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Original article

Patient-level clinically meaningful improvements in activities of daily living and pain after total hip arthroplasty: data from a large US institutional registry

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Abstract

Objective. To characterize patient-level clinically meaningful improvements in pain and limitation of key activities of daily living (ADLs) after primary or revision total hip arthroplasty (THA).

Methods. We analysed prospectively collected data from the Mayo Clinic Total Joint Registry to study clinically meaningful improvements in index hip pain severity and limitation in seven key ADLs (walking, climbing stairs, putting on shoes/socks, picking up objects, getting in/out of car, rising from a chair and sitting), from preoperative to 2- and 5-year post-THA.

Results. The primary THA cohort consisted of 6168 responders preoperatively, 5707 at 2 years and 3289 at 5 years postoperatively. The revision THA cohort consisted of 2063 responders preoperatively, 2682 at 2 years and 1627 at 5 years postoperatively. In the primary THA cohort, clinically meaningful pain reduction to mild or no hip pain at 2 years was reported by 94% with moderate and 91% with severe preoperative pain; respective proportions were 91% and 89% at 5-year follow-up. For revision THA, respective proportions were 84% and 77% at 2 years and 80% and 78% at 5 years. In the primary THA cohort, up to 4% with moderate and 17% with severe preoperative ADL limitation reported severe limitation in the respective activity 2 years post-primary THA; at 5 years, the respective proportions were up to 7% and 20%. Respective proportions for revision THA were up to 10% and 26% at 2 years and 13% and 30% at 5 years.

Conclusions. These comprehensive data for patient-level clinically meaningful improvements in pain and seven key ADLs can help patients set realistic goals for improvement after THA.

Key words: pain, activity limitation, activities of daily living, function, functional limitation, total hip replacement, arthroplasty, joint replacement, outcomes, patient-reported outcomes, primary, revision.

CLINICAL SCIENCE

Introduction

Total hip arthroplasty (THA) is among the commonest elective surgical procedures performed in the USA for the treatment of severe end-stage arthritis [1], with 427 000 THA procedures performed in 2009 according to the Healthcare Cost and Utilization Project [2] and 436 000 in 2007 based on a population-based study [3]. Another population-based study projected the THA volume to almost triple from 2005 to 2030 [4]. Despite being associated with improvement in pain, function and health-related quality of life (HRQOL) [1, 5] and named the operation of the century [6], it is now recognized that THA does not have a 100% success rate [7, 8]. Most previous studies of patient-reported outcomes (PROs) have examined cohort-level data using composite pain and function instruments for THA cohorts (mean scores) [5, 6]. Such an approach has several limitations.

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First, pain and function, two separate domains, are often combined into a single score, making the interpretation of either domain separately very difficult. Second, interpretation of published data is especially challenging for patients. Patients may not understand what relevance a mean 30-point improvement in functional score in a study of 100 patients after hip arthroplasty has for his/her likelihood of improvement in activities of daily living (ADLs). The average improvements combine results from patients with differing levels of improvement that can range widely. It also poses a real challenge for a surgeon who is trying to respond to a question from a patient about to undergo THA 'Considering my current pain, what are my chances that this surgery will reduce my pain to minimally bothersome?' Even more difficult is to answer the question 'I am wondering too as to what are my chances that I will be able to climb stairs with minimal difficulty after my hip replacement?' To our knowledge, these patient-level data are not available at present. Examination of predictors of poor pain and function outcomes after THA highlights the importance of studying poor outcomes after THA [9–14]. We need studies that provide data easily interpretable for outcomes relevant to patients, such as the proportion of patients with clinically meaningful improvements in pain or activity limitation. Consumers and policymakers need this information to make health care decisions on an individual and societal level.

Using the prospectively collected data in the Mayo Clinic Total Joint Registry, a large institutional US joint registry, our objective was to describe patients' experience after THA in easily interpretable format for patients, policymakers and providers. Specifically, we aimed to (i) study pain and limitation in seven key ADLs, pre- and postoperatively, and (ii) describe clinically meaningful changes in pain and seven ADLs, 2 and 5 years after primary and revision THA.

Methods

Setting, participants and data sources

Data collected prospectively in the Mayo Clinic Total Joint Registry were included in the analyses for our study. The Mayo Total Joint Registry collects prospective data on all joint replacements performed at the Mayo Clinic, Rochester, MN. Data included patient demographics, surgery and implant details, date of last evaluation, whether the implant was in place or removed, reoperations, complications, current radiographs and pain and function assessments [15, 16]. All patients who undergo THA at the Mayo Clinic are requested to complete validated Mayo Hip [17–19] questionnaires containing pain and function questions preoperatively and at regular follow-up visits (including 2 and 5 years). These questionnaires are mailed to the patients, administered during the clinic visit or by telephone by experienced, dedicated joint registry staff at 2- and 5-year time points after THA or TKA. The pain and function questions analysed in this study are the same as those in the Harris Hip Score [20], the most widely used questionnaire in THA patients, that has face, content and construct validity. Questionnaire data have been captured electronically starting in 1993. Patients were included in this study if they had undergone a primary or revision THA during 1993–2005 and had responded to pre- and/or post-surgery hip questionnaire (2- or 5-year follow-up). The study was approved by the Institutional Review Board (IRB) at the Mayo Clinic, Rochester, MN, USA, and research conformed to all ethical standards, including the Declaration of Helsinki. Since this was a database study, informed consent was waived by the IRB.

Anxiety, depression and medical comorbidity using the validated Deyo–Charlson index [21] were based on the presence of International Classification of Diseases 9th version (ICD-9) codes in Mayo Clinic electronic databases derived from administrative and clinical records. Demographics (age, gender, etc.), American Society of Anesthesiologist (ASA) class, BMI, distance from medical centre, operative diagnosis and implant fixation were obtained from Total Joint Registry and linked databases.

Outcomes of interest

Study outcomes were PROs obtained from self-reported validated knee and hip questionnaires, namely index hip pain and key ADL limitations, assessed preoperatively and also at 2- and 5-year follow-up time points. Postoperative index hip pain was assessed with a single question on the hip questionnaire, namely 'Do you have pain in the hip in which the joint was replaced?', with answers 'no pain', 'slight', 'moderate' and 'severe'. This question [17–19] is similar to the pain question in Harris Hip Score, a commonly used outcome instrument in patients with THA that is valid, reliable and sensitive to change [22–24]. This question was also administered preoperatively.

Patients self-reported limitations in seven key ADLs that specifically assessed index hip function on validated questionnaires. These included walking, climbing stairs, putting on shoes/socks, picking up objects from the floor, sitting in a chair, getting in/out of the car and rising from a chair to a standing position. For four ADLs (walking, climbing stairs, sitting and rising from a chair), limitations were categorized into no, mild, moderate or severe limitation. For the remaining three ADLs (putting on shoes/socks, picking up objects from the floor and getting in/out of the car), which did not have a response corresponding to the mild category, the limitations were categorized into no, moderate or severe, as previously [25].

Clinically meaningful improvements were defined *a priori* as follows: (i) clinically meaningful improvement in pain: reduction from moderate or severe pain preoperatively to mild pain or no pain postoperatively—occurrence of mild/no pain was deemed as a success; (ii) clinically meaningful improvement in ADL limitation: reduction from moderate or severe preoperative ADL limitation to mild or no postoperative limitation in the respective ADL.

We also defined two composite outcomes, namely post-THA moderate to severe pain and moderate to severe activity limitation, as in previous studies [3, 25], to capture the concept of clinically meaningful outcomes. Moderate and severe pain categories were combined to derive moderate to severe pain outcome, which is undesirable after THA (reference, no pain or slight pain). Moderate to

severe activity limitation was defined as the presence of moderate or severe limitation in three or more ADLs (reference, all other categories), as previously [25], which was also considered undesirable.

Statistical analyses

Clinical and demographic characteristics of patients were provided for preoperative and 2- and 5-year follow-up cohorts. We assessed the proportion of patients with various categories of pain and activity limitation outcomes preoperatively and 2 years and 5 years post-THA. All analyses were done separately for primary and revision THA for each follow-up time point, 2 and 5 years. Responder and non-responder characteristics were compared using logistic regression analyses, which were prespecified to include demographics, comorbidity, implant-related factors and underlying diagnosis. A *P*-value <0.05 was considered significant.

Results

Patient characteristics

Table 1 shows patient characteristics at baseline and at 2- and 5-year follow-up for primary and revision THA. For the 2-year follow-up, the mean age of the primary THA cohort was 65 years, 49% were men, 33% were 60 years or younger and OA was the underlying diagnosis in 87% (Table 1). The revision THA cohort was similar to the primary THA cohort and loosening/wear/osteolysis was the underlying diagnosis in 78% (Table 1).

Table 1 Clinical characteristics of primary and revision THA cohorts

	Primary THA			Revision THA			
	Preop ($n=6168$)	2-year follow-up ($n=5707$)	5-year follow-up ($n=3289$)		Preop ($n=2063$)	2-year follow-up ($n=2682$)	5-year follow-up ($n=1627$)
Age,* years	64 (14)	65 (13)	65 (13)		65 (14)	66 (13)	65 (13)
Female	52	51	53		54	54	54
BMI (kg/m^2)	29 (6)	29 (6)	29 (6)		28 (6)	28 (6)	28 (6)
Age group (years)*							
⩽60	33	30	30		32	30	32
>60–70	30	31	32		26	27	29
>70–80	29	30	31		32	34	32
>80	8	9	6		10	10	7
BMI (kg/m^2)							
⩽24.9	1	1	1		2	1	1
25–29.9	23	23	24		27	28	28
30–34.9	38	39	40		38	39	40
35–39.9	24	24	23		22	22	21
⩾40	8	8	8		7	7	6
ASA score*							
Class I	6	5	5		4	3	4
Class II	57	57	59		52	49	53
Class III	37	37	35		44	47	43
Class IV	1	1	1				
Cemented*							
Yes	11	11	14		NA	NA	NA
Hybrid	53	54	59		NA	NA	NA
Uncemented	36	35	27		NA	NA	NA
Underlying diagnoses**							
OA	87	87	85	Loosening/wear or osteolysis	78	73	75
Rheumatoid/ inflammatory arthritis	3	3	3	Dislocation, bone or prosthesis fracture, instability, non-union	13	17	15
Avascular necrosis	7	7	8	Failed prior arthroplasty with components removed or infection	10	11	11
Other*	3	3	4		NA	NA	NA
Deyo–Charlson index**	1 (2)	1 (2)	1 (2)		1 (2)	1 (2)	1 (1)
Depression	7	7	6		7	6	6
Anxiety	5	5	4		3	3	3

Data are given as mean (S.D.) or percentage. NA: not applicable. *$P<0.05$ for both primary and revision THA. **$P<0.05$ for revision THA.

Non-response bias

Responders to the 2-year post-primary THA survey were more likely to be older [age 61–70, 71–80 and >80 years with odds ratio (OR) 1.4, 1.3 and 1.3, compared with ⩽60 years] and less likely to have BMI ⩾40 (OR 0.7) and ASA class III–IV (OR 0.9). At 5 years, post-primary THA responders were more likely to be older (age 61–70 years with OR 1.4; 71–80 years with OR 1.4) and have BMI 25–29.9 (OR 1.2). Compared with non-responders, responders at 2 years post-revision THA were more likely to be older (age 61–70 years with OR 1.2; 71–80 years with OR 1.3, compared with ⩽60 years) and less likely to have BMI 35–39.9 (OR 0.8), higher Deyo–Charlson index (OR 0.8 for 5-point change) and have an underlying diagnoses of dislocation/fracture (OR 0.7) or failed arthroplasty with components removed/infection (OR 0.7). At 5 years, compared with non-responders, post-revision THA responders were less likely to have BMI 35–39.9 (OR 0.7), ASA class III–IV (OR 0.8) and an underlying diagnosis of dislocation/fracture (OR 0.7) or failed arthroplasty with components removed/infection (OR 0.8).

Prevalence of severe index hip pain and clinically meaningful improvements in index hip pain severity after THA

Severe index hip pain was reported by 44% of patients before primary THA, 1% of patients at 2 years and 2% of patients 5 years post-primary THA (Fig. 1). For revision THA, the respective proportions for severe hip pain were 27% (preoperatively), 3% and 4% (Fig. 1).

In the primary THA cohort, 94% of patients with moderate hip pain preoperatively and 91% with severe hip pain preoperatively had a substantial reduction in pain severity to mild or no hip pain 2 years post-primary THA (Supplementary Fig. 1A, available at *Rheumatology* Online). Similarly, 91% of patients with moderate and 89% with severe preoperative hip pain had substantial improvement to mild or no pain 5 years post-primary THA (Supplementary Fig. 1B, available at *Rheumatology* Online).

In the revision THA cohort, 84% of patients with moderate and 77% with severe preoperative hip pain had substantial improvement to mild or no pain at 2 years post-revision THA (Supplementary Fig. 1C, available at *Rheumatology* Online), while 80% with moderate and 78% with severe hip pain preoperatively had substantial pain reduction to mild or no pain at 5 years post-revision THA (Supplementary Fig. 1D, available at *Rheumatology* Online).

Prevalence of preoperative ADL limitations

Preoperatively, moderate or severe limitations in the seven ADLs assessed were extremely common in patients undergoing primary THA, ranging from 66% for stair climbing to 86% for putting on shoes and socks (Table 2), with two exceptions—sitting (9%) and rising from a chair (37%). Preoperatively, overall activity limitations were mild in 4%, moderate in 7% and severe in 87% of patients in the primary THA cohort.

In the revision THA cohort, preoperative moderate or severe limitations in the seven ADLs were very common, ranging from 62% for stair climbing to 70% for putting on shoes and socks (Table 3), with two exceptions—sitting (5%) and rising from a chair (34%). Overall preoperative activity limitations were reported as mild by 8%, moderate by 9% and severe by 73% of revision THA patients.

Clinically meaningful improvements in ADL limitations after primary and revision THA

Due to the very low prevalence of preoperative limitations in sitting, numbers were small for most estimates for change from preoperative to 2- or 5-year follow-up, which are presented in the table but not discussed in the text below. For the other six activities, 75–85% of those with moderate and 50–59% of those with severe preoperative ADL limitation achieved mild or no limitation 2 years postoperatively in respective ADLs after primary THA (Table 4). At 5 years after primary THA, 67–86% with moderate preoperative and 44–71% with severe preoperative ADL limitation achieved mild or no postoperative ADL limitation (Table 4). Conversely, for the other six activities, up to 4% of those with moderate preoperative activity limitation and 17% with severe preoperative activity limitation reported severe limitation in the respective activity 2 years post-primary THA (Table 4). At 5 years post-primary THA, up to 7% of those with moderate preoperative limitation and 20% with severe preoperative limitation reported severe limitation in the respective activity (Table 4).

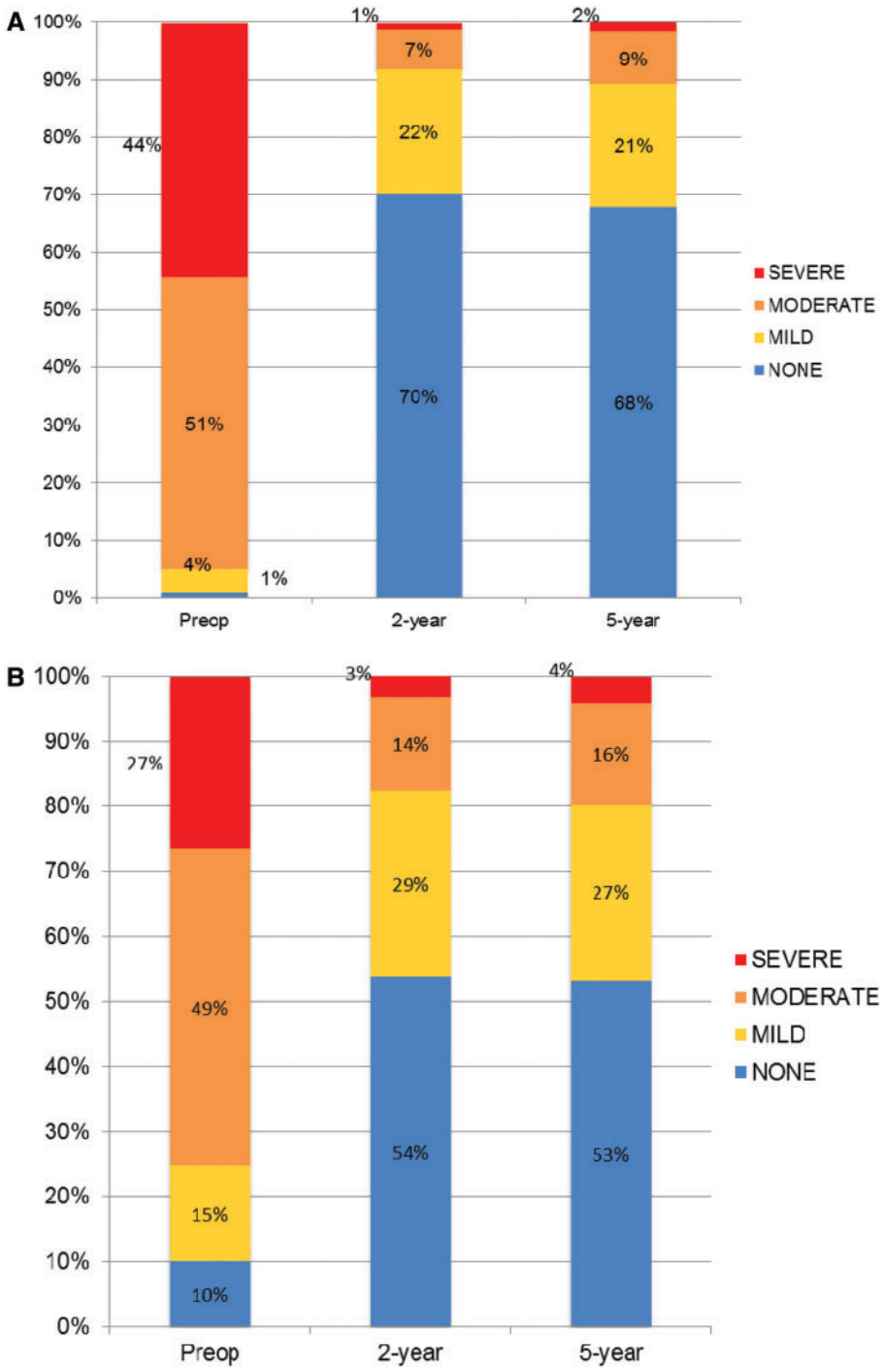
In the revision THA cohort, 51–77% of those with moderate preoperative limitation with six ADLs (except sitting) and 29–58% with severe preoperative ADL limitation reported mild to no limitation postoperatively in respective ADLs at 2 years (Table 5). At 5 years, respective numbers were 44–69% and 26–67% (Table 5). Conversely, at the 2-year follow-up, up to 10% of patients with moderate preoperative activity limitation and 26% with severe preoperative activity limitation in six ADLs reported severe limitation in the respective activity (Table 5). At the 5-year follow-up, up to 13% patients with moderate preoperative limitation and 30% with severe preoperative limitation reported severe limitation (Table 5).

Change in overall ADL limitations after primary and revision THA

In the primary THA cohort, 8% of patients with preoperative moderate overall limitation and 20% with preoperative severe overall limitation had severe overall activity limitation 2 years postoperatively (Supplementary Fig. 2A, available at *Rheumatology* Online). At 5 years, respective proportions were 15% and 23% (Supplementary Fig. 2B, available at *Rheumatology* Online).

In the revision THA cohort, 22% of patients with preoperative moderate overall limitation and 45% with preoperative severe overall limitation reported severe overall activity limitation 2 years post-revision THA (Supplementary Fig. 2C, available at *Rheumatology* Online). The respective proportions at 5 years post-revision

FIG. 1 Prevalence of pain preoperative and 2 and 5 years after primary THA (**A**) and revision THA (**B**).



THA were 26% and 49% (Supplementary Fig. 2D, available at *Rheumatology* Online).

Discussion

In this study we describe the prevalence of various degrees of index THA pain severity and limitation in seven key ADLs in a large cohort of patients with primary or revision THA in a format that is easily understandable and interpretable for patients and policymakers. A more accurate knowledge of expected improvements after THA can help patients to have realistic expectations (and reduce expectation–outcome mismatch) associated with lower pain, function and activity improvements and

Table 2 Primary THA: unadjusted prevalence (percentage) of functional limitation preoperative and at the two follow-up periods (2 and 5 years)

		None	Mild	Moderate	Severe
Walking limitations	Preoperative	8.6	21.2	49.7	20.4
	2-year	52.3	20.1	21.9	5.7
	5-year	44.7	21.4	25.3	8.6
Stair limitations	Preoperative	5.4	28.2	60.2	6.2
	2-year	47.6	34.5	16.3	1.5
	5-year	43.8	34.8	19.2	2.2
Socks/shoes limitations	Preoperative	14.4	NA	68.6	17.0
	2-year	75.2	NA	21.2	3.7
	5-year	72.6	NA	22.9	4.5
Pick up objects limitations	Preoperative	16.3	NA	72.2	11.6
	2-year	75.7	NA	22.0	2.3
	5-year	72.7	NA	23.8	3.5
In/out of car limitations	Preoperative	15.7	NA	83.0	1.3
	2-year	85.0	NA	14.7	0.3
	5-year	81.9	NA	17.7	0.3
Rise from chair limitations	Preoperative	8.1	55.6	35.6	0.7
	2-year	45.8	46.3	7.5	0.4
	5-year	42.5	47.1	9.6	0.8
Sitting limitations	Preoperative	64.8	26.6	8.3	0.3
	2-year	93.8	5.2	0.9	0.1
	5-year	92.4	6.5	1.0	0.2

NA: not applicable, since these ADLs did not have a response for the mild limitation category.

Table 3 Revision THA: unadjusted prevalence (percentage) of functional limitation preoperative and at the two follow-up periods (2 and 5 years)

		None	Mild	Moderate	Severe
Walking limitations	Preoperative	14.9	21.1	37.9	26.1
	2-year	30.6	22.2	33.8	13.4
	5-year	28.4	20.1	36.4	15.2
Stair limitations	Preoperative	9.9	28.0	51.3	10.9
	2-year	25.4	38.3	31.2	5.1
	5-year	24.6	38.5	30.8	6.1
Socks/shoes limitations	Preoperative	29.9	NA	52.6	17.4
	2-year	75.2	NA	21.2	3.7
	5-year	72.4	NA	57.1	50.2
Pick up objects limitations	Preoperative	29.6	NA	56.2	14.2
	2-year	53.5	NA	39.1	7.5
	5-year	26.6	NA	44.7	51.3
In/out of car limitations	Preoperative	33.3	NA	64.5	2.2
	2-year	69.9	NA	29.2	0.9
	5-year	67.5	NA	31.9	0.6
Rise from chair limitations	Preoperative	12.1	53.8	32.4	1.7
	2-year	26.8	56.1	15.8	1.3
	5-year	24.5	56.6	17.6	1.3
Sitting limitations	Preoperative	74.4	20.5	4.7	0.4
	2-year	86.7	11.5	1.6	0.2
	5-year	85.8	12.3	1.5	0.4

NA: not applicable, since these ADLs did not have a response for the mild limitation category.

TABLE 4 Percentage change in ADL limitations from preoperative to 2 and 5 years after primary THA

	2-year postoperative			5-year postoperative		
	None/mild	Moderate	Severe	None/mild	Moderate	Severe
Walking limitations						
Preop none/mild	89.5	9.4	1.0	84.3	13.4	2.4
Preop moderate	74.5	21.9	3.6	67.0	26.1	6.9
Preop severe	50.4	32.8	16.8	44.1	36.0	19.9
Stair limitations						
Preop none/mild	94.0	5.6	0.4	90.4	9.2	0.4
Preop moderate	79.7	19.1	1.2	75.9	22.2	1.9
Preop severe	52.5	38.8	8.7	56.7	34.0	9.3
Socks/shoes limitations						
Preop none/mild	89.4	9.9	0.7	82.4	15.0	2.6
Preop moderate	78.4	19.4	2.2	76.7	20.8	2.5
Preop severe	59.1	29.7	11.2	58.7	30.4	10.9
Pick up objects limitations						
Preop none/mild	87.5	12.2	0.3	85.3	13.4	1.3
Preop moderate	78.0	20.3	1.7	73.5	23.9	2.6
Preop severe	56.5	35.3	8.1	61.7	28.7	9.6
Sitting limitations						
Preop none/mild	99.4	0.5	0.1	99.0	0.9	0.0
Preop moderate	96.5	2.8	0.7	98.2	1.2	0.6
Preop severe	100.0	0.0	0.0	100.0	0.0	0.0
In/out of car limitations						
Preop none/mild	92.0	8.0	0.0	87.4	12.3	0.3
Preop moderate	85.6	14.1	0.3	82.3	17.5	0.2
Preop severe	71.1	26.3	2.6	70.8	29.2	0.0
Rise from chair limitations						
Preop none/mild	95.5	4.3	0.1	93.8	5.8	0.4
Preop moderate	89.3	10.3	0.4	86.0	12.7	1.3
Preop severe	50.0	35.0	15.0	55.6	44.4	0.0

patient satisfaction after THA [13, 26, 27]. This study provides data of PROs at the patient level rather than the cohort level that are easily interpretable. These data can serve as a resource for surgeons, patients and policymakers and are an important educational tool for patients planning to undergo THA. Several findings in this study deserve further discussion.

Consistent with the published literature, we found significant improvements in pain severity after THA. Postoperatively, severe pain was reported by only 1% at 2 years and 2% at 5 years post-primary THA, with proportions slightly higher for those with revision THA at 3% and 4%, respectively. Prevalence of moderate to severe index hip pain of 8% 2 years post-primary THA is similar to the 11% reported in a Danish study at 12–18 months [7]. Slight differences may be related to country setting and follow-up time. The unique contribution of this study is that we also provide estimates of change in pain severity after primary and revision THA and the prevalence of pain severity 2 and 5 years after revision THA. Data presented in Supplementary Fig. 2 (available at *Rheumatology* Online) can be easily used to provide answers to patients' questions related to expectations regarding pain after primary and revision THA. For example, a patient with severe preoperative hip pain can be reassured that 94% of patients like him/her will have no or mild hip pain 2 years post-primary THA. Similarly, 84% of patients with severe pain before revision THA can expect no or mild pain 2 years after revision THA; 14% of patients will have moderate pain and 2% severe pain 2 years after revision THA. This study provides results that can be easily understood by patients and policymakers.

We found that for six ADLs (all except sitting), clinically meaningful improvements occurred in the vast majority of patients from preoperative to postoperative assessments. The clinically meaningful ADL improvements were more remarkable for moderate (versus severe) preoperative ADL limitation and for primary (versus revision) cohorts. We noted that at 2 years post-primary THA, 0.1–5.7% of patients had severe limitation in seven key ADLs; at 5 years, ADL limitation was seen in 0.2–8.6% of patients. In those with revision THA, 0.2–13.4% had severe limitation of each ADL at 2 years. The estimates of each ADL limitation postoperatively within each preoperative

Table 5 Percentage change in ADL limitation from preoperative to 2 and 5 years after revision THA

	2-year postoperative			5-year postoperative		
	None/mild	Moderate	Severe	None/mild	Moderate	Severe
Walking limitations						
Preop none/mild	77.3	19.3	3.4	72.3	21.2	6.5
Preop moderate	50.7	38.9	10.4	44.0	43.2	12.8
Preop severe	28.5	45.1	26.4	25.9	43.7	30.4
Stair limitations						
Preop none/mild	85.4	13.5	1.1	81.9	17.0	1.1
Preop moderate	63.1	35.2	1.7	57.1	38.3	4.6
Preop severe	39.3	41.9	18.8	45.2	37.1	17.7
Socks/shoes limitations						
Preop none/mild	73.3	24.3	2.4	72.8	23.5	3.7
Preop moderate	55.8	39.5	4.8	56.7	37.4	5.9
Preop severe	40.9	34.7	24.4	35.1	44.7	20.2
Pick up objects limitations						
Preop none/mild	75.4	22.3	2.3	70.3	26.8	2.9
Preop moderate	55.1	41.3	3.6	53.8	40.8	5.4
Preop severe	28.1	50.3	21.6	29.2	51.0	19.8
Sitting limitations						
Preop none/mild	98.3	1.6	0.1	99.0	1.0	0
Preop moderate	96.2	3.8	0.0	91.9	8.1	0
Preop severe	100.0	0.0	0.0	100.0	0.0	0
In/out of car limitations						
Preop none/mild	83.4	16.6	0.0	82.9	17.1	0.0
Preop moderate	67.3	32.4	0.3	63.3	35.8	0.9
Preop severe	45.8	50.0	4.2	61.5	38.5	0.0
Rise from chair limitations						
Preop none/mild	90.0	10.0	0.0	87.7	12.1	0.2
Preop moderate	77.0	21.6	1.4	69.0	28.2	2.8
Preop severe	58.3	33.3	8.3	66.7	16.7	16.7

category of ADL limitation should serve as a useful resource for both patients and surgeons. These estimates are particularly important for patients for whom improvement in specific key ADLs is a key goal of the THA surgery.

As much younger patients now undergo THA, patients have higher expectations of THA, such as improvements in social participation, sports and leisure activities. Thus patient expectations are not limited to improvements in pain and function. Therefore our study data are especially relevant for patients with a range of expectations. These estimates are a good source of information to be provided to the patient before THA. Physicians can be proactive in sharing this information so that patients can review these numbers to better understand the benefit of THA, have realistic expectations of THA and can make a more informed decision. Policymakers can use this information to assess the relative benefit in PROs and quality of life of this procedure versus treatment of other medical conditions when allocating resources. Several patient factors such as demographics, obesity, medical comorbidities, depression and pain problems elsewhere impact THA pain and function outcomes [3, 7, 12–14, 25, 28] and need to be taken into account in addition to these data.

An important observation in our study was that the frequency of severe pain was similar at 2 years versus 5 years post-THA. For example, among primary THA patients with preoperative moderate hip pain, 1% each reported severe index hip pain at 2-year and 5-year follow-up. Similarly, in revision THA with preoperative moderate hip pain, 2% of patients at 2 years and 3% at 5 years reported severe pain. This observation was in contrast to moderate or severe activity limitation over time. We noted that the proportion of patients with moderate or severe ADL limitation increased for each ADL between 2- and 5-year follow-up in both primary and revision THA.

The study findings must be interpreted considering study strengths and limitations. Study strengths include a large cohort, prospective standardized data collection using dedicated clinical registry staff and analyses of data collected across a 13-year period. Our study has several limitations. Non-response and referral bias may limit our ability to generalize these findings to other populations. Studies from other large centres are needed to confirm

these findings and ensure their generalizability. However, similarity of patient characteristics and overall prevalence of pain severity to those reported in THA studies previously are reassuring. We made an *a priori* decision to combine moderate and severe categories based on our clinical judgement of what would be considered a suboptimal outcome by operating surgeons. However, we also provided detailed analyses of each ADL for ease of interpretation.

In summary, in this large cohort of primary and revision THA, we reported prevalence of pain severity and limitation of seven ADLs at 2- and 5-year follow-up. More importantly, we presented detailed data related to patient-level clinically meaningful changes in pain severity and ADL limitation that should prove useful for discussion with patients preoperatively. The estimates from this study provide a useful information tool that can be used to enhance patient knowledge and expectations during the informed consent process and allow patients to objectively assess their post-THA goals. These data should allow patients to set realistic expectations from THA. Future studies should provide even longer-term data for clinically meaningful pain and ADL improvements, the main reasons for patients undergoing THA.

Rheumatology key messages

- 90% of patients undergoing primary THA have clinically meaningful pain reduction up to 5 years postoperatively.
- 75% of patients undergoing revision THA report clinically meaningful pain reduction up to 5 years postoperatively.
- 75% of patients with moderate preoperative overall ADL limitation will have mild or no limitation 2 years after primary THA.

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Supplementary data

Supplementary data are available at *Rheumatology* Online.

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