Original Article

Risk Factors for Conversion of Hip Arthroscopy to Total Hip Arthroplasty: A Large Closed-Cohort Study

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Purpose: To evaluate risk factors for conversion of hip arthroscopy to total hip arthroplasty (THA) within 2 years in a closed patient cohort. **Methods:** This study was a case series of consecutive hip arthroscopy procedures from September 2008 to November 2018 in the electronic medical record of Kaiser Permanente Northern California. Patients were included with minimum 2-year follow-up or if they had conversion to THA within 2 years (the primary outcome) regardless of follow-up time. Patient characteristics at the time of the index arthroscopy were extracted; characteristics of patients who experienced the outcome event versus those who did not were compared by use of multivariable logistic regression models and receiver operating characteristic (ROC) curves. **Results:** The mean follow-up time was 4.9 years (median 4.6, range 0.6 to 11.6). The mean age was 37.2 years (range 10 to 88), and 57% were female. During the follow-up period, 82 patients underwent a THA within 2 years of their arthroscopies (5.3%, 95% confidence interval 4.3% to 6.5%) after a median time of 9 months (interquartile range 5.9 to 14.4) after the initial arthroscopy. Increasing age was highly predictive of early THA conversion (area under the ROC curve = 0.78, $P < .001$). Although other predictors showed significant bivariable associations with early failure, body mass index (BMI), race, sex, and prior arthroscopy did not add meaningful independent predictive information. **Conclusions:** The risk of conversion to THA within 2 years after hip arthroscopy increased substantially with patient age at the time of the procedure. BMI, race, sex, and prior arthroscopy were not important independent predictors of conversion beyond the information contained in patient age. **Level of Evidence:** Level IV, therapeutic case series.

The use of hip arthroscopy has rapidly increased in the United States along with improving techniques and indications for surgery.[1-5] Most commonly, hip arthroscopy is used to manage femoroacetabular impingement (FAI) and labral tears.[2,3,6] FAI presents via 3 primary forms: (1) cam-type impingement: a sphericity mismatch of the femoral head to the acetabulum; (2) pincer-type impingement: excess acetabular overhang; or (3) a combined cam/pincer impingement pattern. In cam-type impingement, the sphericity mismatch, particularly during flexion, leads to repetitive trauma, contributing to chondrolabral junction injury and ultimately cartilage damage and thereby osteoarthritis.[7-10] In pincer-type impingement, the linear forces from the acetabular rim and femoral head-neck junction cause acetabular labrum damage anterosuperiorly, and eventually chondral injury through a contra-coup effect posteriorly as the femoral head subluxes in that direction.[8-10] Data have more consistently associated cam-type impingement with the development of osteoarthritis versus pincer-type impingement, although both are associated.[8]

The goal of hip arthroscopy in managing FAI and labral injury is to improve hip function and longevity. By correcting the abnormal hip joint mechanics associated with FAI, hip arthroscopy aims to serve as a native hip preservation surgery, minimizing further joint degeneration and ultimately preventing or delaying the need for total hip arthroplasty (THA). Of

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The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received February 1, 2020; accepted July 9, 2020.

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2666-061X/20147

https://doi.org/10.1016/j.asmr.2020.07.008

particular interest is what preoperative factors may portend better surgical success in terms of clinical function, patient-reported outcomes, and progression to degenerative changes. As osteoarthritis becomes severe enough to impact patient function and activities of daily living, THA becomes a viable surgical option.

Data suggest that most patients improve within 3 months but up to 2 years postoperatively from hip arthroscopy.[11,12] Several studies have evaluated correlates of hip arthroscopy with subsequent hip arthroscopy, imaging-determined degenerative changes, or conversion to THA.[4,7,13-15] Factors associated with failure of hip arthroscopy to manage symptoms have varied among studies but have included body mass index (BMI), sex, age, preoperative patient-reported outcome measures, workers' compensation, preoperative radiographic arthritis scoring, and prior hip surgery.[4,6,12-14,16] Given the increasing use of hip arthroscopy, it is of interest to evaluate current risks of failure in large patient populations with adequate follow-up; there have been limited data on hip arthroscopy in closed patient cohorts.

The purpose of this study was to evaluate risk factors for conversion of hip arthroscopy to THA within 2 years in a closed patient cohort. We hypothesized that older age at the time of hip arthroscopy, increased BMI, and prior hip arthroscopy would increase the risk of conversion to THA.

Methods

This study was performed using information captured by the electronic medical record (EMR) system of Kaiser Permanente Northern California (KPNC). KPNC is a large integrated health plan serving >4 million members through a network of 21 medical centers in Northern California. We performed a retrospective search for all patients who underwent hip arthroscopy from September 2008 through November 2018. Inclusion criteria were any patients undergoing hip arthroscopy with or without labral repair, based on the name of the procedure entered into the KPNC EMR operative database. Cases in which the presurgical diagnosis was trochanteric bursitis, gluteus tendon repair, snapping hip, tumor, or traumatic surgery were excluded. Included diagnoses are listed in Table 1. All patients were followed through the KPNC EMR until August 31, 2019. Patients with <2 years of follow-up were excluded from the study; however, any patient who experienced the THA endpoint within 2 years was included regardless of follow-up time. Patient characteristics at the time of index hip arthroscopy included age, sex, BMI, prior ipsilateral hip arthroscopic procedures, and race (with all nonwhite race categories collapsed for analysis purposes because of small numbers for several groups). The primary endpoint was conversion to ipsilateral THA within 2 years.

Table 1. Distribution of included diagnoses

Diagnosis	n	%
Femoroacetabular impingement	399	25.6
Labral tear	678	43.4
Both	302	19.3
Other	182	11.7

Other diagnoses included loose bodies, osteochondral lesions, slipped capital femoral epiphysis, Perthes disease, dysplasia, and unspecified hip joint pain.

Statistical analyses were performed with SAS software version 9.4 (SAS Institute, Cary, NC) and Stata version 15.1 (StataCorp, College Station, TX) with the threshold of statistical significance set at a 2-sided $P <$ .05. The crude risk of the primary outcome was calculated as the proportion of each study group who experienced the primary endpoint. Bivariable analyses were conducted using logistic regression models. Pairwise comparisons were conducted with Fisher's exact tests for categorical variables (e.g., sex, racial/ethnic groups). Continuous variables were compared with *t* tests and validated with nonparametric Wilcoxon-Mann-Whitney rank-sum tests. Multivariable regression analyses were conducted with logistic regression models. The area under the curve (AUC) of the receiver operating characteristic (ROC) curve was used to estimate the classification performance of the predictor variables and to compare models of patient characteristics in predicting conversion to THA. Statistical comparison of the areas under the ROC curves was conducted with the method of DeLong et al.[17]

The KPNC Research Determination Official determined this study did not meet the definition of human subjects research and therefore did not require institutional review board approval.

Results

In total, 1,561 hip arthroscopy procedures were included (Fig 1). Patients had a minimum of 2 years follow-up, with last chart review of follow-up through August 2019; however, 14 cases were included that had conversion to THA with <2 years of total follow-up. Patient demographics are included in Table 2. The mean follow-up time was 4.9 years (median 4.6, range 0.6 to 11.6). The mean age of all patients was 37.2 years (range 10 to 88) and the majority (57%) of patients were female. Eighty-two patients underwent an ipsilateral THA (5.3%; 95% confidence interval 4.3% to 6.5%) within 2 years of the index arthroscopy procedure, with a median time of 9 months (interquartile range 5.9 to 14.4) after initial arthroscopy.

In bivariable analyses, age, BMI, race, and history of prior arthroscopy were each significantly associated with conversion to THA within 2 years; sex was not significantly associated with the outcome (Tables 2 and 3).

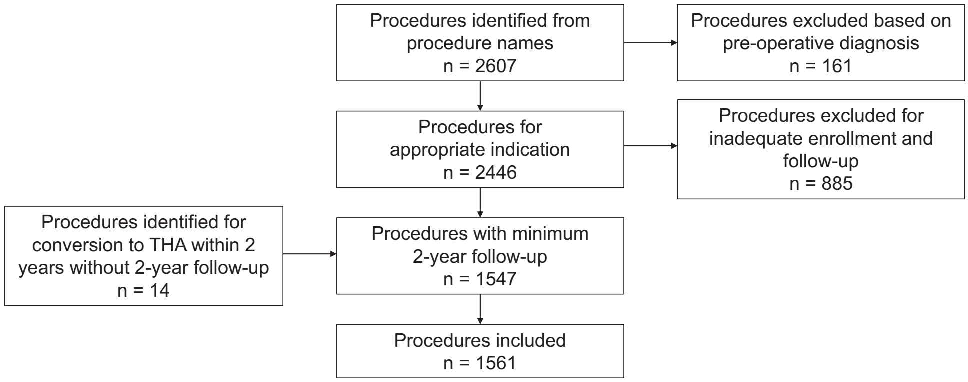

Fig 1. Procedure selection flowchart.

In multivariable logistic regression analyses, age, BMI, and prior arthroscopy remained statistically significant predictors of early THA conversion, with age being most strongly associated (Table 3).

In classification analyses, age was a moderately strong classifier for failure (area under the ROC curve: 0.780, $P < .001$) (Table 3; Fig 2). Adding all other significant predictor variables from the multivariable logistic regression analyses resulted in only a very small and nonsignificant improvement (area under the multivariable ROC curve: 0.790; $P = .08$). We therefore determined that BMI, race, sex, and prior arthroscopy were not important independent predictors of conversion beyond the information contained in patient age. We also tested all pairwise interactions for bivariate significant predictors, and none were significant. The crude rates of conversion based on deciles of age are shown in Table 4.

Discussion

Our analysis in this large, closed patient cohort of 1,561 hip arthroscopies in the Kaiser Permanente Northern California health system demonstrates a strong and significant association of increasing age with risk of early conversion (area under the ROC curve = 0.78, $P < .001$); 5.3% underwent ipsilateral THA within 2 years at a median time of 9 months after arthroscopy. Our models using the ROC curve did not demonstrate significant independent predictive value of BMI, race, sex, or prior hip arthroscopy beyond that contained in the age variable. Although age, BMI, race, and prior arthroscopy were statistically significant on bivariable analyses, on multivariable analyses, only age, BMI, and prior arthroscopy were statistically significant. Furthermore, these other factors examined added limited predictive value to age, adding only an additional 0.010 AUC of the ROC curve (age bivariable AUC = 0.780 versus multivariable AUC = 0.790).

These findings add to the body of literature suggesting that increasing age is associated with progression of osteoarthritis or conversion to THA after hip arthroscopy. Our cohort's cumulative conversion to THA was 5.3%, which is comparable to other studies ranging from 2.9% to 10.6%.[18,19] Several studies note a particularly increased association of age >50 years with conversion.[2,4,16,18,20-22] In the present study, the

Table 2. Demographic and clinical characteristics of patients undergoing hip arthroscopy, overall and stratified by undergoing ipsilateral total hip arthroplasty (THA) within 2 years of arthroscopy

Characteristic	All patients (N = 1,561)	THA within 2 years (n = 82)	No THA within 2 years (n = 1,479)
Demographics			
Age at time of surgery (y)***	37.2 ± 16.7	50.0 ± 10.7	37.2 ± 13.7
Female	886 (56.8)	44 (53.7)	842 (57.0)
Body mass index (kg/m2)**	26.6 ± 4.9	28.3 ± 4.5	26.5 ± 5.0
Race*			
Asian	105 (6.7)	4 (4.9)	101 (6.8)
African-American	93 (6.0)	0 (0)	93 (6.3)
Hawaiian/Pacific Islander	11 (0.7)	1 (1.2)	10 (0.7)
Native American	13 (0.8)	0 (0)	13 (0.9)
White	1,185 (75.9)	74 (90.2)	1,111 (75.1)
Unknown	154 (9.9)	3 (3.7)	151 (10.2)
Prior ipsilateral hip arthroscopy**	57 (3.7)	8 (9.8)	49 (3.3)

Data are mean ± standard deviation or n (%).
*$P < .05$.
**$P < .01$.
***$P < .001$.

Table 3. Bivariable and multivariable estimates of association and classification between predictor variables and early arthroscopy failure with total hip arthroplasty within 2 years

Variable	Bivariable Odds Ratio	*P* Value	Multivariable Odds Ratio	*P* Value	Bivariable AUC	Multivariable AUC
Age (per decade)	1.97	<.001	2.00	<.0001	0.780	0.790
Body mass index (per unit kg/m^2)	1.07	.002	1.06	.02	0.620	
Gender (reference = female)	1.14	.56	1.21	.45	0.517	
Race (reference = nonwhite)	2.89	.02	2.20	.10	0.550	
Prior arthroscopy (reference = no prior arthroscopy)	3.15	.004	3.25	.01	0.532	

AUC, area under the receiver operating characteristic curve.

cumulative conversion rate for those age >50 was 15.2%, which is comparable to the literature.[2,21] Current surgical indications may be shifting surgeons away from hip arthroscopy in older patients, which could influence more recent studies on cumulative conversion rates.[13]

Although age is commonly cited as an association with conversion to THA, Herrmann et al.[23] suggested from their retrospective series of middle-aged patients that age as a sole factor should not be prohibitive of hip arthroscopy, but rather osteoarthritic changes as documented by Kellgren Lawrence grade 3 or joint space width <2 mm. The likely independent influence of degenerative changes is confirmed by a statewide study of hospitals in New York that found both age >60 years and the presence of pre-existing arthritis to be independent risk factors for THA conversion.[16]

It is important to consider that prior studies have not used a consistent definition of osteoarthritis or "failure" of hip arthroscopy. The manner in which studies evaluate progression of disease and outcomes have included clinical diagnoses and electronic medical record coding,[14] patient-reported outcome measures,[6,12,13,24] imaging changes,[7,15] and subsequent hip arthroscopy or THA.[2,4,13,18,19,25] Because of the variability in defining outcomes, it is important to evaluate each study's outcome measures carefully. The present study undertook conversion to THA as a failure of treatment, and risk of subsequent arthroplasty is of perhaps of more tangible benefit when presenting data to patients than are concepts such as imaging-related degenerative changes, patient-reported outcome scores, or perceived pain levels.

Age may also influence patient-reported outcomes. Cvetanovich et al.[6] noted that younger age was associated with higher minimal clinically important difference (MCID) and patient acceptable symptom state ratings (PASS) on the Hip Outcome Score-Activities of Daily Living and the Hip Outcome Score-Sport-Specific Subscale. Conversely, Nho et al.[13] did not find any correlation between age and clinical failure or inferior outcomes, although that may be due to the younger cohort included in the study of 33.3 ± 12.3 years.

Previous studies have found additional factors associated with poorer clinical outcomes, degenerative changes, or conversion to THA that were not found to be associated in the present study. Sex has been identified as a risk factor for poor outcomes in several studies, though they are inconsistent as to male or female.[12,14,16,18,26] A recent systematic review

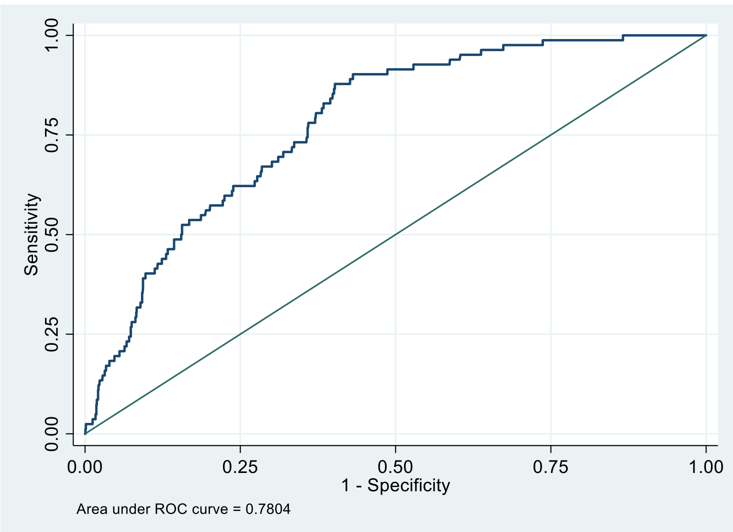

Fig 2. Receiver operating characteristic (ROC) curve for likelihood of conversion to total hip arthroplasty within 2 years of arthroscopy by age (area under the ROC curve = 0.78, $P < .0001$).

Table 4. Total hip arthroplasty conversion rates by age category

Age Group (y)	Number of Conversions	Number of Procedures	Conversion Rate	95% Confidence Interval
0 to 19	1	217	0.46	0.08 to 2.56
20 to 29	2	302	0.18	0.18 to 2.38
30 to 39	7	353	1.98	0.96 to 4.03
40 to 49	29	407	7.13	5.01 to 10.05
50 to 59	29	210	13.81	9.79 to 19.13
60 to 69	12	63	19.05	11.25 to 30.41
≥70	2	9	22.22	6.32 to 54.74

correlated female sex with negative outcomes.[27] On the other hand, some studies report no difference based on sex[28,29] or suggest that there may be variable impact of sex based on age.[30] The present study did not demonstrate a significant association between sex and conversion to THA, and sex did not modify the association of age and early THA.

Some studies have also identified BMI as a risk factor for poorer patient-reported and clinical outcomes.[12,13,16,27,31] Wolfson et al.[12] noted that female sex and BMI >30 were associated with lower rates of achieving a MCID or PASS. Nho et al.[13] also found that BMI was associated with inferior clinical outcomes by not achieving MCID on the Hip Outcome Score-Activities of Daily Living, although it was not associated with failure (repeat arthroscopy or THA). On the other hand, Saltzman et al.[32] did not find significant differences in patient-reported clinical outcomes among BMI classes after multivariate analysis in their 381-patient cohort. Kester et al.[16] found obesity to be an independent risk factor for conversion to THA. In contrast, we did not identify BMI as an important independent predictive factor of conversion to THA, even though it was statistically significant in the logistic regression models.

The present study did not find BMI, sex, or race to be predictive of conversion to THA within 2 years. Other studies have also shown that prior hip arthroscopy or surgeries have been associated with predictors of clinical outcomes,[14,31] whereas the present study did not note prior hip arthroscopy as a significant predictor of conversion, despite it being statistically significant. Additional factors previously associated with conversion have been worsening preoperative evidence of arthritic changes or chondral damage[20,22,23,25,26,28,33-35] or acetabular morphology.[36] Contralateral THA has also been associated with increased conversion to THA after hip arthroscopy.[37]

There are benefits of analyzing this closed patient cohort. Because patients in the Kaiser Permanente system have their routine medical care within the network, the follow-up rates are much higher. Because of this, we were able to exclude patients with <2 years of follow-up and still have a substantial number of procedures. The present study had a median follow-up of 4.6 years after index hip arthroscopy, including 1,561 procedures. Furthermore, whereas many patients in other health networks may have a subsequent THA with a different surgeon at a different institution or practice, the patients in this cohort are more likely to have subsequent operations within the same system. Therefore, the data of conversion rates may be more accurate than datasets involving patients seen in multiple institutions. In addition, the KPNC patient population has been shown to be generally representative of the demographic and socioeconomic diversity of the general Northern California population.[38] Therefore, it is plausible that these data may be generalizable to the broader population outside the studied health system.

Limitations

Several limitations of this study should be noted. First, the observational nature of this study limits findings to association and not necessarily causation. Analyses were performed on patients in a single health system in a single state. Because the surgeries were performed by numerous surgeons throughout the health system, we are unable to evaluate for surgical indications, proficiency, or consistency in surgical technique. Although there has been an increase in the number of surgeons performing arthroscopy of the hip, the proficiency and experience of those surgeons is not clear.[39] Recent studies suggest perhaps a protective benefit with capsular repair, but we did not analyze this factor or other surgical nuances.[13,40,41] Many other studies have looked at imaging changes as a component of failure of treatment, but the present study did not evaluate imaging outcomes pre- or postoperatively and did not stratify outcomes based on any clinical markers of osteoarthritis. Therefore, we are not able to conclude whether age is a risk factor for conversion independent of the degenerative state of the hip. The cohort studied included 17% of conversions in patients age ≥60 years, and the assessment of conversion may be skewed by this and less generalizable to all populations undergoing hip arthroscopy. Furthermore, patient-reported outcome measures were not used in this study, and assessment of the MCID or PASS could not be performed. Lastly, the indications and decisions to proceed with THA may not have been standardized among surgeons or patients.

Conclusions

The risk of conversion to THA within 2 years after hip arthroscopy increased substantially with patient age at the time of the procedure. BMI, race, sex, and prior arthroscopy were not important independent predictors of conversion beyond the information contained in patient age.

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