Purpose: To report contemporary trends in hip arthroscopy case volume in the United States using a large cross-sectional cohort with accurate laterality tracking for assessment of revision surgery and rates of conversion to total hip arthroplasty (THA).

Methods: Using Current Procedural Terminology codes, we queried the Mariner PearlDiver dataset for patients who underwent hip arthroscopy from 2010 to 2017. Patient demographics were recorded and subsequent hip arthroscopy procedures and THA conversion within 2 years after surgery were tracked using International Classification of Diseases, Tenth Revision codes to accurately identify laterality. Emergency department and hospital admission within 30 days after surgery were queried.

Results: Of the 53,103 patients undergoing hip arthroscopy procedures, hip arthroscopy case volume increased 2-fold from 2010 to 2014 but remained relatively unchanged from 2014 to 2017. The most common age group undergoing surgery was 40 to 49 years, and female patients represented 70% of cases. Two-year subsequent surgery rate was 19%, with 15.1% undergoing a revision arthroscopy and 3.9% converting to THA. The most common revision arthroscopy procedures were femoroplasty (9.5%), labral repair (8.5%), and acetabuloplasty (4.3%). Younger patients were more likely to undergo revision arthroscopy (18% age 10-19 years; 15% age 20-29 years). Older patients had a significant risk for conversion to THA within 2 years (36% age 60-69 years; 28% age 50-59 years). Female patients also demonstrated a slightly greater rate of conversion to THA (4.1% female, 3.5% male, \( P < .0001 \)). Patients 20 to 29 years had the greatest risk of emergency department admission (5.4%) and hospital admission (0.8%) within 30 days of surgery.

Conclusions: The rise in hip arthroscopy procedures may be starting to plateau in the United States. Cross-sectional data also indicate that there is a greater than previously reported rate of revision hip arthroscopy in patients younger than 30 years of age and conversion to THA in patients older than 50 years of age. Level of Evidence: III, cross-sectional study.
large population-based studies investigating potential changes to these exponentially rising trends in hip arthroscopy surgery.

In addition, revision hip arthroscopy and conversion to total hip arthroplasty (THA) are important outcomes to track in a large population of patients undergoing hip arthroscopy. Single-surgeon cohort studies of more than 500 patients with a minimum 2-year follow-up demonstrate revision hip arthroscopy rates between 2.5% and 7.7% and THA-conversion rates between 1.2% and 9.1%. Determining rates of revision hip arthroscopy in large population studies can be variable due to lack of extremity laterality identification from administrative coding, but previous database studies have cited 3% to 11% revision surgeries in a 2-year follow-up period. Conversion to THA in large database studies within 2 years of hip arthroscopy has been reported from 5% to 17%, with older age groups exhibiting greater conversion rates. Maradit et al. showed a cumulative incidence of THA as high as 35% at 5 years and 45% at 10 years’ follow-up in the patients aged 55 to 64 years. However, lack of absolute tracking on the laterality for subsequent surgery has also been a major limitation to many of these studies. With new Classification of Diseases, Tenth Revision (ICD-10) codes implemented since 2015 that identify laterality, analysis of more recent data on revision surgery and conversion to THA in a large population undergoing hip arthroscopy surgery is possible.

The purpose of this study is to report contemporary trends in hip arthroscopy case volume in the United States using a large cross-sectional cohort with accurate laterality tracking for assessment of revision surgery and rates of conversion to THA. We hypothesized the steep curve of rising hip arthroscopy cases would plateau and that there would be a significant risk for revision surgery after hip arthroscopy.

Methods

The Mariner dataset (PearlDiver Technologies, Colorado Springs, CO) is a publicly available collection of U.S. orthopaedic patient records from various private insurance payers, Medicaid, Medicare, and self-pay patient populations released in 2020. This database contains more than 122 million patients with Health Insurance Portability and Accountability Act (HIPAA)-compliant records from years 2010 through 2019. International Classification of Diseases, Ninth Revision (ICD-9), ICD-10, and CPT codes can be used to query records.

Data were queried from January 2010 through December 2017 for patients undergoing hip arthroscopy procedures using CPT codes (Appendix Table 1, available at www.arthroscopyjournal.org) from the Mariner Arthroscopy dataset, which included patients who had undergone any arthroscopy procedure. Patients could be tracked until 2019 in this dataset, but new patient data from 2018 and 2019 data were excluded, as they did not meet the 2-year follow-up criteria. Patient demographics with respect to year of surgery, sex, and age group were queried. Patients were then tracked with 2-year follow-up to analyze for subsequent surgeries. To prevent counting multiple patient occurrences, the codes queried contain a unique combination with a patient tracking function. Beginning in 2015 and thereafter, patients with ICD-10 codes allowed for laterality identification and were tracked to ensure that subsequent surgery was on the ipsilateral side as the index procedure. Subsequent surgeries analyzed were revision hip arthroscopy procedures including femoroplasty, acetabuloplasty, labral repair, labral debridement, and synovectomy as well as THA between 6 and 24 months after initial hip arthroscopy.

In addition, Kaplan–Meier survival analysis was conducted for all patients at 6, 12, 18, and 24 months following hip arthroscopy surgery to assess for conversion to THA. Last, adverse events within 30 days of a hip arthroscopy procedure, such as admission to the emergency department (ED) or hospital, were queried.

Statistical Analysis

To determine statistical significance of the procedure based on year, sex, and age group, $\chi^2$ analysis was conducted. To assess trends in incidence, Cochran–Armitage independence testing, and simple linear regression were performed with regards to calendar year or age group. GraphPad Prism Statistics/Data Analysis software (GraphPad Software, Inc., La Jolla, CA) was used for all statistical analysis, and $P < .05$ was considered statistically significant.

This study was exempt from the institutional review board approval due to analysis of only de-identified administrative data.

Results

Queried results found 53,103 patients undergoing hip arthroscopy procedures from 2010 to 2017 (Table 1). All patients were treated for hip-related diagnoses including FAI, labral injury, chondral damage, loose body, or osteoarthritis according to ICD-9 and ICD-10 codes. The frequency of hip arthroscopy surgery increased by nearly 200% from 3,817 cases in 2010 to 7,598 cases in 2014 (Fig 1; $P < .0001$). Simple linear regression predicted a rise of 930 cases per year between this time period. From 2014 to 2017, the case volume for hip arthroscopy surgery slightly decreased by 3%. Simple linear regression projections from 2014 to 2017 predicted a decrease in the number of cases by 38 per year (Fig 1). The incidence of patients undergoing hip arthroscopy per 1,000 patients in the database that year showed the same trend with a rise from 2010 to 2014 before plateauing from 2014 through 2017 (1.5...
in 2010, 2.1 in 2011, 2.4 in 2012, 2.6 in 2013, 2.8 in 2014, 2.8 in 2015, 3.0 in 2016, and 2.8 in 2017).

The most common age group to undergo high arthroscopy surgery was patients aged 40 to 49 years, comprising 26% of cases (12,870), followed by age groups of 30 to 39 years (20%), 50 to 59 years (19%), 20 to 29 years (15%), 10 to 19 years (10%), 60 to 69 years (7%) and 70 to 79 years (2%) (Fig 2). During the study period, all age groups experienced an increase in the number of procedures, with younger patients demonstrating the greatest rise (353% in patients 20 to 29 years and 228% in patients 10 to 19 years, \(P < .0001\); Fig 3). Similar to the yearly arthroscopy trend, case frequency increased considerably for each age group from 2010 to 2014 then remained relatively unchanged from 2014 to 2017.

In this population, hip arthroscopy was performed significantly more frequently in female patients, with 34,429 cases (70%) (\(P < .0001\)). Age distribution analysis showed that younger patients were even more likely to be female (75% in 10-19 age group) compared with older patients (67% in 60- to 69-year age group) (\(P < .0001\)) (Fig 4). CPT code 29914 (femoroplasty) was the most frequent arthroscopic procedure, listed in 27,687 cases (52%), followed by CPT code 29916 (labral repair) in 24,196 cases (46%) (Table 1). The frequency of each arthroscopy procedure by year is shown in Fig 5.

### Revision Surgery and Conversion to Arthroplasty

Analysis of subsequent surgeries within 2 years following hip arthroscopy using ICD-10 codes from 15,128 patients showed that a total of 19% of patients underwent a revision procedure with 15.1% undergoing a revision hip arthroscopy procedure and 3.9% converting to THA. The most common revision procedures were revision femoroplasty (9.5% of all hip arthroscopy patients), labral repair (8.5%), acetabuloplasty (4.3%), labral debridement (3.2%), and synovectomy (2.2%) (Fig 6A). There was no difference in revision hip arthroscopy rate based on sex (15.4% male vs 15.4% female) whereas female patients were slightly more likely to convert to THA (4.1% female, 3.5% male, \(P < .0001\)) (Fig 6B). Younger patients were more likely to undergo revision hip arthroscopy within 2 years (18% in patients 10 to 19 years and 15% in patients 20 to 29 years) (Fig 6C). Simple linear regression showed a 2.8% decrease in revision hip arthroscopy procedures with increasing age group. The most common revision arthroscopy procedures for age groups

![Fig 1](image-url). Hip arthroscopy year trends. The number of patients undergoing hip arthroscopy procedures is shown by year.
younger than 60 years were femoroplasty and labral repair. There was a high risk for conversion to THA within 2 years of hip arthroscopy in older patients, with 36% in the 60- to 69-year age group, followed by the 50- to 59-year age group (28%), 40- to 49-year age group (16%), 70- to 79-year age group (12%), and 30- to 39-year age group (7%) (Fig 7). In patients <30 years, 0% converted within the 24-month follow-up period. Simple linear regression analysis demonstrated a 4.6% increase in conversion to THA within 2 years of hip arthroscopy with increasing age group.

Analysis of ED and hospital readmission rates within 30 days of hip arthroscopy surgery showed 5.4% of all patients were admitted to the ED and 0.8% were admitted to the hospital, with the 20- to 29-year-old age group having the greatest risk for readmissions followed by the 30- to 39-year-old age group (Table 2). Female patients were more likely to require an ED admission (5.5% female, 4.3% male) ($P < .0001$).

**Discussion**

In this study, we found that in a large cross-sectional population, the volume of hip arthroscopy surgery doubled from 2010 to 2014 and then plateaued between 2014 and 2017. Female patients were twice as likely to undergo hip arthroscopy surgery compared with male patients. In addition, there was a significant risk for revision surgery after hip arthroscopy, with younger patients younger than 30 years more likely to have a revision hip arthroscopy surgery whereas patients older than 50 years were more likely to convert to THA within 2-years.
To our knowledge, previous U.S. studies have all reported continued increases in hip arthroscopy volume. However, in this study using an updated large cross-sectional population, we found the volume and incidence of hip arthroscopy surgeries has stabilized from 2014 to 2017. Between 2010 and 2014 the number of cases nearly doubled, but from 2014 to 2017, the case volume was nearly the same each year. Truntzer et al.\textsuperscript{12} also examined the PearlDiver patient records database and reported an increase in hip arthroscopy cases of 117% from 2007 to 2014 with a slower growth rate of 12% from 2011 to 2014. The plateau of cases may be due to a recent influx of literature on outcomes for hip arthroscopy as well as predictors for better results, ultimately refining indications for surgery\textsuperscript{11,14} As a result, major health insurance companies have significantly increased the number of requirements before approval of hip arthroscopy procedures, which may also have curtailed the growth of hip arthroscopy.\textsuperscript{15} Furthermore, there appears to be little sustained benefit for hip arthroscopy in older patient age groups (>50 years) and those with narrowed joint spaces. Philippon et al.\textsuperscript{14,16} in a cohort study of 203 patients 50 years or older, found that 20% of patients underwent conversions to THA within 3 years. Montgomery et al.\textsuperscript{7} and Schairer et al.\textsuperscript{17} both used large population-based studies and showed that age groups 60 to 69 and >70 years demonstrated low incidences of hip arthroscopy.

![Fig 4. Hip arthroscopy age group and sex trends. The percentage of patients having hip arthroscopy procedures by age group and sex is shown.](image1)

![Fig 5. Hip arthroscopy procedure year trends. Yearly distribution of hip arthroscopy procedures. Procedures include diagnostic with or without biopsy; chondroplasty, abrasion arthroplasty, and/or resection of labrum; synovectomy; femoroplasty; labral repair; removal of loose or foreign body; osteoplasty acetabulum (Treatment of Pincer Impingement). Percentages are reflective for total surgery cases that year. The sum of the percentages may be greater than 100% per year, as more than one procedure code is commonly used for each surgery.](image2)
Fig 6. (A) Hip arthroscopy subsequent surgeries within 2 years. The percentage is shown of patients having subsequent surgeries following hip arthroscopy surgery. Subsequent revision surgeries include femoroplasty, acetabuloplasty, labral repair, labral debridement, and synovectomy. Conversion to THA represented. (B) Hip arthroscopy and subsequent surgeries within 2 years sex trends. Percentage is shown of patients having subsequent surgeries following hip arthroscopy surgery by sex. (C) Hip arthroscopy and subsequent surgeries within 2 years age group trends. Percentage is shown of patients having subsequent surgeries following hip arthroscopy surgery by age group. For (B) and (C), brackets represent total revision surgeries and is less than the sum of the percentages of individual procedures because multiple procedure codes could be listed within the same procedure. (THA, total hip arthroplasty.)
between 2004 and 2013. In our study, this trend continued as patients in the 60- to 69-year and 70- to 79-year age group made up only 5% and 2%, of the population undergoing hip arthroscopy, respectively, and the rate of hip arthroscopy cases plateaued at a relatively similar rate between the older and younger age groups.

Comparison of patient sex showed that more than two thirds of patients undergoing hip arthroscopy were female in our population. This trend is also true across age group and year as younger patients were even more likely to be female. Hale et al. similarly reported a 67% female to 33% male rate in their database study of 1,893 patients from Minnesota, whereas Bozic et al., Baron et al., and Maradit et al. also reported a greater percentage of female patients undergoing hip arthroscopy at 60% of 1,574 patients, 64.1% of 785 patients, and 61% of 10,042 patients respectively. Hale et al. also reported that between 2000 and 2016 female patients in their cohort had a greater incidence of FAI at all time points and Clohisy et al. noted a greater percentage of female patients (55%) undergoing FAI surgery from the ANCHOR cohort of 1,076 patients. These trends for increased hip arthroscopy in female patients are interesting as it has been reported that male patients are more likely to have radiographic findings for larger impingement lesions. In addition, various studies have reported radiographic findings with FAI are less common in asymptomatic female patients compared with asymptomatic male patients. Based on the contrasting rates of surgery in a general population shown from our study, further research evaluating the discrepancies in surgical treatment trends between patient sex is warranted.

We found an overall revision hip arthroscopy rate of 15.1% within 2 years from our population, which is greater than reported from previous single-surgeon cohorts, such as Nho et al.’s 2.5% in 23 patients, Gupta et al.’s 7.7% in 47 patients, and Cvetanovich et al.’s 1.2% in 386 patients. The greater revision rate in a cross-sectional population may be due to improved outcomes (and low revision rates) in high-volume hip arthroscopy surgeons that are not reflected by surgeons across the country who are not performing hip arthroscopy as commonly. In addition, when a patient does not improve after surgery, it is likely for them to seek care from a different surgeon for a second opinion. Therefore, the original surgeon may underestimate the true need for revision surgeries in their own patient cohort. Two previous database studies reported high revision hip arthroscopy rates in-line with our findings. Baron et al., in a Humana database study of 785 procedures from 2007 to 2015, found a hip arthroscopy revision rate of 18% with 1-year minimum follow-up and Maradit et al. reported a 2-year hip arthroscopy reoperation rate of 11% in 10,000 patients. We were able to use laterality tracking via ICD-10 codes in our current analysis to ensure accuracy for subsequent ipsilateral surgeries and still found a greater-than-expected revision arthroscopy rate at 15%. Previous literature also found that incomplete cam resection is the most common risk for revision hip scope. Our results indicate that revision femoroplasty was indeed the most common revision arthroscopy procedure, with
9.5% of all patients, but it was followed closely by revision labral repair in 8.5% of patients. In addition, a concerning finding is that younger patients aged 10 to 19 years have a high risk for revision hip arthroscopy at 18% within 2 years. Menge et al.26 and Litrenta et al.27 reported a 10% and 7.4% revision rate in patients younger than 20 years. However, these studies were conducted in a case series of 70 cases and retrospective review of 96 cases, respectively.26,27 Therefore, further research may be needed to investigate outcomes of hip arthroscopy in the younger age group.

As patient age increased, the risk of revision hip arthroscopy decreased but the risk of conversion to THA increased considerably. We showed a THA conversion rate of 36% in the 60- to 69-year age group and 28% in the 50- to 59-year age group, which was greater compared with Sing et al.,8 who reported patients aged 50 to 59 years converting to THA at 17% and patients aged >60 years at 16% with data from 2007 to 2011. Domb et al.28 also reported a similar rate to Sing et al.8 with 17.3% converting to THA in patients older than 50 years. The increased THA conversion rate in our data may be a result of increased recognition of the lower success rate of hip arthroscopy in older patients,14,29 whereby surgeons would recommend conversion to THA more readily if there is minimal improvement within the first 1 to 2 years following hip arthroscopy.29 This increased rate of THA conversion compared with previous reports may also be related to a lack of follow-up or changing of surgeons as patients may be more likely to seek a different surgeon for arthroplasty surgery unknownst to the original hip arthroscopist. As this database study cannot elicit the indications for hip arthroscopy surgery, another reason for the increased conversion rate is if the index hip arthroscopy was performed in the presence of hip osteoarthritis. Patients with osteoarthritis and joint space narrowing have been shown to be at significant risk for conversion to THA regardless of age,30,31 but data on specific osteoarthritis indicators such as Tönnis grade were not available in this dataset. Lastly, our results further caution hip arthroscopy surgery in patients older than 50 years old, as not only was there a high conversion to THA in these patients but there was also a significant risk for revision hip arthroscopy surgery as the risk for any type of reoperation within 2 years was 40% and 38% in the 60- to 69-year and 50- to 59-year age groups, respectively.

### Table 2. ED and Hospital Readmissions After Hip Arthroscopy by Age Group and Sex

<table>
<thead>
<tr>
<th>Age group, y</th>
<th>Percentage of Patients With ED Admission Within 30 Days of Hip Arthroscopy</th>
<th>Percentage of Patients With Hospital Readmission Within 30 Days of Hospital Arthroscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>5.4%</td>
<td>0.8%</td>
</tr>
<tr>
<td>&lt;10</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>10 to 19</td>
<td>5.2%</td>
<td>0.4%</td>
</tr>
<tr>
<td>20 to 29</td>
<td>6.4%</td>
<td>0.7%</td>
</tr>
<tr>
<td>30 to 39</td>
<td>6.2%</td>
<td>0.6%</td>
</tr>
<tr>
<td>40 to 49</td>
<td>4.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>50 to 59</td>
<td>3.8%</td>
<td>0.6%</td>
</tr>
<tr>
<td>60 to 69</td>
<td>4.0%</td>
<td>0.8%</td>
</tr>
<tr>
<td>70 to 79</td>
<td>2.9%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>5.5%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Male</td>
<td>4.3%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

ED, emergency department.
Finally, hospital admission rates within 30 days in our study were 0.8% which is comparable with Hartwell et al. and Du et al., who reported admission rates after hip arthroscopy to be 1.3% and 0.9%, respectively, using data from the National Surgical Quality Improvement Program (NSQIP) database. In addition, 5.4% ED admission rates within 30 days from our study was also similar to data from the NSQIP database as reported by Sivasundaram et al. at 3.5% at 30 days. Although specific events for ED and hospital readmissions could not be ascertained from this database, the readmission rates help to validate our dataset as the findings from this retrospective analysis of administrative records were consistent with prospectively collected postoperative data from the NSQIP database.

Limitations
Limitations to this paper include biases inherent with a large administrative database such as errors in coding via CPT and ICD-10 codes. Certain hip arthroscopy procedures that lacked specific coding, such as hip capsule repair/plication or labral reconstruction, could not be accurately assessed in this dataset. In addition, the database lacks access to data through the 2020 calendar year. There is a lag of typically 1 year before data availability from most health insurance databases, as additional time is needed to organize and stratify the data for it to be suitable for research. With the introduction of ICD-10 codes in 2015, we were able to account for extremity laterality, which is an improvement from previous research studies using surgical coding. However, we were unable to track for laterality from the years 2010 to 2014, so patients from these years were not used for the analysis on revision surgeries and limited the sample size for revision tracking. Another limitation is that patients who change insurance plans may not have complete follow-up recorded in the database. Since the Mariner dataset now has multiple insurance carriers compared with previous iterations of Pearl-Diver, this limitation may be somewhat mitigated. Finally, these administrative data lack information on certain risk factors for failure of hip arthroscopy, such as indications for the index surgery, severity of cartilage degeneration, or osteoarthritis, and surgeon-specific factors, such as specialty training, experience, and surgeon case volume.

Conclusions
The rise in hip arthroscopy procedures may be starting to plateau in the United States. Cross-sectional data also indicate that there is a greater than previously reported rate of revision hip arthroscopy in patients younger than 30 years of age and conversion to THA in patients older than 50 years of age.

References


### Appendix Table 1. CPT and ICD Codes Used for Data Query

<table>
<thead>
<tr>
<th>Description</th>
<th>CPT/ICD Codes Queried</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip arthroscopy, diagnostic with or without biopsy</td>
<td>CPT-29860</td>
</tr>
<tr>
<td>Hip arthroscopy, removal of loose body or foreign body</td>
<td>CPT-29861</td>
</tr>
<tr>
<td>Hip arthroscopy, chondroplasty, abrasion arthroplasty and/or resection of labrum</td>
<td>CPT-29862</td>
</tr>
<tr>
<td>Hip arthroscopy, synovectomy</td>
<td>CPT-29863</td>
</tr>
<tr>
<td>Hip arthroscopy, femoroplasty</td>
<td>CPT-29914</td>
</tr>
<tr>
<td>Hip arthroscopy, osteoplasty acetabulum</td>
<td>CPT-29915</td>
</tr>
<tr>
<td>Hip arthroscopy, labral repair</td>
<td>CPT-29916</td>
</tr>
<tr>
<td>Arthroplasty, acetabular and proximal femoral prosthetic replacement</td>
<td>CPT-27130</td>
</tr>
<tr>
<td>Conversion of previous hip surgery to total hip arthroplasty</td>
<td>CPT-27132</td>
</tr>
</tbody>
</table>