Return to activity following revision total hip arthroplasty

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Background: Demand for revision total hip arthroplasty (RTHA) continues to grow worldwide and is expected to more than double within the next 1-2 decades. The primary aim of this study was to examine return to function following revision THA in a UK population.

Patients & methods: We assessed 118 patients (132 RTHAs, mean age 65 years SD 13, range 23 to 88) at a mean follow-up of 7.9 years (SD 4.4) postoperatively. Preoperative age, gender, BMI, social deprivation, operative indication, comorbidities, activity level (UCLA score) and Oxford Hip Scores (OHS) were recorded. Postoperative UCLA score, OHS, EQ-5D, satisfaction levels and performance in activities of daily living (ADLs) were obtained and univariate and multivariate analysis performed.

Results: Mean UCLA activity score improved following RTHA ($p<0.001$): UCLA activity score improved in 37% and was unchanged in 50%; 49% of patients engaged in at least moderate level activities (UCLA score ≥ 6). Patient BMI, gender, age and reason for revision did not influence levels of pain, stiffness or activity at follow up. Preoperative UCLA activity scores ($p<0.001$) independently predicted long-term UCLA scores. Independent predictors ($p<0.05$) of poor hip specific function (OHS) following revision included social deprivation, revision for peri-prosthetic fracture and lower preoperative OHS. Difficulties with ADLs were associated with increasing deprivation, ≥3 comorbidities, and revision for periprosthetic fracture or infection ($p<0.05$). Overall, 79% of patients remained satisfied or very satisfied following revision THA. Following RTHA, 10% suffered a dislocation and 13% required reoperation for complications.

Conclusion: Revision THA facilitates long-term return to preoperative levels of physical activity in the majority of patients, though activity levels increase in one third only. Overall over three quarters are satisfied with their outcome, but revision for periprosthetic fracture or dislocation gives the worse overall outcomes and lower satisfaction levels.

Introduction

Demand for revision total hip arthroplasty (RTHA) continues to grow worldwide in developed countries and is expected to increase a further 137% by 2030 [1, 2]. Factors contributing to rising demand include broadening surgical indications and younger patient age at primary surgery. Ageing populations are resulting in increasing numbers of patients outliving their primary THA, despite National Arthroplasty Registries consistently demonstrating greater than 90% 10-year primary THA survivorship [3, 4]. The rate of periprosthetic fracture (PPF), recognised to be the main risk of re-revision (apart from dislocation) in the second decade after primary THA, is expected to rise in an ageing population, further adding to the revision burden [5].

A growing revision THA burden has significant implications for patients and health care systems. The excellent levels of patient satisfaction, pain relief and improvement in quality of life associated with primary THA are less consistently reproduced by RTHA [6]. Length of hospital-stay and costs are higher in RTHA, with negative financial implications for care providers [7-10]. The influence on implant survivorship of surgical technique, implant type and bone loss management at RTHA has been described previously [11-13]. However, implant survivorship is not the only metric of success, with postoperative physical function and mobility a greater influence on patient satisfaction [14]. Patient expectations of the outcome of their revision THA are often poorly related to their preoperative level of function or disability and often need managing to avoid an expectation/outcome mismatch [15-17].

The primary aim of this study was to examine return to physical activity following revision THA using univariate and multivariate analysis.

Patients and methods

Following local ethical approval, patients who had undergone revision THA by 4 consultant orthopaedic surgeons at a single United Kingdom orthopaedic teaching hospital over a 14-year period (1999-2013) were identified from a prospectively collected arthroplasty database. Electronic healthcare records were examined and operative details recorded including reason for revision, the revision components used and postoperative complications. Patients that had undergone bilateral procedures were excluded unless over 12 months had elapsed between procedures. The presence of additional joint replacements was also noted.

Prior to surgery, patients completed validated assessments of hip function (Oxford hip score) and physical activity level (University of California, Los Angeles (UCLA) activity scale) and the presence of additional comorbidities was noted. Specifically, patients were asked if they had heart disease, hypertension, lung disease, diabetes, kidney disease, liver disease, vascular disease, anaemia, depression, back pain or pain in other joints. The Oxford Hip Score (OHS) contains 12 individual questions assessing hip pain and function on a scale of 0 to 5, with responses combined to generate an overall score between 0 and 48, with lower scores indicating more severe problems [18]. The UCLA activity scale measures physical activity on a scale from 1 (“no physical activity, dependent on others”) to 10 (“regular participation in impact sports”) and has been described as the most appropriate scale for assessment of physical activity levels in patients undergoing total joint arthroplasty [19, 20].

Postoperative questionnaires assessing patient reported outcome measures (PROMs) were sent to patients in December 2014 at mean follow up of 7.9 years (SD 4.4). The UCLA activity score, OHS, EQ-5D-3L, WORQ (Work, Osteoarthritis and joint Replacement Questionnaire) and satisfaction levels were assessed. The EQ-5D-3L, developed by the EuroQol Group, was included to provide a standardized measure of patient health status [21]. It produces a simple descriptive profile of five health domains (mobility, self-care, ability to perform usual activities, pain/discomfort, and anxiety/depression), each rated 1 to 3 (Level 1, no problems; Level 2, moderate difficulties; Level 3 severe difficulties) in addition to two visual analogue scales of health and pain (scale 0 to 100). These scores can be combined further using population weightings to produce a single index value for health status. Ability to perform activities of daily living was assessed via the Work, Osteoarthritis and joint-Replacement Questionnaire (WORQ). As a validated scoring system WORQ assess difficulty experienced performing 13 functional activities (crouching, kneeling, clambering, walking on level ground, operating a vehicle, operating foot pedals, sitting, walking on uneven ground, stairs, standing, lifting/carrying, pushing/pulling, working with hands below knee height) on a 5-point scale from “no difficulty” to “unable to perform”[22]. Patient satisfaction was rated using a five-point scale, with ‘very satisfied’, ‘satisfied’, ‘unsure’, ‘dissatisfied’ or ‘very dissatisfied’ possible responses to the question ‘How satisfied are you with your operated hip?’. To allow further analysis, we dichotomized the responses for satisfaction to positive or negative statements (equivocal answers were considered negative). Collection of data was independent of the routine clinical care of the patient.

The Scottish Index of Multiple Deprivation (SIMD) was used to assign social deprivation quintiles to patients based upon postcode. The SIMD ranks geographic areas based upon seven domains: income, employment, education, housing, health, crime, and geographical access. Data zones are defined by postcodes and once ranked nationally are divided into population-weighted quintiles with 1 representing the most deprived and 5 the least deprived.

Statistical Analysis

Statistical analysis was performed using IBM Statistical Package for Social Sciences version 25.0 (SPSS Inc, IBM Corporation, Armonk, NY, USA). Differences in continuous data (OKS, UCLA, EQ-5D) between groups was assessed using parametric (Student’s t-test: paired and unpaired) and non-parametric (Mann-Whitney U test) tests as appropriate. One-way analysis of variance (ANOVA) was used to compare continuous variables with multiple groups. Nominal categorical variables (satisfaction, WORQ outcomes) were assessed using a Chi square or Fisher's exact test. Pearson's correlation was used to assess the relationship between linear variables. Variables found to be significantly ($p<0.05$) associated with UCLA activity score and OHS were entered stepwise into a multiple linear regression analysis to identify independent predictors of outcome after correcting for compounding factors. Significance was taken as $p<0.05$.

Results

From 1999 to 2013, 118 patients underwent 132 revision THAs at a mean age of 65 years (SD 13.0, range 23 to 88). Mean post-operative follow-up was at 7.9 years (SD 4.4, range 1.6 to 15.6) and 73/118 patients were female (62%). Mean patient BMI was 27.6 kg/m^2 (SD 5.0, range 18.5-40.5) and mean length of inpatient stay was 8.3 days (SD 5.3, range 3-33). Patient characteristics are given in Table 1.

Twenty four cases were re-revision procedures and 107/132 were first time revisions. In addition to the hip, 46/132 patients (35%) had undergone another lower limb joint replacement (Table 1). The most frequent indication for revision THA was aseptic loosening. Most patients revised for infection (11/17) underwent a 2-stage procedure. The indication for primary THAs was osteoarthritis in 80% (Table 1).

Table 1. Summary of patient preoperative characteristics

Surgical variable	Breakdown	Patient Number [% patients]
Gender	Female	73 [62]
Mean age, yrs (SD, range)		65 (SD 13.0, 23 to 88)
Mean BMI, kg/m^2 (SD, range)		27.6 (SD 5.0, 18.5-40.5)
SIMD Quintile	1	8 [6]
	2	20 [15]
	3	29 [22]
	4	33 [25]
	5	42 [32]
Number of comorbidities	0	17 [13]
	1	37 [28]
	2	37 [28]
	3+	41 [31]
Indication for revision THA	Aseptic loosening	59 [45]
	Dislocation/instability	32 [24]
	Infection	17 [13]
	Implant wear/fracture	9 [7]
	Peri-prosthetic fracture	9 [7]
	Mixed indications	6 [4]
Components Revised	Femoral stem and acetabulum	105 [80]
	Acetabulum only	18 [14]
	Femoral stem only	2 [1]
	Isolated femoral head/acetabular liner change	7 [5]
Other joints replaced	None	86 [65]
	One	31 [24]
	Two	3 [2]
	Three or more	12 [9]
Indication for original THA	Osteoarthritis	106 [80]
	Rheumatoid arthritis	12 [9.1]
	Avascular necrosis	2 [1.5]
	DDH	5 [4]
	Ankylosing spondylitis	2 [1.5]
	Perthes' disease	2 [1.5]
	Juvenile idiopathic arthritis	3 [2.3]

BMI, Body Mass Index; THA, total hip arthroplasty; SIMD, Scottish Index of Multiple Deprivation.

Table 2. Summary of patient PROMs.

Surgical variable	Breakdown	
Mean OHS (SD, range)		
	Pre-revision	22 (9.2, 3 to 46)
	1 year	36 (10.0, 11 to 48)
	Follow-up	32 (11.2, 6 to 48))
Median UCLA (IQR)	Pre-revision	4 (3 to 6)
	Follow-up	5 (3 to 6)
At long term follow up:		
Mean EQ-5D score (SD, range)	Health	71.9 (22.9, 0 to 100)
	Pain	68.8 (29.0, 0 to 100)
Satisfaction, n(%)	Very satisfied	65 [49]
	Satisfied	39 [30]
	Neither	16 [12]
	Dissatisfied	5 [4]
	Very dissatisfied	7 [5]

BMI, Body Mass Index; THA, total hip arthroplasty; OHS, Oxford Hip Score; OKS, Oxford Knee Score; UCLA, University of California, Los Angeles; IQR, interquartile range; EQ-5D, EuroQol-5D

Functional outcome

Activity Levels

Mean UCLA activity scores improved significantly (p<0.001, T-test), from 4 (IQR 3 to 6) preoperatively (regularly participates in mild activities) to 5 (IQR 3 to 6) at follow-up (sometimes participates in moderate activities such as swimming) (Table 2). The proportion of patients that were engaging regularly in moderate or more intensive activities such as swimming, golf or cycling (UCLA score ≥ 6), increased from 29% preoperatively to 49% at follow-up (Figure 1). Mean individual improvement in UCLA score was 0.8 (SD 2.2, range -6 to 9), with 50% of patients achieving preoperative levels and 37% improving their UCLA activity score compared to preoperative levels at follow-up (Figure 1). Twelve percent of patients reported decreased UCLA activity scores following revision THA (Table 3) and were less likely to be very satisfied at follow-up (13% (2/15) versus 61% (27/44), p=0.004, chi-squared). However, overall satisfaction rates were high (79%) (Table 2).

Figure 1. Patient UCLA activity scale performance before and after revision THA.

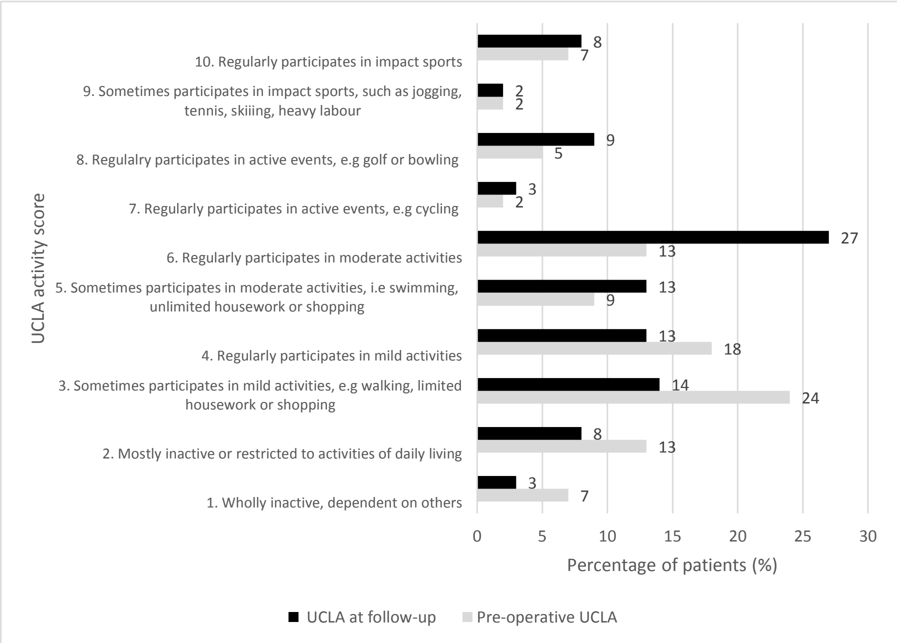


Table 3. Comparison of patients with increased and decreased postoperative UCLA scores

	UCLA Increased (n=44)	UCLA Decreased (n=15)	p-value
Mean age (SD)	63.8 (14.4)	67.5 (8.7)	0.36
Mean BMI (SD)	26.7 (4.3)	29.0 (5.5)	0.33
Female gender, n (%)	26 (59)	9 (60)	0.951
Mean Comorbidities (SD)	1.8 (1.2)	1.9 (1.2)	0.89
SIMD, n (%)			0.544
1	4 (9)	1 (7)	
2	5 (12)	4 (27)	
3	11 (26)	4 (27)	
4	15 (35)	1 (7)	
5	8 (18)	5 (33)	
Indication (n)			0.829
Aseptic loosening	19 (43)	8 (53)	
Infection	4 (9)	2 (13)	
Dislocation/ instability	12 (27)	3 (20)	
Component wear/ fracture	3 (7)	1 (7)	
Periprosthetic fracture	4 (9)	0 (0)	
Other	2 (5)	1 (7)	
OHS (SD)			

Prerevision	23.1 (9.2)	18.4 (5.7)	0.180
Final follow-up	34.9 (10.3)	26.7 (12.0)	0.014¥
EQ-5D score (SD)			
Health	74.1 (22.5)	66.7 (23.7)	0.285
Pain	68.7 (28.8)	80.2 (28.8)	0.152
Satisfaction (n)			0.004*
Very satisfied	27 (61)	2 (13)	
Satisfied	7 (16)	9 (60)	
Neither	6 (14)	2 (13)	
Dissatisfied	2 (5)	0 (0)	
Very dissatisfied	2 (5)	2 (13)	

BMI, Body Mass Index; THA, total hip arthroplasty; OHS, Oxford Hip Score; OKS, Oxford Knee Score; UCLA, University of California, Los Angeles; IQR, interquartile range; EQ-5D, EuroQol-5D
P<0.05 * Chi-squared test ¥ Student's t-test

Postoperative UCLA activity scores correlated significantly with preoperative UCLA activity scores (p<0.001, r=0.570, Pearson's correlation) and were negatively influenced by re-revision (Table 7). Patient gender, BMI, SIMD quintile and reason for revision did not influence UCLA activity score (p>0.05)(Tables 6 and 7). Although pre and postoperative UCLA activity scores were lower in those undergoing re-revision, the absolute gain in UCLA activity score was not significantly different to those undergoing a first-time revision THA (0.81, SD 1.7 *versus* 0.80, SD 2.3, p=0.202, t-test). Preoperative UCLA score (p<0.001) was the only independent predictor of post-operative UCLA score on multivariate analysis (Table 4).

Table 4. Multivariate analysis of predictors of long-term UCLA and OHS score following revision THA.

Dependent factors	B (95% CI)	p-value
Predictors of UCLA Score (R^2 =0.38)		
Pre-operative UCLA score	0.54 (0.36 to 0.65)	<0.001
Re-revision cases	0.11 (0.36 to 0.65)	0.147
Predictors of OHS Score (R^2=0.367)		
Presence ≥3 comorbidities	-0.08 (-6.9 to 3.1)	0.459
Revision for periprosthetic fracture	-0.33 (-25.0 to -5.8)	0.002
Social deprivation	0.27 (1.6 to 13.4)	0.013
Preoperative OHS	0.23 (0.03 to 0.6)	0.029

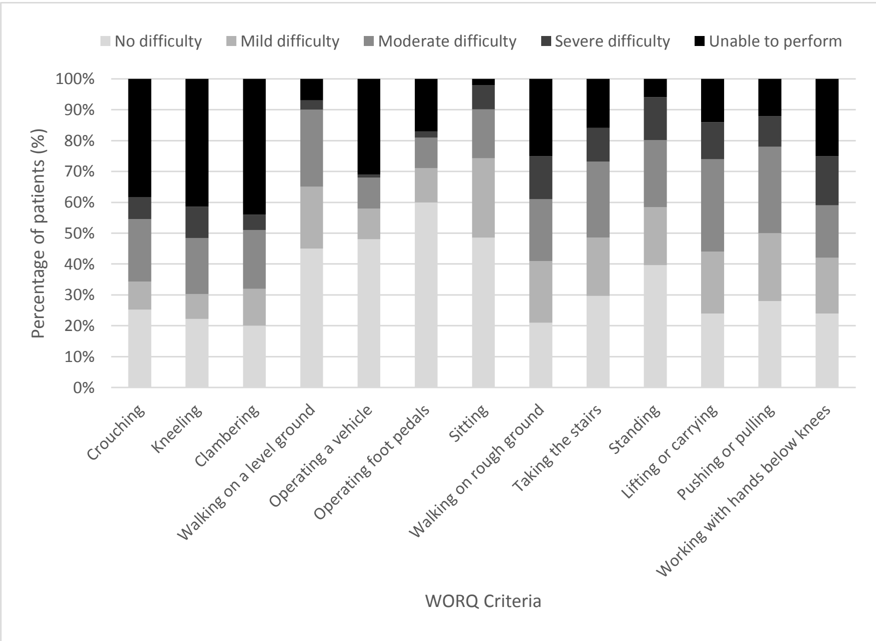
Undergoing further surgery	0.05 (-4.4 to 7.6)	0.608
Re-revision cases	0.01 (-5.8 to 6.4)	0.914

Other PROMs

Mean OKS improved significantly ($p<0.001$) from 22 (SD 9.2) preoperatively to 36 (SD10.0) at one year and 32 (SD 11.2) at longer term follow-up (Table 2). Relative to preoperative scores, 87% of patients had improved OKS, 1% maintained their OKS and 12% had decreased OKS at long-term follow-up. Worse follow-up OHSs were associated with lower preoperative OHS ($p=0.002$, $r=0.349$, Pearson's correlation), ≥3 comorbidities ($p=0.016$, t-test), revision for periprosthetic fracture ($p=0.001$, ANOVA), reoperation ($p=0.039$, t-test) and increasing deprivation ($p<0.001$, ANOVA). On multivariate analysis lower OHS at follow up was independently predicted by deprivation, revision THA for PPF and preoperative OHS (Table 4).

Assessment of performance in ADLs through the WORQ criteria found that crouching, kneeling and clambering were amongst the most difficult activities for patients to perform at follow up (Figure 2). However, most patients had limited difficulty with activities such as walking on a level ground, operating foot pedals, sitting and standing.

Figure 2. Patient performance in functional activities assessed by WORQ criteria



Patient gender, BMI and age had no effect on performance in functional activities assessed by the WORQ criteria, or on other PROMs (UCLA, OHS, satisfaction, stiffness, EQ-5D health, EQ-5D pain) at follow up (p>0.05).The presence ≥3 comorbidities, social deprivation (SIMD I and II) and revision for infection or fracture were associated with more severe difficulty in performing a range of physical activities (Table 5).

Table 5. Factors associated with moderate or more severe difficulty in performing WORQ criteria

Proportion and (%) of patients in each subcategory reporting moderate or more severe difficulty performing WORQ criteria displayed.

	Crouching	Kneeling	Clambering	Walking on level ground	Vehicle usage	Working pedals	Sitting	Walking on rough ground	Stair usage	Standing	Lifting objects	Push/pulling	Using hands below knees
Revision for Infection and fracture	19/24 (79)	19/26 (73)	21/25 (84)	16/25 (64)	14/25 (56)	12/23 (52)	10/24 (42)	15/26 (58)	46/96 (48)	16/25 (64)	18/25 (72)	44/98 (45)	54/97 (56)
Revision for other indications	62/99 (63)	67/100 (67)	65/101 (64)	26/97 (27)	38/101(38)	19/82 (23)	22/98 (22)	54/100 (54)	12/26 (46)	35/97 (36)	53/101 (53)	18/26 (69)	15/26 (58)
p-value	0.032*	0.112	0.023*	0.004*	0.010*	0.026*	0.008*	0.105	0.291	0.011*	0.040*	0.267	0.193
SIMD I and II	22/26 (85)	21/16 (81)	20/26 (77)	17/26 (65)	20/26 (77)	14/24 (58)	13/24 (54)	17/26 (65)	20/26 (77)	19/25 (76)	21/24 (88)	20/26 (*43*)	19/25 (76)
SIMD III, IV and V	68/95 (72)	66/98 (67)	41/98 (42)	24/96 (25)	44/98 (45)	17/79 (22)	17/94 (18)	24/94 (26)	40/94 (43)	31/95 (33)	48/98 (49)	41/96 (43)	52/96 (54)
p-value	0.183	0.133	0.001*	0.005*	0.003*	0.001*	<0.001*	0.024*	0.001*	0.001*	0.001*	0.015*	0.008*
Re-revisions	18/25 (72)	20/25 (80)	19/25 (76)	6/25 (24)	12/25 (48)	7/22 (32)	7/25 (28)	37/101 (37)	14/25 (56)	12/25 (48)	17/25 (68)	16/25 (64)	15/25 (60)
First-time revisions	38/98 (39)	69/101 (69)	43/101 (43)	5/97 (5)	543/101 (53)	24/83 (29)	23/97 (24)	13/25 (52)	49/97 (51)	39/97 (40)	55/101 (55)	48/99 (48)	57/98 (58)
p-value	0.013*	0.135	0.024*	0.034*	0.936	0.888	0.057	0.009*	0.78	0.598	0.252	0.107	0.892
< 3 comorbidities	30/83 (36)	33/86 (38)	36/86 (42)	22/83 (27)	27/86 (31)	7/73 (10)	17/82 (21)	26/86 (30)	16/82 (19)	13/82 (16)	18/86 (21)	10/84 (12)	25/83 (30)
3^+ comorbidities	26/40 (65)	32/40 (80)	26/40 (65)	20/39 (51)	25/40 (63)	13/32 (41)	13/40 (33)	23/40 (58)	16/40 (40)	11/40 (28)	15/40 (38)	17/40 (43)	26/40 (65)
p-value	0.016*	<0.001*	0.004*	0.089	0.002*	0.001*	0.185	0.018*	0.005*	0.008*	0.002*	0.001*	0.001*

p<0.05 * Chi squared

Table 6. Breakdown of demographics and PROMs by SIMD Quintiles (SD, range)

Commented [cs1]: There are a lot of tables with a lot of figures. So that it doesn't look like fishing please replace this table with pre and postop OHS by SIMD – it's the only real interest here

Variable	Mean age	Mean BMI	Median Comorbidities (SD, range)	Median preoperative UCLA score	Median postoperative UCLA score	Mean preoperative OHS	Mean postoperative OHS
SIMD (n)							
1	61.8 (15.0, 38.5 to 84.5)	24.1 (1.2, 22.7 to 25.0)	2 (1.0, 1 to 2.75)	3 (2.5, 2 to 5)	6 (2.7, 5 to 9)	18.3 (10.0, 7 to 26)	29.7 (11.6, 13 to 45)
2	64.0 (10.0, 43.8 to 80.3)	28.6 (4.0, 24.6 to 36.2)	2 (1.3, 1 to 3)	3 (2.4, 2 to 4)	3 (2.5, 2 to 5.75)	15.9 (5.9, 5 to 27)	20.8 (13.3, 6 to 48)
3	61.7 (16.0, 23.0 to 87.8)	24.9 (2.4, 22.9 to 29.3)	2 (1.1, 2 to 3)	4 (2.9, 2 to 6)	5 (2.4, 3.25 to 7.75)	25.9 (8.8, 4 to 39)	34.3 (8.1, 20 to 48)
4	68.0 (13.5, 25.9 to 88.4)	26.6 (4.6, 18.5 to 37.0)	2 (1.3, 1 to 3)	3 (2.1, 3 to 5)	6 (2.1, 3.5to 6.5)	21.8 (8.3, 3 to 38)	34.7 (11.2, 11 to 48)
5	67.4 (10.8, 43.3 to 86.5)	29.6 (6.8, 23.0 to 40.6)	1 (1.1, 1 to 2.5)	5 (2.2, 3 to 6)	5 (1.9, 4 to 6)	22.7 (8.9, 10 to 39)	33.0 (9.3, 11 to 48)
p-value	0.236	0.272	0.339	0.233	0.067	0.603	<0.001^

Impact of mode of failure, re-revisions, component revised and other joint replacements

Table 7. Breakdown of demographics and PROMs by reason for revision

Indication (n)	Mean age, yrs	BMI	Median comorbidities	Median preoperative UCLA score	Median postoperative UCLA score	Mean preoperative OHS	Mean postoperative OHS
Aseptic loosening	62.4 (15.7, 23.0 to 88.4)	27.6 (22.7 to 40.6)	2 (1.0, 1 to 2)	4.0 (2.3, 3 to 6)	6.0 (2.3, 3 to 6)	23.9 (8.9, 4 to 39)	34.8 (10.0, 6 to 42)
Infection	64.4 (11.6, 43.7 to 87.8)	30.4 (8.2, 24.7 to 36.2)	2 (1.2, 1 to 3)	3.5 (2 to 5)	4.5 (2.25 to 5.75)	17.8 (5.7, 10 to 28)	27.9 (10.2, 9 to 48)
Dislocation/ instability	72.3 (8.6, 50.7 to 84.9)	27.1 (3.7, 23.0 to 36.8)	2.5 (1.3, 1 to 3)	4.0 (2.8, 3 to 7.5)	5.0 (2.8, 3 to 7.75)	20.2 (9.9, 3 to 39)	31.6 (11.0, 9 to 48)
Component wear/ fracture	68.3 (4.8, 58.7 to 74.3)	26.0 (10.7, 18.5 to 33.6)	2 (1.5, 1 to 3)	6.5 (2.9, 3.5 to 9.75)	6.5 (2.9, 6 to 9.75)	23.0 (10.8, 7 to 30)	32.4 (12.5, 11 to 46)
Periprosthetic fracture	65.7 (4.6, 60.5 to 70.8)	29.7 (4.2, 19.4 to 40.0)	2 (1.2, 1. to 4)	3.0 (1.0, 1.75 to 3.25)	5.5 (1.0, 1.75 to 6)	18.0 (6.0, 12 to 26)	20.2 (11.9, 6 to 45)
Other	55.9 (6.7, 46.0 to 65.3)	27.5 (5.0, 18.5 to 40.5)	1 (0.5, 1 to 2)	3.5 (1.4, 2.75 to 4.5)	4.5 (1.4, 2.25 to 6)	23.8 (8.9, 3 to 39)	29.0 (12.6, 11 to 43)
p-value	0.006^	0.893	0.102	0.085	0.343	0.066	0.005^

p<0.05 ^ ANOVA

Revisions for PPF and infection were more likely to report moderate or more severe difficulty with a range of physical activities (Table 5). Patients revised for aseptic loosening had higher mean OHS at follow-up than all other patients (34.8 SD 10.0 *versus* 29.2 SD 11.6, p=0.004, unpaired t-test, 95% CI 1.79 to 9.41), whilst revision THA for PPF had a significantly lower OHS at follow up compared to all other patients (Table 7). Patients revised for aseptic loosening also had higher EQ-5D index scores than revisions for other indications (0.65 SD 0.32 *versus* 0.51 SD 0.35, p=0.025, unpaired t-test, 95% confidence interval (CI) -0.26 to -0.02).

Compared to primary revisions, re-revision patients reported lower pre and postoperative UCLA activity levels and increased difficulties in selected ADLs (Tables 5 and 7). Risk of dislocation and undergoing further surgery was not increased in re-revisions (p>0.05).

Table 7. Breakdown of demographics and PROMs by Revision Status

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Revision Status	Mean age, yrs (SD, range)	BMI, Kg/m2 (SD, range)	Median comorbidities (IQR)	Median preoperative UCLA score (IQR)	Median postoperative UCLA score (IQR)	Mean preoperative OHS (SD, range)	Mean postoperative OHS (SD, range)
1stTime Revision	66.2 (13.0, 39 to 88)	27.7 (5.0, 18.4 to 40.6)	2 (1 to 3)	4 (3 to 6)	6 (4 to 7)	22.7 (10.3, 8 to 39)	32.3 (10.7, 6 to 47)
Re-revision	62.5 (12.6, 23 to 88)	27.0 (5.1, 22.9 to 36.8)	2 (1.75 to 3)	3 (2 to 4.25)	4 (2.75 to 6)	21.7 (8.6, 3 to 39)	28.9 (12.8, 10 to 48)
p-value	0.194	0.750	0.58	0.021	0.013	0.015	0.156

p<0.05 ^ ANOVA, * Chi squared, **Student's t-test, ¥ Fisher's exact test.

Functional outcome was not influenced by the component revised or other lower limb joint replacement, with no significant difference (p>0.05) in UCLA activity level, OHS, EQ-5D, stiffness, pain, satisfaction or performance in the WORQ criteria found.

Complications

Dislocation occurred in 13/132 (10%) patients during long-term follow up, and 17/132 (13%) patients underwent reoperation (Table 6).

Table 8. Complications following revision THA.

Reason for further surgery	Frequency	Percentage of cases (%)
Recurrent dislocation	5	4
Femoral fracture	4	3
Acetabular fracture	1	<1
Infection	6	5
Aseptic loosening of acetabular cup	1	<1

Undergoing reoperation for complications was associated with lower OHS scores at follow up (32.8 SD 10.8 *versus* 27.4 SD 12.5, p=0.039, unpaired t-test, 95% confidence interval (CI) 0.23 to 10.4).

However, long-term UCLA score, performance in WORQ criteria, satisfaction levels, EQ-5D index, stiffness and pain levels were unaffected (p>0.05). BMI (p=0.921) and age (p=0.055) was not significantly different between patients requiring further surgery or not.

Patients who suffered a dislocation following revision THA reported increased levels of dissatisfaction at follow up (54% (7 from 13) *versus* 17 % (19 from 111), p=0.006, chi-squared). However, functional outcome did not appear to be affected, with no significant difference (p>0.05) demonstrated in UCLA activity score, performance in WORQ criteria, stiffness, pain, EQ-5D, OHS and willingness to have the operation again.

Discussion

At a mean follow-up approaching 8 years in a UK population, UCLA activity levels were improved or maintained following revision THA in 87% of patients relative to preoperative levels, whilst nearly 80% of patients remained satisfied or very satisfied following revision THA. Revision for infection or peri-prosthetic fracture, increasing social deprivation and the presence of 3 or more comorbidities was associated with increased impairment in a range of ADLs at follow-up. Patient gender, BMI, age, component revised and reason for revision did not influence UCLA activity score, pain or stiffness levels at follow up. Revision for aseptic loosening was associated with better PROMs at follow-up, whilst revision for periprosthetic fracture had the worst PROMs. Dislocation occurred in 10% of patients and was associated with a lower patient satisfaction, whilst 13% of patients required reoperation for complications and had lower associated OHS.

Previous studies have demonstrated that patient expectations of revision THA outcome are often unrealistic and independent of preoperative level of function [15-17, 23]. Improvements in UCLA activity score here compare well to the literature [6, 24]. Our most common outcome, in over half of patients, was for activity levels to be unchanged from preoperative levels at long-term follow-up. Patients should be counselled not to expect their activity levels to increase significantly postoperatively, with preoperative function the only predictor of postoperative activity level. In primary hip and knee arthroplasty, it has been reported that patients are more likely to report dissatisfaction if levels of preoperative function and expectation are not achieved [25-27]. Our study replicated these findings in revision THA patients, with patients that experienced decreased levels of long-term function found to be less satisfied. It was also notable that the proportion of patients who identified as being dependent upon others or inactive decreased from 20% preoperatively to 11% postoperatively. Providers of a revision arthroplasty service often face the prospect of significant operative and medical costs, which tariffs can fail to fully reimburse [7-9]. When the reduction in number of patients requiring assistance or support is added to the number of patients able to maintain or increase their mobility (88%), the cost-effectiveness of revision THA to society is increased further.

Age and gender

In contrast to primary hip and knee arthroplasty, there are few analyses of predictors of outcome following revision THA. Saleh *et al.* performed a meta-analysis and identified twenty-eight cohorts of patients in which preoperative and postoperative Harris hip scores (a clinician-based rating system) were reported [28]. At an average of fifty-seven months after revision THA, there were large improvements in the Harris hip scores, with two-thirds of the patients attaining a good or excellent result. Jain *et al.* used multivariate analysis to retrospectively evaluate predictors of outcome, as rated with the WOMAC, in patients undergoing cementless acetabular revision. They found female gender and increasing age was associated with decreased function, whilst concurrent femoral revision improved outcome. However, in the case of acetabular revision with a roof reinforcement ring, age, gender and number of past revisions did not affect outcome [29, 30]. Within primary THA, MacWilliam *et al.* found that preoperative function and comorbidity were predictive of postoperative pain and function scores at six-month follow-up evaluations [31]. Similarly, Davis *et al.* reported a trend toward preoperative function predicting function following revision THA, with experience of complications the only independent predictor of pain and function at 24 months [32]. These results are in keeping with our findings, with 3 or more comorbidities leading to poorer function in a range of ADLs, and surgical complications being associated with lower OHS at follow-up.

BMI and deprivation

Analysis of patient BMI found no impact on activity levels, other PROMs, or indeed on risk of undergoing further surgery. These findings are in keeping with Watts et al, who reported that morbidly obese (body mass index [BMI] ≥40 kg/m^2) and non-obese patients (BMI <30 kg/m^2) undergoing first-time aseptic revision THA had similar hip specific scores and risk of further complications [33]. However, in the case of revision for infection, other studies have demonstrated increased rates of reinfection, reoperation, and component resection as well as poorer intermediate-term clinical outcome scores in obese patients [34-36].

Socioeconomic status has previously been shown to negatively affect the functional outcome of primary total hip and knee replacement, with inferior joint-specific and health scores demonstrated [37-39]. This also appears the case for revision THA, with significantly lower OHS, EQ-5D index scores and increased difficulties reported in a range of ADLs found in patients with increased social deprivation. Deprivation level did not affect satisfaction or UCLA activity levels at long-term follow.

Reason for revision

Whilst reason for revision did not impact significantly upon activity level, revision THA for PPF and dislocation had the worst overall outcome and lower satisfaction levels. The risk of dislocation after revision was relatively high at 10% in the observation period and whilst this had no impact on function scores, patients with dislocation were less likely to be satisfied. Patients revised for PPF displayed poorer OHS scores and greater difficulties with ADLs, which were also found in patients revised for infection. Looking to the future, these results are concerning as projections suggest the number of periprosthetic fractures is expected to increase by 4.6% every decade over the next 30 years [5]. The burden of infected total hip and knee arthroplasties requiring revision is also increasing in arthroplasty registries worldwide [40]. Singh *et al*. analysed the impact of operative diagnosis on outcome 2 and 5 years after revision THA [41]. At two years, revision for loosening/wear/osteolysis had decreased ADL limitations compared to revisions for other indications, although pain levels were not affected, in keeping with our findings.

Limitations

Collection of outcomes such as the WORQ criteria and patient expectations preoperatively would have provided greater context for understanding postoperative outcomes. Whilst significant attempts were made to note re-operations and complications following revision THA through accessing national electronic healthcare and radiograph archives, this data was not collected prospectively and it remains possible that some complications were lost. It was also not possible to comment on how long patients had been waiting for surgery once the decision for revision had been made. Previous studies have demonstrated that disability and pain is increased post-operatively in those who have to wait for longer than 6 months [42].

Conclusions

In summary, patients undergoing revision THA can expect to achieve a high level of satisfaction and achieve a level of function on average at least as good as pre-operative levels which is sustained at long-term follow up. Patients with increased medical comorbidities, lower preoperative function, higher social deprivation and undergoing revision for periprosthetic fracture or infection achieve the worst functional outcome. The long-term risk for dislocation is relatively high (10%) and adversely affects patient satisfaction. As the incidence of revision THA will inevitably increase in future, significant health care resources will be required to match the complex clinical demand from these patients.

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