse mOHSs than all the other categories. The mOHS for the dislocation group was ten points higher than the infection group at baseline. The worst pain during activity was reported among the dislocation group. These baseline differences drove statistically different improvements among different groups over time. The revision groups that scored the worst preoperatively had the greatest improvement over the first year after surgery. However, those results should be interpreted with caution as PROMs are inherently biased by patients' expectations, beliefs, and anxiety.

Philpott et al,[35] in a retrospective long-term follow-up study, reported that the indication for revision had no significant influence on patient-reported satisfaction. That report, along with the fact that the infection group reported a significantly better improvement in terms of OHS and EQ-5D-3L over time than any other group except for the aseptic loosening group, is in line with our findings.

Similarly, Singh and Lewallen[33] re-evaluated a prospective database of rTHA and did not find any difference in pain scores at two- or five-year follow-up between different diagnoses. However, they reported that reasons for revision other than "aseptic loosening/wear" were independently associated with poorer functional outcome and moderate to severe restrictions of activities of daily living two years after rTHA. Our study did not confirm those findings, although their revision categories were not comparable with ours.

Contrary to our findings, Davis et al[24] observed that patients with higher preoperative pain scores had worse outcomes following rTHA in a prospective study of 126 rTHAs. Nonetheless, they did not clearly report whether those patients with worse outcomes belonged to any specific reason for revision group.

Biring et al[34] found a higher preoperative Western Ontario and McMaster Osteoarthritis Index (WOMAC)[49] to be a predictor of better WOMAC function and pain and University of California Los Angeles activity scale[50] outcomes following rTHA in of a prospective cohort of 222 patients. Moreover, they stated that aseptic loosening as indication for revision was also a predictor of better outcomes. However, the majority of their study population had aseptic loosening (187 patients; 84%) and causes such as infection, instability, and fracture were grouped into a single category. In our study, with a larger sample size, we could not confirm those findings.

The complication, reoperation, and re-revision rates we found are comparable to those previously reported in literature.[51–54] In particular, we did not find any difference in the overall number of complication and re-revisions between different reasons for revision groups, which also held true when correcting for potentially confounding variables.

The type of complication differed between the reasons for revision groups. The most common type of complication resembled the reason for initial revision: deep infection in the infection group, instability/dislocation in the instability group, and soft-tissue-related pain in the malposition/pain group. Although these complications may be new complaints, it is also likely that they may be related to existing problems that were unresolved by the rTHA. Further studies are needed to give statistical strength to this hypothesis.

Davis et al[24] reported fewer complications (22% of patients with complications, compared to our 35.4%) and found that complications were a significant predictor of less favourable pain and function scores two years after surgery. They also recorded an overall failure rate of 3%, less than our 9.7%. In our study, of the patients with complications, 27.5% underwent a subsequent re-rTHA. Nevertheless, we did not find any differences in failure rates between different revision groups. However, our findings could have been determined by the relatively short follow-up.

Our results should be interpreted in light of a number of limitations. First, patient stratification into five strict reason-for-revision categories has made it difficult to compare our study with other reports using different definitions. Additionally, some of the subgroups had a relatively small sample size, for which results should be interpreted with caution. Further, this group assignment, in the presence of potentially more than one reason for revision per patient, can also carry a risk of bias. In those cases, in which more than one reason for revision could be reasonable, consensus was reached between hip surgeons with extensive experience in rTHA following the same diagnostic flowchart. Second, rTHA was performed by different hip surgeons using different rTHA systems. However, as mentioned above, only experienced high-volume rTHA surgeons performed those complex surgical procedures. Furthermore, the use of different hip revision systems in our dataset may have resulted in heterogeneity in our groups. Nonetheless, this may represent a strength rather than a weakness for the routine surgical practice. Finally, longer-term follow-up of our sample

for five to ten years is warranted to gain further insights into the outcomes of the different reasons for revision.

In conclusion, we observed a substantial significant difference in PROMs between different reason for revision groups preoperatively, causing statistically different improvements among different groups over time. The patients who reported the poorest scores with respect to physical function, pain, and quality of life preoperatively showed the best improvement over time. After the first year, all groups scored similarly and stabilized with respect to improvement up to two years' follow-up. Complication and reoperation rates did not differ between groups with different indications for rTHA and were in line with previous reports. Future larger registry studies may be performed with the addition of PROMs to provide enough data to draw firmer conclusions. Furthermore, we would recommend carrying out a consensus-based categorization of the reason for rTHA definitions in order to carry out better comparable future prospective studies.

### Take home message

- Preoperative patient-reported outcome measures (PROMs) significantly differed between different reasons for revision total hip arthroplasty (THA), which disappeared at one and two years postoperatively.
- Complication and reoperation rates did not statistically significantly differ with reason for revision THA, and the most common types of complications resembled the initial reasons for revision.
- Ideally, PROMs should be added to large national implant registries.

### Twitter

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### Supplementary material

Tables displaying statistics from linear mixed models and analysis of variance with and without covariates in the model, and overall complications and related treatments.

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