

The relationship between patient-reported outcomes and preoperative pain characteristics in patients who underwent total hip arthroplasty



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Aims

This study aims to answer the following questions in patients with hip osteoarthritis (OA) who underwent total hip arthroplasty (THA): are patient-reported outcome measures (PROMs) affected by the location of the maximum severity of pain?; are PROMs affected by the presence of non-groin pain?; are PROMs affected by the severity of pain?; and are PROMs affected by the number of pain locations?

Methods

We reviewed 336 hips (305 patients) treated with THA for hip OA from December 2016 to November 2019 using pain location/severity questionnaires, modified Harris Hip Score (mHHS), Hip Outcome Score (HOS), international Hip Outcome Tool (iHOT-12) score, and radiological analysis. Descriptive statistics, analysis of covariance (ANCOVA), and Spearman partial correlation coefficients were used.

Results

There was a significant difference in iHOT-12 scores between groups experiencing the most severe pain in the groin and the trochanter ($p = 0.039$). Additionally, more favourable mHHS scores were related to the presence of preoperative pain in trochanter ($p = 0.049$), lower back ($p = 0.056$), lateral thigh ($p = 0.034$), and posterior thigh ($p = 0.005$). Finally, the maximum severity of preoperative pain and number of pain locations had no significant relationship with PROMs (maximum severity: HHS: $p = 0.928$, HOS: $p = 0.163$, iHOT-12 $p = 0.233$; number of pain locations: HHS: $p = 0.211$; HOS: $p = 0.801$; iHOT-12: $p = 0.112$).

Conclusion

Although there was a significant difference in iHOT-12 scores between patients with the most severe pain in the groin or trochanter, and the presence of pain in the trochanter, lower back, lateral thigh, or posterior thigh was related to higher mHHS scores, the majority of preoperative pain characteristics did not have a significant impact on outcomes. Therefore, a broad array of patients with hip OA might expect similar, favourable outcomes from THA notwithstanding preoperative pain characteristics.

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Keywords: Pain characteristics, Patient-reported outcomes, Total hip arthroplasty

Introduction

Total hip arthroplasty (THA) is increasingly being performed on patients with hip osteoarthritis (OA) to meet the needs of an ageing population.^{1,2} Hip OA is related to increased disability levels and lower quality of life,³ so treatment with THA is recommended due to its favourable outcomes for patients with OA.^{4–6} Additionally, THA is being performed

in younger patients, however their clinical outcomes have not improved over time, which could be because a larger percentage of patients have rheumatoid arthritis or other systemic inflammatory diseases.⁷

Patients with hip OA report pain in a variety of areas. Preoperative pain in patients with OA can be located in the greater trochanter (77% of patients), the groin

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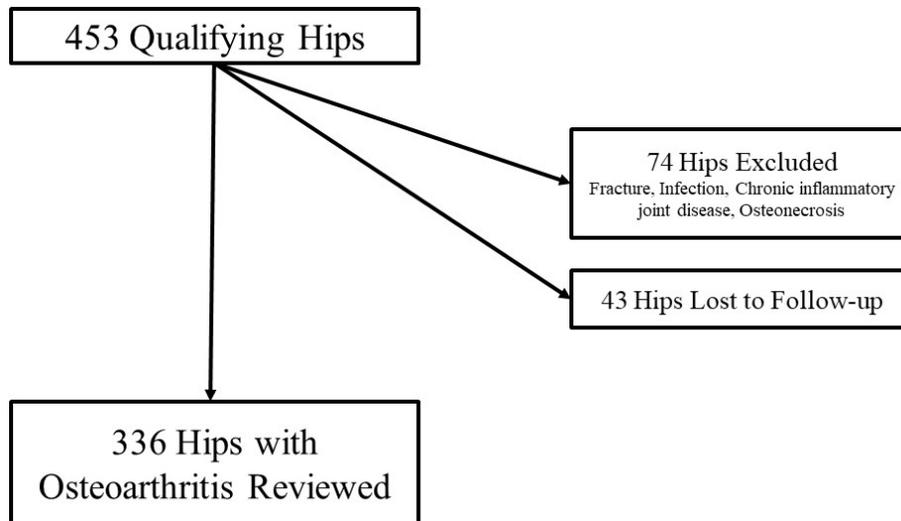


Fig. 1

Flow diagram for inclusion and exclusion in this study.

(53%), the anterior/lateral thigh (42%), the buttock (38%), knee (17%), or the lower leg (15%).⁸ In hips with acetabular dysplasia, the majority of patients have pain in the groin (72%) and lateral hip (66%), while in patients with femoroacetabular impingement, groin pain was the most common (83%).^{9,10} Although outcomes from THA and pain locations in patients with OA have been studied separately, no study has, to our knowledge, examined the association between preoperative pain characteristics and postoperative outcomes in patients who received THA for OA. This correlation has been examined in patients who received periacetabular osteotomy for acetabular dysplasia, and no significant relationship between preoperative pain characteristics and postoperative outcome measures was found.¹¹ Understanding the relationship between preoperative pain characteristics and postoperative THA outcomes is important to help patients and orthopaedic surgeons determine who is most likely to benefit from THA as the demand continues to increase.

In this study, we aim to answer the following questions: does the maximum severity of pain being located in the groin, trochanter, or both locations affect PROMs?; are PROMs affected by the presence of non-groin pain?; are PROMs affected by the severity of pain?; and are PROMs affected by the number of pain locations?

Methods

Participants. This is a prospective study of 336 hips (305 patients) that underwent THA by a single orthopaedic surgeon (JW) who is fellowship-trained in hip preservation and hip arthroplasty. UT Southwestern institutional review board approval was obtained for the present study. All patients who underwent THA for symptomatic hip OA from December 2016 to November 2019 were eligible for inclusion in the study. Patients were excluded

if they received THA due to fracture, infection, chronic inflammatory joint disease, osteonecrosis, or diagnosis other than hip OA. Patients presenting to the treating orthopaedic surgeon with symptomatic hip OA were offered treatment with THA. In total, 453 THAs were performed on 416 patients during the study period, with 74 hips meeting the exclusion criteria and 43 hips being lost to follow-up (Figure 1).

Surgical technique. For patients in this study, THA was performed either by direct anterior (DA) (163 hips, 49%)¹² or posterolateral (PL) approach (173 hips, 51%).¹³ THA was performed on 183 right hips (54%) and 153 left hips (46%).

Clinical and radiological outcomes. Location of maximum pain severity, number of pain locations, maximum severity of pain, modified Harris Hip Score (mHHS),¹⁴ Hip Outcome Score (HOS),¹⁵ and international Hip Outcome Tool (iHOT-12)¹⁶ were assessed by patient self-reported hip questionnaires completed at preoperative and postoperative visits.¹¹ Postoperative outcome measures were recorded at the most recent follow-up appointment. The mHHS, HOS, and iHOT-12 all range on a scale of 0 to 100, with 100 being the highest possible score for each outcome measure. The minimal clinically important difference (MCID) values used in this study for mHHS, HOS, and iHOT-12 are 8.0, 6.0, and 13.0, respectively.^{11,17,18}

Patients marked their locations of pain on questionnaires (Figure 2). Pain could be located in the groin, anterior thigh, knee, lower back, buttock, posterior thigh, trochanter, and/or lateral thigh. In addition, patients noted the severity of pain at each location based on the following, previously reported scale:^{11,19-21} 0 = no pain, 1 = pain with extreme activity only (running, excessive walking, etc.), 2 = pain with moderate activity or specific movements only (getting in/out of a chair or car; going

Pain Drawing and Scales

Patient Name: _____

ALL QUESTIONS RELATE TO THE OPERATIVE SIDE – LEFT

- 1.) Please identify any area(s) where you are experiencing pain by placing a number in the box next to the area(s) on the diagram below. Use the scale below to identify your level of pain.

0 = No Pain

1 = Pain with extreme activity only (running, excessive walking, etc.)

2 = Pain with moderate activity or specific movements only (getting in/out of a chair or car; going up/down stairs)

3 = Pain with daily activities (bathing, getting dressed, going to bathroom, etc.)

4 = Pain at rest during the day

5 = Pain at night that wakes you up, or pain all the time

- 2.) For any areas on the diagram where you indicated having pain, please check one small box that best represents the frequency of this pain. (Daily, Weekly, or Monthly)

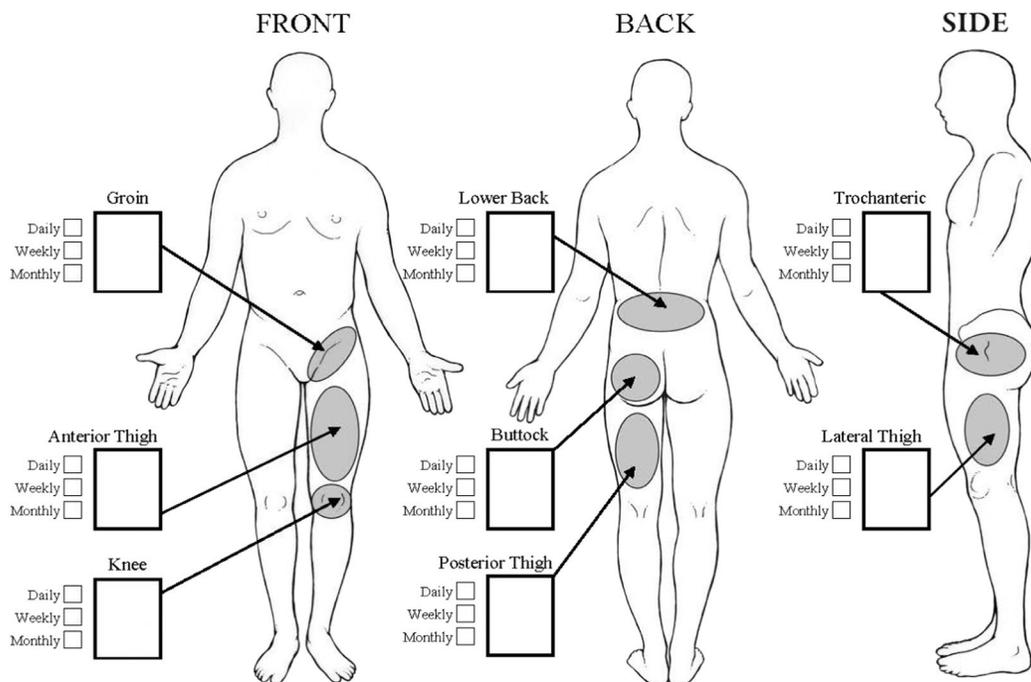


Fig. 2

Pain severity and locations drawing included on the hip questionnaire which was sent to potential study participants.

up/down stairs), 3 = pain with daily activities (bathing, getting dressed, going to bathroom, etc.), 4 = pain at rest during the day, 5 = pain at night that wakes you up, or pain all the time. Locations of pain were confirmed by the senior author (JW) during examination of the patients.

Preoperative Tonnis Grade measurements were made by the senior author and orthopaedic surgeon (JW), who has a previously reported intraclass correlation coefficient (κ) for Tonnis Grade of 0.71.²² This is a good degree of reliability.²³ Tonnis Grade is clinically important as it can be used as both a predictive tool of the eventual need for THA, as well as a tool of communication and prognosis.²⁴ Age, sex, BMI, weight, height, race, and previous

hip surgery data were collected from electronic medical records.

Statistical analysis. This study uses similar statistical analysis methodology to Everett et al.¹¹ “demographic and clinical characteristics for the sample of patients who underwent” THA for hip OA “were described using the sample mean and standard deviation for continuous variables and the frequency and percentage for categorical variables. A separate fixed-effects general linear model analysis of covariance (ANCOVA), with robust standard errors (SEs; HC3 sandwich first order residual empirical estimator), was used to examine the main effect of pain locations on each postoperative PROM, while controlling for preoperative patient-reported

Table I. Demographic and clinical characteristics of the overall sample.

Preoperative characteristics	Overall sample (n = 336 hips)
Mean age, yrs (SD, range)	66.94 (10.66; 37 to 92)
Female sex, % (n)	58 (195)
Mean BMI, kg/m ² (SD; range)	29.05 (5.31; 17.64 to 45.07)
Mean time pre- to post-treatment, days (SD; range)	340.52 (172.24; 74 to 1,079)
Mean Pain Severity Scale (SD; range)*	4.11 (1.04; 1 to 5)
Mean number of pain locations (SD; range)	3.45 (2.37; 1 to 8)
Mean HHS (SD; range)	40.41 (14.93; 0 to 88)
Mean HOS (SD; range)	39.86 (17.41; 2 to 87)
Mean iHOT-12 (SD; range)	26.44 (17.05; 0 to 100)
Previous hip surgery, % (n)	18.75 (63)
Tonnis Grade 1, % (n)	2.38 (8)
Tonnis Grade 2, % (n)	10.71 (36)
Tonnis Grade 3, % (n)	86.90 (292)

*Pain Severity Scale ranges from 1 to 5 (higher score = greater severity of pain).

HOS, Hip Outcome Score; iHOT-12, international Hip Outcome Tool; mHHS, modified Harris Hip Score; SD, standard deviation.

measures, age, sex, BMI, and follow-up time. Least squares means (LSM, adjusted means) of the PROM were estimated as part of the ANCOVA model and were compared between various pain locations.” The Tukey-Kramer post-hoc test was used to evaluate all pairwise comparisons among pain locations. “Next, the mean of mHHS, HOS, and i-HOT12 at pre- and post-treatment stratified by pain level was compared using the dependent samples *t*-test. Finally, a correlation analysis, using the Spearman partial correlation coefficient (r_s), was conducted to evaluate the relationship between preoperative maximum severity of pain and number of pain locations with postoperative PROM, while controlling for preoperative patient-reported measures, age, sex, BMI, and follow-up time. Statistical analyses were carried out using SAS software v. 9.4 (SAS Institute, Cary, NC). The level of significance was set at $\alpha = 0.05$ (two-tailed)” and we implemented the false discovery rate (FDR) procedure to control false positives over the multiple tests.

Results

Participant characteristics. The sample of 305 patients (336 hips) consisted of 195 females (58%), with a mean age of 66.94 years (SD 10.66; 37 to 92). Mean BMI was 29.05 kg/m² (SD 5.31). The mean time in days from pre- to post-treatment assessment was 340.52 days (SD 172.24; 74 to 1,079). A total of 307 hips (91%) had groin pain, 190 (57%) had trochanter pain, 146 (43%) had lower back pain, 127 (38%) had buttock pain, 116 (35%) had anterior thigh pain, 112 (33%) had knee pain, 101 (30%) had lateral thigh pain, and 62 (18%) had posterior thigh pain. Table I presents patient demographic and preoperative clinical characteristics. When comparing the two different approaches used in THA, the ANCOVA revealed a significant difference for postoperative iHOT-12

(DA LSM 84.77 (SE 1.28), PL LSM 78.28 (SE 1.69), $p = 0.004$, FDR = 0.011) and postoperative mHHS (DA LSM 95.29 (SE 0.47); PL LSM 93.63 (SE 0.58), $p = 0.039$, FDR = 0.058), but not on postoperative HOS (DA LSM 85.17 (SE 1.41) vs PL LSM 82.57 (SE 1.37), $p = 0.201$, FDR = 0.201).

Location of maximum severity of preoperative pain. Patients were grouped based on where they experienced the greatest severity of pain, either the groin, trochanter, equal in both the groin and trochanter, or another location indicated on Figure 2. In total, 180 hips (53.57%) had the most severe pain in the groin, 44 hips (13.10%) had the most severe pain in the trochanter, 80 hips (23.81%) had equally severe pain in the groin and trochanter, and 32 hips (9.52%) had the most severe pain in other areas such as lower back, buttock, anterior thigh, knee, lateral thigh, and posterior thigh. The ANCOVA revealed a significant main effect of location on iHOT-12 ($p = 0.009$, FDR = 0.026), but not on mHHS or HOS (Table II). The Tukey-Kramer test for all pairwise comparisons among the four pain locations on iHOT-12 revealed that only groin was significantly different from trochanter ($p = 0.039$); no other pairwise contrasts were significantly different from each other on iHOT-12. The Tukey-Kramer test for all pairwise comparisons also revealed no significant differences among the four pain locations on HOS and mHHS.

Presence of non-groin pain. The relationship between each of the preoperative pain locations on Figure 2 and each of the postoperative hip outcome scores was examined using ANCOVA, while controlling for preoperative patient-reported measures, age, sex, BMI, and follow-up time. However, the groin location was not included in this analysis, as 91% of hips experienced groin pain. The ANCOVA results revealed a significant relationship between postoperative mHHS and the presence of pain in the trochanter ($p = 0.049$, FDR = 0.098), lower back ($p = 0.056$, FDR = 0.098), lateral thigh ($p = 0.034$, FDR = 0.098), and posterior thigh ($p = 0.005$, FDR = 0.035), with a greater mHHS LSM when pain was present in each of these locations (Table III). The ANCOVA showed no significant relationship between non-groin pain location and postoperative HOS and iHOT-12 (Table III).

Maximum severity of pain. For maximum severity of 1 to 5, every group saw an improvement in all outcome measurements from preoperative to postoperative (Table IV), with significant differences from preoperative scores to postoperative scores that met the MCID for each outcome score for every patient, on average, regardless of their maximum pain severity level. Overall, 335 (99.7%) hips met the MCID for mHHS. Of the 284 hips with a pre- and postoperative HOS score, 273 (96.1) met the MCID for HOS. Of the 285 hips with a pre- and postoperative iHOT-12 score, 265 (93.0%) met the MCID for iHOT-12. Three hips had a preoperative maximum severity of 1 (0.89%), 25 hips had a

Table II. Patient-reported outcomes following total hip arthroplasty by location of maximum pain severity.

Outcome variable	Adjusted LSM (SE)				p-value*	FDR
	Groin (n = 180)	Trochanter (n = 44)	Equal in groin and trochanter (n = 80)	Other (n = 32)		
mHHS	94.27 (0.49)	96.37 (0.83)	94.04 (0.68)	93.74 (1.46)	0.108	0.162
HOS	83.94 (1.30)	81.64 (2.47)	84.49 (1.84)	84.56 (3.13)	0.806	0.806
iHOT-12	83.82 (1.17)	75.34 (2.96)	77.65 (2.49)	85.79 (3.56)	0.009	0.026

*One-way analysis of covariance was used to test for the difference of the least squares means estimate among the four pain locations on each postoperative outcome. "Other" includes lower back, buttock, anterior thigh, knee, lateral thigh, and posterior thigh. FDR, false discovery rate; HOS, Hip Outcome Score; iHOT-12, international Hip Outcome Tool; LSM, least squares mean; mHHS, modified Harris Hip Score; SE, robust standard error.

Table III. Postoperative patient-reported outcomes by presence or absence of pain in non-groin locations.

Pain location	mHHS		HOS		iHOT-12	
	Adjusted LSM (SE)	p-value*	Adjusted LSM (SE)	p-value*	Adjusted LSM (SE)	p-value*
Trochanter						
Yes (n = 190)	95.08 (0.43)	0.048	84.43 (1.17)	0.476	80.06 (1.46)	0.120
No (n = 146)	93.63 (0.58)		83.06 (1.50)		83.21 (1.40)	
Lower back						
Yes (n = 146)	95.22 (0.51)	0.056	83.24 (1.19)	0.588	79.20 (1.74)	0.068
No (n = 190)	93.83 (0.50)		84.29 (1.19)		83.14 (1.24)	
Buttock						
Yes (n = 127)	94.00 (0.62)	0.372	84.09 (1.62)	0.835	79.44 (1.75)	0.135
No (n = 209)	94.70 (0.45)		83.67 (1.15)		82.63 (1.24)	
Anterior thigh						
Yes (n = 116)	94.93 (0.62)	0.338	85.23 (1.55)	0.290	80.97 (1.83)	0.754
No (n = 220)	94.18 (0.44)		83.09 (1.20)		81.67 (1.26)	
Knee						
Yes (n = 112)	94.98 (0.66)	0.301	84.87 (1.54)	0.441	80.08 (1.90)	0.382
No (n = 224)	94.16 (0.43)		83.31 (1.20)		82.10 (1.24)	
Lateral thigh						
Yes (n = 101)	95.58 (0.58)	0.034	85.07 (1.66)	0.391	79.31 (2.14)	0.214
No (n = 235)	93.94 (0.45)		83.30 (1.14)		82.33 (1.14)	
Posterior thigh						
Yes (n = 62)	96.18 (0.60)	0.005	85.77 (1.04)	0.402	81.68 (2.20)	0.904
No (n = 274)	94.04 (0.42)		83.44 (1.04)		81.37 (1.18)	

*Analysis of covariance was used to test for the difference of the least squares means estimate between non-groin pain location and each postoperative outcome. False discovery rate (FDR) values for mHHS were 0.098 (for p = 0.048), 0.098 (for p = 0.056), 0.372 (for p = 0.372), 0.372 (for p = 0.338), 0.372 (for p = 0.301), 0.098 (for p = 0.034) and 0.035 (for p = 0.005); FDR values for HOS were > 0.666; FDR values for iHOT-12 were > 0.315. HOS, Hip Outcome Score; iHOT-12, international Hip Outcome Tool; LSM, least squares mean; mHHS, modified Harris Hip Score; SE, robust standard error.

maximum severity of 2 (7.44%), 74 hips had a maximum severity of 3 (22.02%), 64 hips had a maximum severity of 4 (19.05%), and 170 hips had a maximum severity of 5 (50.60%). Correlation analysis using Spearman partial correlation coefficients (r_s) indicated no significant relationship between preoperative maximum severity of pain and postoperative PROM, while controlling for preoperative patient-reported measures, age, sex, BMI, and follow-up time (HHS: $r_s = -0.005$, $p = 0.928$; HOS: $r_s = -0.077$, $p = 0.163$; iHOT-12: $r_s = -0.066$, $p = 0.233$).

Number of pain locations. There were 103 hips with one pain location (30.65%), 50 hips with two pain locations (14.88%), 42 hips with three pain locations (12.50%), 33 hips with four pain locations (9.82%), 29 hips with five pain locations (8.63%), 27 hips with six pain locations (8.04%), 22 hips with seven pain locations

(6.55%), and 30 hips with eight pain locations (8.93%). Spearman partial correlation analysis determined no significant relationship between number of pain locations (1 to 8) and postoperative outcome measures (HHS: $r_s = 0.069$, $p = 0.211$; HOS: $r_s = 0.014$, $p = 0.801$; iHOT-12: $r_s = -0.088$, $p = 0.112$). Patients were also divided into "pain locations ≤ 3 " (195 hips, 58.04%) or "pain locations > 3 " (141 hips, 41.96%) using a median split. The ANCOVA results indicated no significant difference between these two patient groupings (≤ 3 vs > 3) on any postoperative PROM (Table V). Finally, Spearman point-biserial partial correlation analysis also revealed no significant relationship between the number of pain locations when divided into two groups (≤ 3 vs > 3) and postoperative outcome measures (HHS: $r_s = 0.101$, $p =$

Table IV. Patient-reported outcomes by preoperative maximum severity of pain.

Maximum severity of pain (n)	Preoperative mean (SD)	Postoperative mean (SD)	p-value*
mHHS			
1 (3)	47.00 (9.16)	93.66 (7.76)	0.033
2 (25)	45.40 (17.13)	95.90 (6.82)	< 0.001
3 (74)	41.62 (14.28)	93.69 (6.69)	< 0.001
4 (64)	43.45 (14.79)	96.21 (5.01)	< 0.001
5 (170)	37.88 (14.66)	93.89 (7.14)	< 0.001
HOS			
1 (3)	34.77 (4.01)	80.08 (32.95)	0.1665
2 (25)	44.85 (19.58)	86.32 (21.20)	< 0.001
3 (74)	40.34 (16.72)	83.55 (16.60)	< 0.001
4 (64)	44.44 (17.85)	87.76 (14.68)	< 0.001
5 (170)	37.28 (16.97)	82.17 (18.09)	< 0.001
iHOT-12			
1 (3)	46.33 (46.48)	91.66 (7.63)	0.273
2 (25)	31.14 (20.42)	87.23 (17.73)	< 0.001
3 (74)	28.09 (16.23)	79.89 (18.88)	< 0.001
4 (64)	28.48 (15.16)	83.18 (17.19)	< 0.001
5 (170)	23.92 (16.50)	80.40 (19.34)	< 0.001

*Two-tailed dependent samples *t*-test was used to test for differences in sample means from pre- to postoperation. Change was operationally defined as post- minus preoperative score. False discovery rates were 0.0001 (for $p < 0.0001$), 0.037 (for $p = 0.0327$), 0.178 (for $p = 0.1665$), and 0.273 (for $p = 0.2730$).

HOS, Hip Outcome Score; iHOT-12, international Hip Outcome Tool; mHHS, modified Harris Hip Score; SD, standard deviation.

Table V. Postoperative patient-reported outcomes by number of preoperative pain locations.

Grouped number of pain locations	Adjusted LSM of outcome measure (SE)	p-value (FDR)
mHHS		
> 3	95.21 (0.53)	0.077 (0.231)
≤ 3	93.88 (0.49)	
HOS		
> 3	84.24 (1.43)	0.709 (0.709)
≤ 3	83.53 (1.23)	
iHOT-12		
> 3	79.67 (1.74)	0.154 (0.231)
≤ 3	82.69 (1.22)	

Sample sizes for pain location groups > 3 and ≤ 3 were 141 and 195, respectively. Analysis of covariance was used to test for the difference of the least squares means estimate between the grouped number of pain locations and each postoperative outcome.

FDR, false discovery rate; HOS, Hip Outcome Score; iHOT-12, international Hip Outcome Tool; LSM, least squares mean; mHHS, modified Harris Hip Score; SE, robust standard error.

0.066; HOS: $r_s = 0.019$, $p = 0.730$; iHOT-12 $r_s = -0.060$, $p = 0.277$).

Discussion

There is a gap in current research on the impact of preoperative pain characteristics on outcomes in patients electing to undergo THA for hip OA. In our practice, we have found that patients often present with multiple areas of pain, and some often report pain in a location other than the groin, yet have advanced radiological OA. Our study aims to fill this gap, as it is the first study, to our knowledge, to evaluate the

relationship between preoperative pain characteristics and postoperative PROMs.

This study found that the most common locations of preoperative pain in patients with OA were the groin (91% of hips) and trochanter (57%). This contrasts with Poulsen et al,⁸ who found the most common locations of pain to be the trochanter (77%) followed by the groin (53%). However, their study included fewer patients (108) and used a different pain location map.

Addressing the first of our objectives, there is a main effect of location by measure of iHOT-12 between both the groin and trochanter, but all other measured outcomes showed no statistical significance by paired locations. It is possible that because iHOT-33, and thus iHOT-12, was developed for younger, active patients,²⁵ the trochanter pain prior to THA limits how active patients are afterwards. This trochanteric pain could be caused by an extra-articular pathology, such as an abductor tendinopathy or trochanteric bursitis,^{26,27} which might not be alleviated by THA and thus limit activity after treatment. For mHHS and HOS, there was no significant difference in outcomes between the four groups. Overall, this study would suggest that regardless of where patients are experiencing the maximum severity of pain, they can expect similar outcomes when measured by mHHS or HOS, but might experience less favourable outcomes when measured by iHOT-12 if they have the most severe preoperative pain in the trochanter.

Secondly, the presence of non-groin pain in the preoperative period located in the trochanter, lower back, lateral thigh, or posterior thigh was found to be related to

better mHHS scores compared to patients with no pain in those locations. Both HOS and iHOT-12 showed no difference among non-groin locations when comparing patients with or without pain in those locations. Additionally, there seems to be no discernible pattern that would suggest that either the presence or absence of pain in any non-groin location relates to better PROMs across the three outcome scores. Therefore, these results suggest that the presence or absence of pain in any non-groin location does not relate to a significant difference in PROMs, although patients with pain in the trochanter, lower back, lateral thigh, or posterior thigh might expect better outcomes when measured by mHHS. Further investigation may be necessary to determine why patients with pain in the trochanter, lower back, lateral thigh, or posterior thigh have better mHHS scores than patients without pain in those locations.

Thirdly, the results found that there was no significant relationship between preoperative maximum severity of pain and postoperative PROMs. Although there was a small inverse correlation between preoperative maximum pain severity and PROMs, the correlation coefficients are negligible and not significant.

Finally, there was no significant relationship found between the number of preoperative pain locations and PROMs after THA. Although there was a positive correlation between number of pain locations and mHHS/HOS, as well as a negative correlation between number of pain locations and iHOT-12, the correlations were small and not significant. These trends were maintained even when patients were grouped by ≤ 3 or > 3 pain locations. This suggests that patients who have pain in more locations had similar outcomes for each measured PROM after THA compared to those who had pain in fewer locations.

This study has limitations. First, the surgeries were performed by one surgeon, and therefore the results may not be representative of other surgeons or centres. However, previously reported THA techniques^{12,13} and PROMs were used.¹⁴⁻¹⁶ Additionally, questionnaires are subjective, and there may be inter-subject variation in how the questions were interpreted. However, we did use a valid instrument that has been published previously to help minimize this.¹⁹⁻²¹ Another limitation is the variance in follow-up time, which could affect postoperative outcome measures. The standard follow-up times with the senior author are six weeks, four months, two years, five years, and ten years for patients receiving THA. However, due to scheduling and patient follow-up, follow-up times can vary, especially since this cohort included follow-up times that were affected by the COVID-19 pandemic. In order to mitigate the impact of variance in follow-up time on the internal and statistical validity of the findings, we controlled for this in our statistical models. Additionally, patients on either side of the follow-up time spectrum had comparable postoperative outcome

measures, and increased follow-up time was not associated with better outcomes.

In summary, this study examined the relationship between preoperative pain characteristics and postoperative PROMs in patients with hip OA who underwent THA. It was found in the study that the groin and trochanter showed a significant effect of location between each other on iHOT-12. Non-groin pain in the trochanter, lateral thigh, and posterior thigh showed more favourable mHHS scores compared to patients with no pain in those locations, with HOS and iHOT-12 showing no significant difference. There was no correlation between maximum severity of pain and postoperative PROMs despite a small inverse correlation, found to be negligible when looking at the correlation coefficients. No significant relationship was found between patients grouped by ≤ 3 or > 3 pain locations and PROMs. Finally, the majority of patients (93%) saw dramatic improvement in all patient-reported outcome scores after THA. To our knowledge, this is the first study that evaluated these questions. Future studies should aim to address why some patients with a maximum severity of pain in the trochanter might have worse iHOT-12 outcomes than patients with a maximum severity of pain elsewhere. Other future studies could also examine why some patients with the presence of pain at certain non-groin locations have better mHHS outcomes than patients without pain in those locations. In conclusion, this study suggests that for the majority of pain characteristics, a broad array of patients with hip OA should expect favourable outcomes from THA, and patients who do not have classic groin pain may still have excellent outcomes following THA.



Take home message

- This study attempts to fill a current gap in knowledge that could help orthopaedic surgeons better understand the association between preoperative pain location/pain severity and postoperative outcomes for patients following total hip arthroplasty.

References

1. Wolford ML, Palso K, Bercovitz A. Hospitalization for total hip replacement among inpatients aged 45 and over: United States, 2000–2010. *NCHS Data Brief*. 2015;186:1–8.
2. Nemes S, Gordon M, Rogmark C, Rolfson O. Projections of total hip replacement in Sweden from 2013 to 2030. *Acta Orthop*. 2014;85(3):238–243.
3. Boutron I, Rannou F, Jardinaud-Lopez M, Meric G, Revel M, Poiraudreau S. Disability and quality of life of patients with knee or hip osteoarthritis in the primary care setting and factors associated with general practitioners' indication for prosthetic replacement within 1 year. *Osteoarthritis Cartil*. 2008;16(9):1024–1031.
4. Zhan C, Kaczmarek R, Loyo-Berrios N, Sangl J, Bright RA. Incidence and short-term outcomes of primary and revision hip replacement in the United States. *J Bone Joint Surg Am*. 2007;89-A(3):526–533.
5. Nilsson AK, Petersson IF, Roos EM, Lohmander LS. Predictors of patient relevant outcome after total hip replacement for osteoarthritis: a prospective study. *Ann Rheum Dis*. 2003;62(10):923–930.
6. Fortin PR, Clarke AE, Joseph L, et al. Outcomes of total hip and knee replacement: preoperative functional status predicts outcomes at six months after surgery. *Arthritis Rheum*. 1999;42(8):1722–1728.
7. Adelani MA, Keeney JA, Palisch A, Fowler SA, Clohisey JC. Has total hip arthroplasty in patients 30 years or younger improved? A systematic review. *Clin Orthop Relat Res*. 2013;471(8):2595–2601.

8. **Poulsen E, Overgaard S, Vestergaard JT, Christensen HW, Hartvigsen J.** Pain distribution in primary care patients with hip osteoarthritis. *Fam Pract.* 2016;33(6):601–606.
9. **Nunley RM, Prather H, Hunt D, Schoenecker PL, Clohisy JC.** Clinical presentation of symptomatic acetabular dysplasia in skeletally mature patients. *J Bone Joint Surg Am.* 2011;93 Suppl 2:17–21.
10. **Clohisy JC, Knaus ER, Hunt DM, Lesher JM, Harris-Hayes M, Prather H.** Clinical presentation of patients with symptomatic anterior hip impingement. *Clin Orthop Relat Res.* 2009;467(3):638–644.
11. **Everett BP, Nakonezny PA, Mulligan EP, Chhabra A, Wells J.** The relationship between pre-operative pain characteristics and periacetabular osteotomy outcomes in patients with acetabular dysplasia. *J Hip Preserv Surg.* 2022;hnac004.
12. **Post ZD, Orozco F, Diaz-Ledezma C, Hozack WJ, Ong A.** Direct anterior approach for total hip arthroplasty: indications, technique, and results. *J Am Acad Orthop Surg.* 2014;22(9):595–603.
13. **Ait Mokhtar M.** Postero-posterolateral approach in total hip arthroplasty. *Int Orthop.* 2020;44(12):2577–2585.
14. **Kumar P, Sen R, Aggarwal S, Agarwal S, Rajnish RK.** Reliability of Modified Harris Hip Score as a tool for outcome evaluation of total hip replacements in Indian population. *J Clin Orthop Trauma.* 2019;10(1):128–130.
15. **Naal FD, Impellizzeri FM, von Eisenhart-Rothe R, Mannion AF, Leunig M.** Reproducibility, validity, and responsiveness of the hip outcome score in patients with end-stage hip osteoarthritis. *Arthritis Care Res (Hoboken).* 2012;64(11):1770–1775.
16. **Stasi S, Stamou M, Papanthasiou G, et al.** International Hip Outcome Tool (12-items) as health-related quality-of-life measure in osteoarthritis: validation of Greek version. *J Patient Rep Outcomes.* 2020;4(1):41.
17. **Kemp JL, Collins NJ, Roos EM, Crossley KM.** Psychometric properties of patient-reported outcome measures for hip arthroscopic surgery. *Am J Sports Med.* 2013;41(9):2065–2073.
18. **Nwachukwu BU, Chang B, Beck EC, et al.** How should we define clinically significant outcome improvement on the iHOT-12? *HSS J.* 2019;15(2):103–108.
19. **Nam D, Nunley RM, Clohisy JC, Lombardi AV, Berend KR, Barrack RL.** Does patient-reported perception of pain differ based on surgical approach in total hip arthroplasty? *Bone Joint J.* 2019;101-B(6_Supple_B):31–36.
20. **Nam D, Nunley RM, Sauber TJ, Johnson SR, Brooks PJ, Barrack RL.** Incidence and location of pain in young, active patients following hip arthroplasty. *J Arthroplasty.* 2015;30(11):1971–1975.
21. **Nam D, Meyer Z, Rames RD, Nunley RM, Barrack RL, Roger DJ.** Is the direct superior, iliotibial band-sparing approach associated with decreased pain after total hip arthroplasty? *J Arthroplasty.* 2017;32(2):453–457.
22. **Wells J, Millis M, Kim YJ, Bulat E, Miller P, Matheny T.** Survivorship of the Bernese periacetabular osteotomy: what factors are associated with long-term failure? *Clin Orthop Relat Res.* 2017;475(2):396–405.
23. **Cicchetti DV.** Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychol Assess.* 1994;6(4):284–290.
24. **Kovalenko B, Bremjit P, Fernando N.** Classifications in brief: Tönnis Classification of hip osteoarthritis. *Clin Orthop Relat Res.* 2018;476(8):1680–1684.
25. **Griffin DR, Parsons N, Mohtadi NG, Safran MR.** Multicenter arthroscopy of the hip outcomes research network. a short version of the international hip outcome tool (ihot-12) for use in routine clinical practice. *Arthroscopy.* 2012;28(5):611–616.
26. **Mulligan EP, Middleton EF, Brunette M.** Evaluation and management of greater trochanter pain syndrome. *Phys Ther Sport.* 2015;16(3):205–214.
27. **Aresti N, Kassam J, Nicholas N, Achan P.** Hip osteoarthritis. *BMJ.* 2016;354:i3405.

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