

Risk of failure of primary hip arthroscopy—a population-based study

Ryan M. Degen¹, Ting J. Pan², Brenda Chang², Nabil Mehta²,
Peter D. Chamberlin², Anil S. Ranawat¹, Danyal H. Nawabi¹, Bryan T. Kelly¹
and Stephen Lyman^{2*}

¹Department of Sports Medicine and Shoulder Service, Center for Hip Preservation and

²Department of Orthopedic Surgery, Healthcare Research Institute, Hospital for Special Surgery, 525 East 70th Street, New York, NY, 10021, USA

*Correspondence to: S. Lyman. E-mail: lymans@hss.edu

Submitted 1 February 2017; Revised 22 March 2017; revised version accepted 21 April 2017

ABSTRACT

The aims of this study are (i) to report on the rates of subsequent surgery following hip arthroscopy and (ii) to identify prognostic variables associated with revision surgery, survival rates and complication rates. The Statewide Planning and Research Cooperative System database, a census of hospital admissions and ambulatory surgery in New York State, was used to identify cases of primary hip arthroscopy. Demographic information and rates of subsequent revision hip arthroscopy or arthroplasty were collected. The risks were modeled with use of age, sex, procedure and surgeon volume as risk factors. Survival analyses were also performed, and 30-day complication was recorded. We identified 8267 procedures in 7836 patients from 1998 to 2012. Revision surgery occurred in 1087 cases (13.2%) at a mean of 1.7 ± 1.6 (mean \pm SD) years. Revision arthroscopy accounted for 311 cases (3.8%), and arthroplasty for 796 (9.7%) cases. Survival analysis showed a 2-year survival rate of 88.1%, 5-year of 80.7% and 10-year of 74.9%. Regression analysis revealed that age >50 years [hazard ratio (HR) 2.09; confidence interval (CI) 1.82–2.39, $P < 0.01$] and a diagnosis of osteoarthritis (HR 2.72; CI 2.21–3.34, $P < 0.01$) were associated with increased risk of re-operation. Labral repair was associated with a lower risk of re-operation (HR 0.71; CI 0.54–0.93, $P = 0.01$). Finally, higher surgeon volume (>164 cases/year) resulted in a lower risk of re-operation versus lower volume (<102 cases/year) (HR 0.42; CI 0.32–0.54, $P < 0.01$). The 30-day complication rate was 0.2%. Older age and pre-existing osteoarthritis increased the likelihood of re-operation following hip arthroscopy, whereas performing a labral repair and having the procedure performed by a higher-volume surgeon lowered the risk of re-operation.

INTRODUCTION

Hip arthroscopy utilization has significantly increased over the past decade, with annual rates increasing as much as 25-fold over that time period [1–4]. Despite improvements in equipment and training, it remains a challenging procedure, with some studies reporting revision surgery rates of anywhere from 6.3% [5] to 16.9% [6–8]. However, many of the available studies are limited to single-institution designs with limited sample size and follow-up duration. Presently, there is limited available information on the long-term need for subsequent surgery from a population standpoint.

Similarly, smaller, retrospective studies have identified factors associated with the need for revision surgery. Revision hip arthroscopy has most commonly been associated with residual impingement, while conversion to hip arthroplasty has been associated with advanced patient age, prolonged pre-operative symptoms, acetabular dysplasia, and osteoarthritis (OA) (Tönnis grade 2 or 3) [9–15], although these results have not all been corroborated in larger sample studies. Additionally, while studies have demonstrated that complication rates are closely associated with surgeon volume [16–19], the impact of surgeon volume on re-operation rates has not been previously explored.

The purpose of this study was therefore 2-fold: (i) to report on population-based rates of subsequent surgery following hip arthroscopy, including revision hip arthroscopy and conversion to arthroplasty and (ii) to identify prognostic variables associated with the need for revision surgery, including the impact of procedural volume, and to identify survival rates and complication rates associated with hip arthroscopy. Our hypothesis was that revision arthroscopy and arthroplasty would occur at a higher rate in older patients and those treated by lower-volume surgeons.

MATERIALS AND METHODS

The Statewide Planning and Research Cooperative System database, a census of all non-federal acute care hospital admissions and ambulatory surgery in New York State, was used to identify cases of outpatient primary hip arthroscopy between 1998 and 2012. Access to the database was granted via request (Request #1107-04) from the Data Governance Committee of the New York State Department of Health. Patients were identified by use of Current Procedural Terminology (CPT) codes specific for hip arthroscopy (Table I).

Demographic information was collected for these patients including patient age, sex, race/ethnicity, insurance status, discharge disposition, and year of surgery. International Classification of Diseases, Ninth Edition (ICD-9) diagnostic codes were also used to identify a diagnosis of OA (codes 715.15, 715.35 and 715.95). After case identification, unique patient identifiers were used to track patients for repeat surgical intervention. Revision ipsilateral hip arthroscopy was identified using the same CPT codes, while total hip arthroplasty (THA) and resurfacing were identified with

Table I. Hip arthroscopy CPT codes

Code	Procedure listing
29860	Hip Arthroscopy, diagnostic, with or without synovial biopsy
29861	Hip Arthroscopy, removal of loose body or foreign body
29862	Hip Arthroscopy, chondroplasty, abrasion arthroplasty, and/or resection of labrum
29863	Hip Arthroscopy, synovectomy
29914	Hip Arthroscopy, with femoroplasty
29915	Hip Arthroscopy, with acetabuloplasty
29916	Hip Arthroscopy, with labral repair

procedure-specific ICD-9-clinical modification (CM) codes (Table II). ICD-9 diagnostic codes were also used to determine whether patients carried a diagnosis of hip OA (codes 715.15, 715.35 and 715.95). Unique patient identifiers were then used to track patients for 30-day complications requiring re-admission (Table III). The list of procedural complications was derived from a more extensive list of 'Hospital Acquired Conditions' on the Center for Medicare & Medicaid Services website (https://www.cms.gov/medicare/medicare-fee-for-service-payment/hospitalacqcond/hospital-acquired_conditions.html).

Descriptive statistics were calculated as means with standard deviations, while categorical variables were presented as frequency counts and percentages. Kaplan–Meier survival analysis, with end points of revision hip

Table II. Hip arthroplasty and resurfacing ICD-9 CM codes

ICD9 code	Description
81.51	Total hip replacement
00.85	Resurfacing hip, total, acetabulum and femoral head
00.86	Resurfacing hip, partial, femoral head
00.87	Resurfacing hip, partial, acetabulum

Table III. Potential complications screened for post-operatively

Acute myocardial infarction (AMI)
Pulmonary embolism (PE)
Deep vein thrombosis (DVT)
Sepsis/Septicemia/Shock
Surgical Site Infection
Wound infection
Dislocation
Pneumonia
Heterotopic Ossification
Abdominal Compartment Syndrome
Septic arthritis (hip)

Identified from a more extensive list of 'Hospital Acquired Conditions' on the Center for Medicare & Medicaid Services website (https://www.cms.gov/medicare/medicare-fee-for-service-payment/hospitalacqcond/hospital-acquired_conditions.html).

arthroscopy or conversion to THA, was performed and revision hazards were measured at two, five and ten years following the index hip arthroscopy procedure.

Surgeon volume was analysed by looking at different volume strata. These were determined by creating a stratum-specific likelihood ratio (SSLR) threshold-analysis model, looking at the endpoint of revision hip arthroscopy, hip resurfacing or THA within 5 years of the index hip arthroscopy procedure. The methodology for creating this model was adapted from a previous study [20]. To summarize, physician license numbers were utilized to determine career surgeon volume. The cohort was first partitioned into as many volume strata as possible based on career volume. Subsequently, a risk ratio was calculated for each group for the endpoint of clinical failure (revision scope, resurfacing or THA). These ratios were then reviewed to identify specific points where there was a difference in rates of endpoints. Utilizing these points, the individual strata were then combined to produce larger groups until a significant difference in risk ratios was observed between adjacent groups with a $P < 0.05$. If multiple thresholds were found in close proximity to each other, we selected the threshold that had the largest risk ratio differences.

A Cox regression analyses was performed to determine the effect of age [21], sex [7], race [22], insurance status [22], diagnosis of OA [22] and surgeon volume as potential risk factors. If a patient did not experience additional surgery, he/she was censored at the end of study timeframe (31 December 2012), and the time to additional hip surgery was calculated from the date of index hip scope to the time of revision. Results were reported as hazard ratios with 95% confidence intervals (CI).

All analyses were performed using the SAS System 9.3 (Cary, NC, USA). SSLR analyses were performed in Microsoft Excel 2010 (Microsoft, Redmond, WA, USA).

RESULTS

Demographics and utilization

We identified 8267 hip arthroscopy cases in 7836 patients from 1998 to 2012. This included 23 simultaneous bilateral procedures and 408 staged bilateral procedures. Procedures were performed by 295 surgeons in 137 different surgical centers (Fig. 1). Males represented 46.1% of patients, with 80.1% carrying private insurance (Table IV). Annual hip arthroscopy rates increased 88-fold over the observation period, with a 750% increase over the last 10 years (Fig. 2).

Survival analysis

Revision surgery (scope or arthroplasty) was required in 1087 cases (13.2%) at a mean of 1.7 ± 1.6 years, with 1028 (12.4%) of the revisions occurring within 5 years. More specifically, revision hip arthroscopy was required in 311 cases (3.8%) at a mean of 1.8 ± 1.6 years after the index procedure, while conversion to resurfacing or THA was required in 796 (9.6%) cases at an average of 1.7 ± 1.7 years. Twenty patients (0.2%) had both a revision hip arthroscopy and conversion to hip arthroplasty. A Kaplan–Meier analysis was performed to determine the survivorship of primary hip arthroscopy (Fig. 3). From this, we identified a 2-year survival rate of 88.1%, 5-year of 80.7% and 10-year of 74.9% (Table V). Exclusively reporting on endpoint of conversion to arthroplasty, the survival rate was 91.1% at 2 years, 85.6% at 5 years and 80.7% at 10 years (Table V).

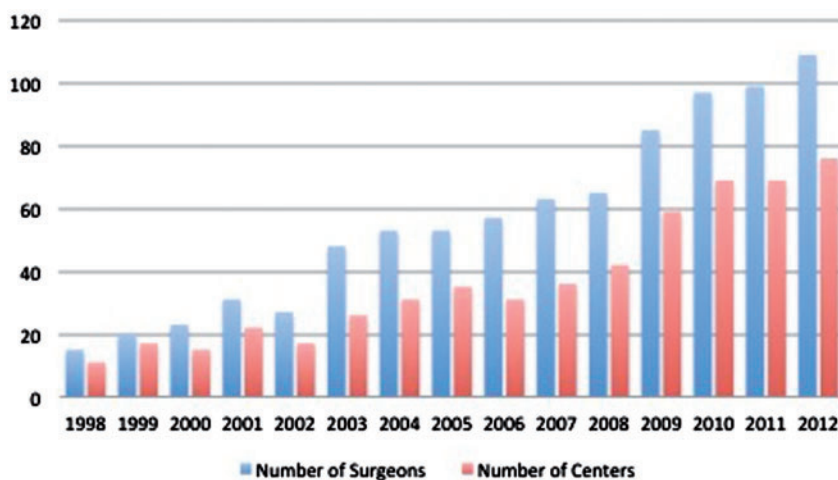


Fig. 1. Annual volume of surgeons and centers performing hip arthroscopy.

Table IV. Patient demographics

<i>Patient characteristics</i>	
Age	
Mean age, years (range)	38 (7–84)
Sex, n (%)	
Male	3,801 (46.1)
Female	4,443 (53.9)
Race, n (%)	
White	6,057 (73.5)
Black	307 (3.7)
Asian	88 (1.1)
Other	1,214 (14.7)
Missing	578 (7.0)
Insurance status, n (%)	
Medicare	321 (3.9)
Medicaid	267 (3.2)
Private	6,607 (80.1)
Worker's compensation	683 (8.3)
Other	364 (4.4%)

Regression analysis

Cox proportional hazard analysis revealed that age > 50-years was associated with a significantly increased risk of re-operation (HR 2.11; CI 1.84–2.41, $P < 0.01$). Additionally, patients diagnosed with OA had a higher risk of re-operation compared with those without (HR 2.72; CI 2.21–3.34, $P < 0.01$). Patients who had either an isolated diagnostic scope, or a labral repair, had a lower risk of subsequent surgery (HR 0.42; CI 0.23–0.79, $P = 0.01$ and HR 0.71; CI 0.54–0.93, $P = 0.01$). Patients that underwent a removal of loose body had a higher risk of subsequent surgery (HR 1.61; CI 1.25–2.06, $P < 0.01$) (Table VI).

Finally, surgical volume was also associated with an increased risk of re-operation. Patients of surgeons with annual case volumes of higher than 164 cases/year had a lower risk of re-operation compared with those operated on by surgeons with a case volume of <102 cases/year (HR 0.41; CI 0.32–0.54, $P < 0.01$) (Table VI). The cut-points from the SSLR analysis were used to create 5-year survival curves with four volume strata (Fig. 4). The

survival rate at 2, 5 and 10 years was also determined for each volume strata (Table VII).

Complication rates

Complications included both medical (myocardial infarction, ileus, pneumonia, sepsis) and surgical (mechanical complication, hardware failure, DVT/PE, wound infection, dislocation/iatrogenic instability, major bleed). The 30-day procedural complication rate, excluding revision surgery, was 0.2%. The 30-day all-cause re-admission rate was 0.7%.

DISCUSSION

This study reports on the survival rates following primary hip arthroscopy in a population-based cohort. From 1998 to 2012, we identified a rapid and consistent increase in hip arthroscopy utilization, with a cumulative volume of 8244 primary hip arthroscopy cases. Subsequent surgery was required in 13.4% of patients. More specifically, revision hip arthroscopy was required following 311 cases (3.8%) and conversion to hip arthroplasty was required following 796 cases (9.6%). Older age (>50 years old) and a pre-operative diagnosis of OA were associated with a higher risk of failure, while performing a labral repair and having the procedure performed by a higher volume surgeon were associated with lower risk of failure.

While the trends of increased utilization of hip arthroscopy identified with this study are not unique [2–4, 22], this study provides population-level information on the survival of primary hip arthroscopy. Our results are similar to those recently reported in the literature. Sing *et al.* [21] performed a review of a private payer health insurance population to assess trends in arthroscopic volume, as well as conversion rates. A total of 8227 cases were identified, from which the authors noted a similar overall conversion rate to THA of 8.7% at 24-month follow-up. Malviya *et al.* [7] conducted a similar review, examining all hip arthroscopy cases identified from an administrative hospital database for National Health Service patients in England between 2005 and 2013. From 6395 cases of inpatient hip arthroscopy, they reported comparable revision arthroscopy rates of 4.5% at a mean of 1.7 years and conversion rates to hip resurfacing or THA of 10.6% at a mean of 1.4 years. Gupta *et al.* [8] reported on a series of 595 patients treated with hip arthroscopy by a single surgeon at a high-volume surgical center. They, too, noted similar rates of revision hip arthroscopy (7.7%) and conversion to hip arthroplasty (9.2%), within 30 months of their index procedure, although the mean duration until failure was not reported for these cases. Finally, Schairer *et al.* [22] reported on utilization trends and arthroplasty conversion rates following hip arthroscopy utilizing California and

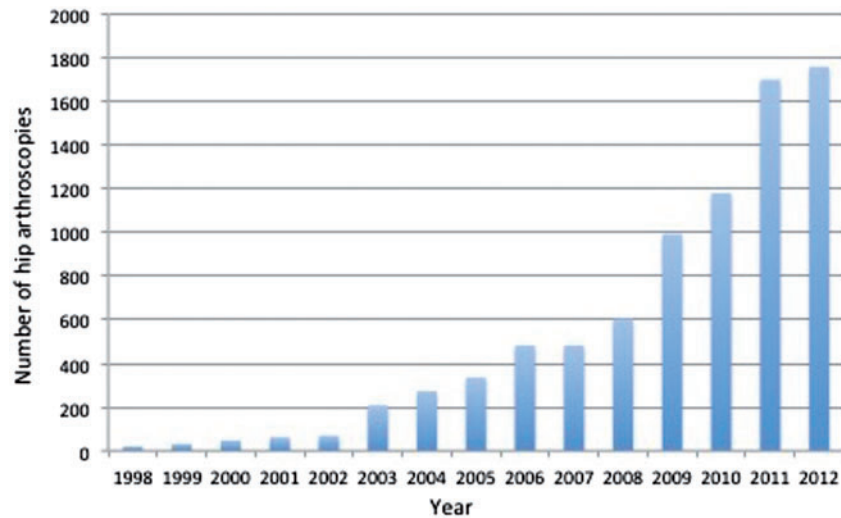


Fig. 2. Annual volume of primary hip arthroscopy cases.

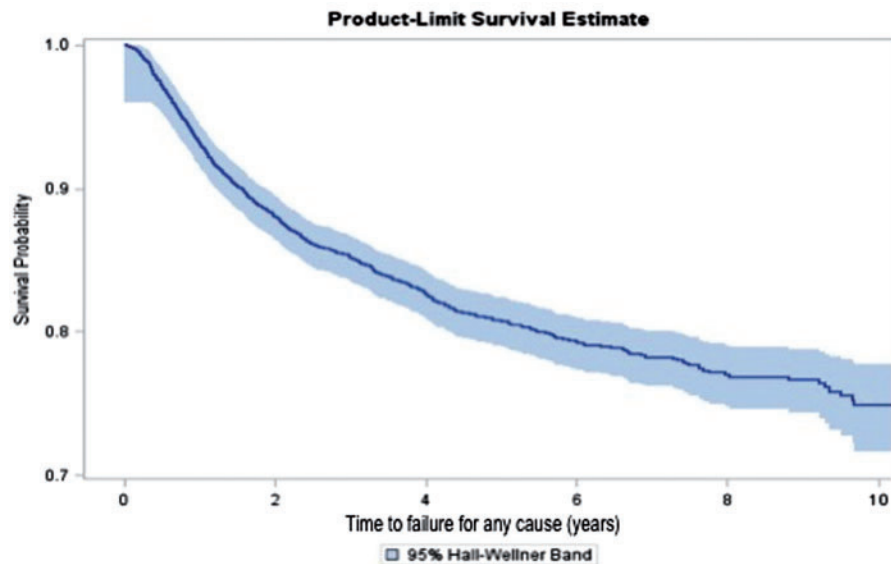


Fig. 3. Kaplan–Meier survival curve for primary hip arthroscopy over a 10-year time period. Failure was defined as the need for revision hip arthroscopy or conversion to total hip arthroplasty or hip resurfacing. x -axis represents time to failure in years, y -axis is the cumulative survival rate.

Florida statewide databases. They identified a similar increase in utilization, with a conversion rate of 11.7% within 2 years of primary hip arthroscopy.

Similar to Malviya *et al* [7], we performed a survivorship analysis following primary hip arthroscopy finding a cumulative survival rate of 82.6% at 8 years. In our study, survival analysis revealed similar rates of 85.6% and 80.7% of patients that did not require THA at the 5- and 10-year follow-up. Additionally, we added revision arthroscopy to our survival analysis, which reduced the overall survival

(i.e. no further revision surgery) to 80.7% and 74.9% at 5 and 10 years, respectively.

Beyond looking at rates of repeat surgery, further analysis was performed to identify prognostic variables associated with the need for revision hip arthroscopy or conversion to arthroplasty. Consistent with the findings presented here, these previously referenced studies also identified that increasing age at the time of surgery was associated with a greater risk for conversion to THA [7, 21, 23]. Malviya *et al.* [7] found age >50 years was

Table V. Kaplan–Meier survival analysis with reported survival rates at 2, 5 and 10 years following hip arthroscopy

Time point	Conversion to THA/resurfacing (%)			Revision surgery (revision scope/THA/resurfacing) (%)		
	Survival rate	Lower CI	Upper CI	Survival rate	Lower CI	Upper CI
2 years	91.1	90.4	91.8	88.1	87.3	88.8
5 years	85.6	84.5	86.6	80.7	79.5	81.9
10 years	80.7	78.6	82.8	74.9	72.6	76.9

Table VI. Cox proportional hazard model analysis assessing for the effect of various patient/surgeon variables on the risk for requiring revision surgery

	Hazard ratio	95% HR confidence limits		P-value
Age \geq 50 (Ref: < 50)	2.09	1.82	2.39	<0.01
Female (Ref: Male)	0.89	0.79	1.01	0.08
Race (Ref: White)				
Non-white	0.74	0.64	0.86	<0.01
Payer status (Ref: Private)				
Medicare	1.22	0.94	1.59	0.13
Medicaid	1.33	0.94	1.89	0.11
Worker's Compensation	0.95	0.76	1.18	0.63
Other	0.72	0.50	1.03	0.07
Hip OA (Ref: No OA)	2.72	2.21	3.34	<0.01
CPT Code ^a				
Diagnostic	0.42	0.23	0.79	0.01
Removal of loose body	1.61	1.25	2.06	<0.01
	0.71	0.54	0.93	0.01
Hip scope annual volume (Ref: < 102)				
102 \leq Volume < 164	0.90	0.74	1.10	0.30
164 \leq Volume < 340	0.42	0.32	0.54	<0.01
340	0.17	0.07	0.38	<0.01

Analysis included patient age, gender, race, insurance status, procedural codes and surgeon volume. Ref., reference group for each category used to compare successive groups for statistical differences; i.e. patients with an age \geq 50 years were compared with patients with an age < 50 years as denoted by Ref: < 50.

^aFor CPT code, the reference group included all patients without the specified CPT code; bolded values denote statistically significant comparisons to reference group.

associated with a 4.7 times higher risk of conversion compared with patients younger than 50 years, whereas Sing *et al.* [21] found a 17% conversion rate in patients over the age of 50 years. This is likely attributable to more severe

chondral damage or advanced joint degeneration in these patients, which several studies have demonstrated as a risk factor for conversion to THA following hip arthroscopy [10–12, 21, 24]. The age of 50 years was chosen as a cut-

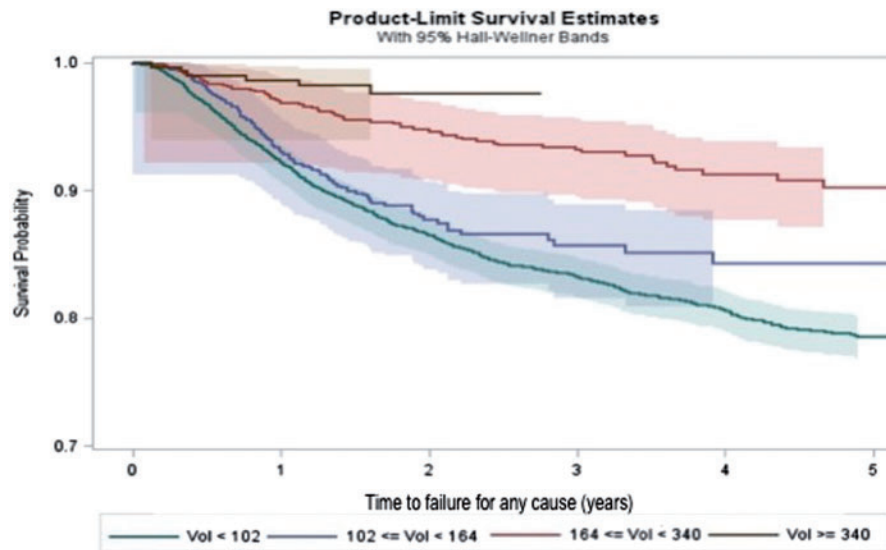


Fig. 4. Kaplan–Meier survival curve for primary hip arthroscopy over a 5 year time period for the different volume-strata identified with SSLR threshold-analysis model. Failure was defined as the need for revision hip arthroscopy or conversion to total hip arthroplasty or hip resurfacing. *x*-axis represents time to failure in years, *y*-axis is the cumulative survival rate.

Table VII. Survival rates of each respective surgeon volume strata

Time point	Conversion to THA/resurfacing (%)			All-cause failure (revision scope/THA/resurfacing) (%)		
	Survival rate	Lower CI	Upper CI	Survival rate	Lower CI	Upper CI
2 years						
Volume < 102	89.6	88.6	90.4	86.5	85.5	87.5
102 ≤ Volume < 164	91.2	89	93	87.7	85.3	89.8
164 ≤ Volume < 340	96.9	95.4	97.9	94.6	92.8	96
Volume ≥ 340	99.6	97.1	99.9	97.6	94.6	98.9
5 years						
Volume < 102	83.5	82.2	84.7	78.5	77.1	79.9
102 ≤ Volume < 164	87.7	82.7	91.3	82.7	77.6	86.7
164 ≤ Volume < 340	93.4	90.5	95.4	90.2	87.1	92.6
Volume ≥ 340	99.6	97.1	99.9	97.6	94.6	98.9
10 years						
Volume < 102	78.7	76.5	80.8	72.7	70.4	74.8
102 ≤ Volume < 164	87.7	82.7	91.3	82.7	77.6	86.7
164 ≤ Volume < 340	92.2	88.3	94.9	90.2	87.1	92.6
Volume ≥ 340	99.6	97.1	99.9	97.6	94.6	98.9

off point for our regression analysis based on prior studies indicating that arthroscopic results in patients above the age of 50 years were inferior to younger patients, with higher rates of conversion to hip arthroplasty [12, 24, 25].

Interestingly, female sex was not associated with an increased risk of revision surgery. This is in contrast to the results reported by Malviya *et al.* [7] and Gupta *et al.* [8], where they identified that female sex was associated with an increased risk of revision surgery. This discrepancy is likely multifactorial and is difficult to explain, particularly as all studies have limited information regarding the underlying diagnosis and reason for surgery. Additionally, surgical indications may have also differed based on regional practices, which could contribute to this discrepancy.

A pre-operative diagnosis of hip OA was also associated with a higher risk of subsequent surgery. This is consistent with the findings of Schairer *et al.* [22], who identified that a diagnosis of OA was associated with a hazard ratio of 2.3 for requiring subsequent conversion to THA. This was also corroborated in a two recent systematic reviews, where patients with a Tönnis grade of 1 or greater, or less than two mm of available joint space, were at higher risk of poor outcomes and subsequent conversion to hip arthroplasty [10, 26].

Labral repair was also found to be associated with a lower risk of requiring subsequent surgery compared with patients that did not have a labral repair. While this has not been reported in prior studies, it is consistent with prior reports that labral repair resulted in improved clinical outcomes compared with selective labral debridement [27–29]. It may relate to the fact that the labral tissue appeared healthy or was preserved, indicating the procedure was performed early in the disease process limiting further intra-articular damage, contributing to the lower revision risk. Similarly, patients that underwent a diagnostic scope were found to have lower risk of conversion versus those who did not. This cohort may reflect those without significant intra-articular pathology that did not require osteochondroplasty or labral repair, potentially explaining this discrepancy, although this is largely speculative. Conversely, patients that underwent removal of loose bodies were found to have higher rates of revision arthroscopy or conversion to arthroplasty. This may be reflective of a cohort with more extensive intra-articular damage and chondral delamination producing loose bodies, explaining the higher rate of subsequent surgery. This is supported by the studies mentioned earlier, reporting higher conversion with OA [10, 22] and additional studies reporting higher conversion rates with more advanced intra-operative chondral damage at the time of hip arthroscopy [23, 30].

Unique to our study, the SSLR threshold-analysis model and subsequent Cox proportional hazard analysis identified that individual surgeon volume correlated with the need for revision arthroscopy or conversion to arthroplasty. The need for revision surgery was higher with lower surgeon volume (<102 cases/year). This is the first study to our knowledge to assess individual surgeon volume as it relates to surgical outcomes. Schairer *et al.* [22] provided the only other assessment of the effect of surgical volume on outcomes, however their results report on center volume, rather than individual surgeon volume. They reported that patients who had hip arthroscopy in lower volume surgical centers (<10 cases/year), had a higher risk of requiring conversion to THA compared with both moderate- (11–49 cases/year) and high-volume (>50 cases/year) surgical centers. The paucity of available data on the volume–outcome relationship in hip arthroscopy highlights the importance of the present findings. To date, the only related literature has reported on the associated ‘learning curve’ of hip arthroscopy [16–18, 31]. In the majority of these studies, roughly 30 cases has been identified as the threshold beyond which the rate of procedural complications are noted to decrease [16–18]. However, these results do not define competency, but rather focus on safety as the analyses center on a reduction in associated surgical complications, rather than the effect on patient outcomes. This study provides the first attempt to quantify volume-based competency, although further study and validation of statistical methodology is required.

Finally, the complication rates identified in our study were found to be comparable to those reported by Malviya *et al.* [7]. They reported a 30-day re-admission rate of 0.5%, comparable to our rate of 0.7%. Further comparisons to studies are limited because of the restrictions of using an administrative database for event identification. Complications reported in our study reflect only those events requiring re-admission, which have historically been considered as ‘major complications’ in other studies. These primarily include deep infection, deep vein thrombosis, pulmonary embolism, vascular injury, fracture, dislocation and death. Similar rates of major complications have previously been reported in systematic reviews by both Harris *et al.* (0.58%) [5] and Kowalczyk *et al.* (0.3%) [32].

Limitations of this study include that it was based on data obtained from administrative databases tracking outpatient surgery. Limited data was available for each procedure, limiting the generalizability of these results. Conclusions derived from CPT codes alone may be prone to errors due to miscoding or incorrect assumptions, and should be interpreted with caution. Additionally, complication data primarily captured more severe complications

requiring re-admission, rather than the more common complications (lateral femoral cutaneous nerve palsy, heterotopic ossification, superficial wound infection) that are often dealt with in an outpatient setting. As a result, the true procedural complication rate may be underreported, although the rates provided are consistent with other study reports of 'major' complications. Similarly, patients having revision or subsequent procedures out of state are also not captured and may not be adequately reflected in the results. Finally, while laterality is available for outpatient procedures, including primary and revision hip arthroscopy, it is not routinely listed for the THA or resurfacing procedures. Based on expert opinion (B.T.K.), it was felt that it would be an exceedingly uncommon clinical scenario where a patient receives an ipsilateral hip arthroscopy and contralateral hip arthroplasty within 2 years. As a result, assumptions were made that these procedures were performed on the same side as the primary hip arthroscopy. As a result, the rate of conversion may be falsely elevated by assuming a worst-case scenario for each case; however, the conversion rates appear consistent with figures published in comparable studies.

In conclusion, following hip arthroscopy, Kaplan–Meier survival analysis showed a 2-year survival rate of 88.1%, 5-year of 80.7% and 10-year of 74.9%. Age greater than 50, years and a diagnosis of OA increased risk of re-operation, while performing a labral repair and having the procedure performed by a higher volume surgeon was associated with a lower risk of re-operation.

AUTHOR CONTRIBUTION

ICMJE criteria for authorship

R.M.D., T.J.P., B.C., N.M., P.D.C., D.H.N., S.L.: substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; R.M.D., T.J.P., B.C., N.M., P.D.C., A.S.R., B.T.K., D.H.N., S.L.: drafting the work or revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST STATEMENT

R.M.D., T.J.P., B.C., N.M., P.D.C., A.S.R., D.H.N. and S.L. do not have any relevant disclosures. B.T.K. does not have disclosures relevant to the current study, but does report personal fees from Arthrex and A-3 surgical.

FUNDING

Research reported in this publication was supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health under Award Number R01AR066069. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

ETHICAL REVIEW COMMITTEE

Institutional review board approval was not required for the current study as this is publicly accessible data. A copy of the approved data request form will be uploaded.

REFERENCES

1. Cvetanovich GL, Chalmers PN, Levy DM *et al.* Hip arthroscopy surgical volume trends and 30-day postoperative complications. *Arthroscopy* 2016; 1–7.
2. Bozic KJ, Chan V, Valone FH *et al.* Trends in hip arthroscopy utilization in the United States. *J Arthroplasty* 2013; **28**:140–3.
3. Montgomery SR, Ngo SS, Hobson T *et al.* Trends and demographics in hip arthroscopy in the United States. *Arthroscopy* 2013; **29**:661–5.
4. Colvin AC, Harrast J, Harner C. Trends in hip arthroscopy. *J Bone Jt Surg* 2012; **94**:e23 (1)-e23 (5).
5. Harris JD, McCormick FM, Abrams GD *et al.* Complications and reoperations during and after hip arthroscopy: a systematic review of 92 studies and more than 6,000 patients. *Arthroscopy* 2013; **29**:589–95.
6. Cvetanovich GL, Harris JD, Erickson BJ *et al.* Revision hip arthroscopy: a systematic review of diagnoses, operative findings, and outcomes. *Arthrosc J Arthrosc Relat Surg* 2015; **31**:1382–90. DOI: 10.1016/j.arthro.2014.12.027.
7. Malviya A, Raza A, Jameson S *et al.* Complications and survival analyses of hip arthroscopies performed in the National Health Service in England: a review of 6,395 cases. *Arthrosc J Arthrosc Relat Surg* 2015; **31**:836–42.
8. Gupta A, Redmond JM, Stake CE *et al.* Does primary hip arthroscopy result in improved clinical outcomes? 2-year clinical follow-up on a mixed group of 738 consecutive primary hip arthroscopies performed at a high-volume referral center. *Am J Sports Med* 2016; **44**:74–82.
9. Ross JR, Larson CM, Adeoyo O *et al.* Residual deformity is the most common reason for revision hip arthroscopy: a three-dimensional CT study. *Clin Orthop Relat Res* 2015; **473**:1338–95. DOI: 10.1007/s11999-014-4069-9.
10. Domb BG, Gui C, Lodhia P. How much arthritis is too much for hip arthroscopy: a systematic review. *Arthrosc J Arthrosc Relat Surg* 2015; **31**:520–9.
11. Skendzel JG, Philippon MJ, Briggs KK *et al.* The effect of joint space on midterm outcomes after arthroscopic hip surgery for femoroacetabular impingement. *Am J Sports Med* 2014; **42**:1127–33.
12. Philippon MJ, Briggs KK, Carlisle JC *et al.* Joint space predicts THA after hip arthroscopy in patients 50 years and older. *Clin Orthop Relat Res* 2013; **471**:2492–6.

13. Parvizi J, Bican O, Bender B *et al.* Arthroscopy for labral tears in patients with developmental dysplasia of the hip: a cautionary note. *J Arthroplasty* 2009; **24**:110–3.
14. Ross JR, Clohisy JC, Baca G *et al.* Patient and disease characteristics associated with hip arthroscopy failure in acetabular dysplasia. *J Arthroplasty* 2014; **29**:160–3.
15. Saadat E, Martin SD, Thornhill TS *et al.* Factors associated with the failure of surgical treatment for femoroacetabular impingement: review of the literature. *Am J Sports Med* 2014; **42**:1487–95.
16. Dietrich F, Ries C, Eiermann C *et al.* Complications in hip arthroscopy: necessity of supervision during the learning curve. *Knee Surg Sports Traumatol Arthrosc* 2014; **22**:953–8.
17. Lee Y-K, Ha Y-C, Hwang D-S *et al.* Learning curve of basic hip arthroscopy technique: CUSUM analysis. *Knee Surgery, Sport Traumatol Arthrosc* 2013; **21**:1940–4.
18. Hoppe DJ, de Sa D, Simunovic N *et al.* The learning curve for hip arthroscopy: a systematic review. *Arthroscopy* 2014; **30**:389–97.
19. Konan S. Hip arthroscopy: analysis of a single surgeon's learning experience. *J Bone Jt Surg* 2011; **93**:52.
20. Lyman S, Wilson T, Pan TJ *et al.* Threshold analysis of the volume-outcomes relationship in total knee arthroplasty. *International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine (ISAKOS)*. Lyon, France, 2015.
21. Sing DC, Feeley BT, Tay B *et al.* Age-related trends in hip arthroscopy: a large cross-sectional analysis. *Arthrosc J Arthrosc Relat Surg* 2015; **31**:2307–13.e2.
22. Schairer WW, Nwachukwu BU, McCormick F *et al.* Use of hip arthroscopy and risk of conversion to total hip arthroplasty: a population-based analysis. *Arthrosc J Arthrosc Relat Surg* 2016; **32**:587–93.
23. Gupta a, Redmond JM, Stake CE *et al.* Does primary hip arthroscopy result in improved clinical outcomes? 2-year clinical follow-up on a mixed group of 738 consecutive primary hip arthroscopies performed at a high-volume referral center. *Am J Sports Med* 2015; 1–9.
24. Philippon MJ, Schroder E Souza BG, Briggs KK. Hip arthroscopy for femoroacetabular impingement in patients aged 50 years or older. *Arthroscopy* 2012; **28**:59–65.
25. Domb BG, Linder D, Finley Z *et al.* Outcomes of hip arthroscopy in patients aged 50 years or older compared with a matched-pair control of patients aged 30 years or younger. *Arthrosc J Arthrosc Relat Surg* 2015; **31**:231–8.
26. Degen RM, Nawabi DH, Bedi A *et al.* Radiographic predictors of femoroacetabular impingement treatment outcomes. *Knee Surg Sports Traumatol Arthrosc* 2017; **25**:36–44.
27. Larson CM, Giveans MR, Stone RM. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement: mean 3.5-year follow-up. *Am J Sports Med* 2012; **40**:1015–21.
28. Krych AJ, Thompson M, Knutson Z *et al.* Arthroscopic labral repair versus selective labral debridement in female patients with femoroacetabular impingement: a prospective randomized study. *Arthroscopy* 2013; **29**:46–53.
29. Ayeni OR, Adamich J, Farrokhyar F *et al.* Surgical management of labral tears during femoroacetabular impingement surgery: a systematic review. *Knee Surg Sports Traumatol Arthrosc* 2014; **22**:756–62.
30. Dwyer MK, Lee JA, McCarthy JC. Cartilage status at time of arthroscopy predicts failure in patients with hip dysplasia. *J Arthroplasty* 2015; **30**:121–4.
31. Souza BGSE, Dani WS, Honda EK *et al.* Do complications in hip arthroscopy change with experience?. *Arthrosc - J Arthrosc Relat Surg* 2010; **26**:1053–7.
32. Kowalczyk M, Bhandari M, Farrokhyar F *et al.* Complications following hip arthroscopy: A systematic review and meta-analysis. *Knee Surgery, Sport Traumatol Arthrosc* 2013; **21**:1669–75.